Effect of Enzyme Supplementation on the Performance of Growing-Finishing Pigs Fed Barley-Based Diets Supplemented with Soybean Meal or Canola Meal

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ABSTRACT : This experiment was conducted to determine the effects of enzyme supplementation on the performance of 80 growing-finishing pigs (26.2 kg) fed diets containing either soybean or canola meal. Barley-based diets formulated using either soybean meal or canola meal were fed with or without enzyme (Allzyme Vegpro, Alltech Biotechnology Centre). Eight castrates and twelve gilts were fed each diet. Digestibility of dry matter, crude protein and gross energy was 8.0 (p=0.0001), 7.9 (p=0.0005) and 7.9 (p=0.0003) percent lower for pigs fed diets containing canola meal compared with soybean meal. Enzyme supplementation had no effect on nutrient digestibility (p>0.05). There was a significant interaction between protein source and enzyme for all three nutrients. Over the entire experimental period (26.2 to 77.9 kg), pigs fed canola meal consumed 9.4% less feed (p=0.001), gained weight 20.4% slower (p=0.001) and had a 12.9% poorer feed conversion (p=0.001) than pigs fed soybean meal. Weight gain, feed intake and feed conversion were unaffected by enzyme addition (p>0.05). Castrates gained weight 11.4% faster (p=0.001), consumed 9.3% more feed (p=0.001) and had a 2.6% better feed conversion (p=0.026) than gilts. There was a significant interaction between protein source and sex of pig for feed conversion. Pigs fed diets based on canola meal had a significantly lower carcass value index (p=0.01), lower lean yield (p=0.007) and lower lean depth over the loin (p=0.001) than pigs fed diets based on soybean meal. Enzyme addition significantly increased lean depth over the loin (p=0.01). There was a significant interaction between protein source and enzyme for carcass value index (p=0.04), estimated lean yield (p=0.05) and fat depth over the loin (p=0.05). These results confirm previous studies which have demonstrated poorer pig performance when canola meal completely replaces soybean meal in diets fed to growing-finishing pigs. In addition, the results provide little justification for the inclusion of the Vegpro enzyme in diets fed to pigs of this weight range. *(Asian-Aust. J. Anim. Sci. 2001. Vol. 14, No. 7 : 1008-1013)*

Key Words : Soybean Meal, Canola Meal, Swine, Digestibility, Growth, Enzyme

INTRODUCTION

The cell walls of cereal grains, legumes and oilseed meals are comprised of complex carbohydrates commonly referred to as non-starch polysaccharides (Choct, 1997). Non-starch polysaccharides consist of a wide range of plant polymers which include cellulose, hemicellulose, pectins, β-glucans, a-glactosides (raffinose, stachyose and verbascose) and pentosans (Kitchen 1997). These non-starch polysaccharides may exhibit anti-nutritional activity by interfering with nutrient accessibility which can negatively affect the performance of pigs and poultry (Dierick and Decuypere, 1994).

Numerous attempts have been made to improve the performance of pigs fed diets based on cereal grains by dietary supplementation with exogenous enzymes. However, these experiments have generally failed to show improvements in performance of a similar magnitude to those observed in poultry for either growing/finishing (Graham et al., 1986; Van Lunen and Schulze, 1996; Thacker and Campbell, 1999) or starter pigs (Inborr et al., 1993; Baidoo et al., 1998; Jensen et al., 1998; Li et al., 1999).

Most commercially available cell-wall degrading preparations target cereal cell-wall constituents. However, one enzyme product specifically aims to hydrolyze the protein, non-starch polysaccharrides, lipids and oligosaccharides in vegetable protein seeds and meals (Allzyme Vegpro, Alltech Biotechnology Centre, Nicholasville, Kentucky). The objective of this experiment was to test this product to determine if the performance of growing-finishing pigs fed diets supplemented with either soybean meal or canola meal could be enhanced through enzyme supplementation. Canola meal (obtained from low erucic acid, low glucosinolate cultivars of rapeseed) was tested because it is one of the most widely utilized protein sources fed to pigs in Canada. Typically, canola meal contains approximately 35% crude protein, 2.3% lysine, 1.7% threonine and 1.2% methionine and cystine (Thacker, 1990).

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MATERIALS AND METHODS

Growth trial

Eighty crossbred pigs (Camborough 15 Line female ×Canabred sire, Pig Improvement Canada Ltd, Acme

Alberta) weighing an average of 26.2±2.65 kg were assigned on the basis of sex, weight and litter to one of four dietary treatments in a factorial (2 protein sources×2 enzyme levels×2 sexes) arrangement. All diets were based on Lacombe barley and were supplemented with either soybean meal or canola meal with half of each diet supplemented with 0.1% enzyme (Vegpro, Alltech Biotechnology Center, Nicholasville, Kentucky). Manufacturers specifications indicated that the principal enzyme activities present in the cocktail were protease, cellulase, xylanase, α-galactosidase and amylase.

During the growing period (26.2 to 50.3 kg), the experimental diets were formulated to supply 15.3% crude protein (table 1) while in the finishing period (50.3-77.9 kg), the diets were formulated to supply approximately 13% crude protein (table 2). The diets were deliberately formulated to provide lower levels of protein and energy than those recommended by the National Research Council (1998) to ensure that a growth response would be seen if the enzyme caused additional nutrients to be released.

All diets were supplemented with sufficient vitamins and minerals to meet or exceed the levels recommended by the National Research Council (1998). The diets were pelleted using low-pressure steam at approximately 60℃ to ensure minimal heat destruction of the enzyme product. The trial was run for 70 days and concluded when the pigs reached an average weight of 77.9 kg.

The pigs were housed in groups of four in 2.7× 3.6 m concrete floored pens and were provided water ad libitum. The pens were equipped with four individual feeders. Each pig was allowed access to its own individual feeder for 30-min twice daily (07:00 h and 15:00 h). Individual body weights, feed consumptions and feed efficiencies were recorded weekly. Eight castrates and twelve gilts were fed each diet. Pigs were assigned to feeders in such a way as to minimize the potential for treatment effects to be confounded with environmental effects.

Digestibility determination

Total tract digestibility coefficients for dry matter, crude protein and gross energy were determined using four castrates per treatment starting at an average weight of 39.3 kg. The pigs were housed under identical conditions as those used in the growth trial and were fed the same diets as those used during the growing stage modified only by the addition of 0.5% chromic oxide as a digestibility marker. The marked feed was provided for a seven day acclimatization period, followed by a three day fecal collection. Fecal collections were made by bringing animals into a

Table 1. Formulation and chemical composition of grower pig (26.2-50.3 kg) diets containing either soybean meal or canola meal fed supplemented or unsupplemented with Vegpro enzyme

	Soybean Meal		Canola Meal	
	Control	+Enzyme	Control	+Enzyme
Diet formulation (% as fed)				
Barley (10.95% CP)	80.35	80.25	72.60	72.50
Soybean meal (45.68% CP)	14.65	14.65	-	-
Canola meal (33.70% CP)	-	-	22.40	22.40
Tallow	1.00	1.00	1.00	1.00
Dicalcium phosphate	1.50	1.50	1.50	1.50
Limestone	1.50	1.50	1.50	1.50
Salt	0.50	0.50	0.50	0.50
Vitamin-mineral premix[1]	0.50	0.50	0.50	0.50
Vegpro enzyme	-	0.10	-	0.10
Chemical composition (% as fed)				
Moisture	12.21	12.50	12.00	12.31
Crude protein	15.92	15.41	15.62	15.81
Ash	5.71	5.56	5.95	5.91
Ether extract	2.84	2.81	3.19	3.01
Acid detergent fibre	7.17	6.56	10.50	10.48
Calcium	0.94	0.93	1.03	1.03
Phosphorus	0.74	0.69	0.86	0.86
Digestible energy (kcal/kg)[2]	3057	3054	2941	2937

[1] Supplied per kilogram of diet: 8250 IU vitamin A; 825 IU vitamin D3; 40 IU vitamin E; 4 mg vitamin K; 1 mg thiamin; 5 mg riboflavin; 35 mg niacin; 15 mg pantothenic acid; 2 mg folic acid; 12.5 μg vitamin B_{12}; 0.2 mg biotin; 80 mg iron: 25 mg manganese; 100 mg zinc; 50 mg Cu; 0.5 mg I; 0.1 mg selenium.

[2] Digestible energy calculated based on values published in NRC (1998).

Table 2. Formulation and chemical composition of finisher pig (50.3-77.9 kg) diets containing either soybean meal or canola meal supplemented or unsupplemented with Vegpro enzyme

	Soybean Meal		Canola Meal	
	Control	+Enzyme	Control	+Enzyme
Diet formulation (% as fed)				
Barley (10.95% CP)	87.50	87.40	83.60	83.50
Soybean meal (45.68% CP)	7.50	7.50	-	-
Canola meal (33.7% CP)	-	-	11.40	11.40
Tallow	1.00	1.00	1.00	1.00
Dicalcium phosphate	1.50	1.50	1.50	1.50
Limestone	1.50	1.50	1.50	1.50
Salt	0.50	0.50	0.50	0.50
Vitamin-mineral premix[1]	0.50	0.50	0.50	0.50
Vegpro enzyme	-	0.10	-	0.10
Chemical composition (% as fed)				
Moisture	12.99	12.85	12.42	11.95
Crude protein	13.18	13.23	13.08	13.46
Ash	5.29	5.22	5.37	5.54
Ether extract	2.87	2.83	3.09	3.28
Acid detergent fibre	7.06	6.76	8.60	8.83
Calcium	0.76	0.86	0.84	0.90
Phosphorus	0.66	0.66	0.71	0.73
Digestible energy (kcal/kg)[2]	3018	3015	2959	2955

[1] Supplied per kilogram of diet: 8250 IU vitamin A; 825 IU vitamin D3; 40 IU vitamin E; 4 mg vitamin K; 1 mg thiamin; 5 mg riboflavin; 35 mg niacin; 15 mg pantothenic acid; 2 mg folic acid; 12.5 μg vitamin B_{12}; 0.2 mg biotin; 80 mg iron: 25 mg manganese; 100 mg zinc; 50 mg Cu; 0.5 mg I; 0.1 mg selenium.

[2] Digestible energy calculated based on values published in NRC (1998).

clean room immediately after feeding and recovering freshly voided feces. The fecal samples were frozen for storage. Prior to analysis, the samples were dried in a forced air oven dryer at 66℃ for 60 h, followed by fine grinding (0.5-mm screen).

Carcass measurements

The 32 castrates were maintained on their respective diets following the conclusion of the performance trial and were slaughtered at a commercial abattoir at an average weight of 104.6 kg. Carcass weight was recorded and dressing percentage calculated. Carcass fat and lean measurements were obtained with a Destron PG 100 probe placed over the 3rd and 4th last ribs, 70 mm off the midline. These values were then used in calculating Carcass Value Indices according to the table of differentials in effect at the time of the experiment (Saskatchewan Pork Producers Marketing Board, 1997). The gilts were transferred to a reproductive study and were therefore unavailable for slaughter.

Chemical analysis

Samples of the growing and finishing rations were analyzed for dry matter, crude protein, acid detergent fibre, ash and ether extract according to the methods of the Association of Official Analytical Chemists (1980). An adiabatic oxygen bomb calorimeter (Parr; Moline, Illinois) was used to determine gross energy content. Chromic oxide was determined by the method of Fenton and Fenton (1979). An amino acid analysis of the grower diets (table 1) was performed using a LKB-Biochrome 4151 Alpha Plus Amino Acid Analyzer after hydrolysis for 22 h with 6 N HCl.

Statistical analysis

Pig performance data were analyzed as a 2×2×2 factorial using the General Linear Models procedure of the Statistical Analysis System Institute, Inc. (SAS 1990) with the factors in the model consisting of protein supplement, enzyme treatment, sex and all two way interactions. The digestibility trial and carcass data were analyzed as a 2×2 factorial with the factors in the model being protein supplement, enzyme treatment and their interaction.

RESULTS

The effects of protein source and enzyme addition on nutrient digestibility are presented in table 3. Digestibility of dry matter, crude protein and gross energy was 8.0 (p=0.0001), 7.9 (p=0.0005) and 7.9 (p=0.0003) percent lower for pigs fed diets supplemented with canola meal in comparison with soybean meal. Digestibility coefficients for the enzyme supplemented diets were numerically higher than for

Table 3. The effects of protein supplement and enzyme addition on digestibility coefficients for dry matter, crude protein and gross energy for growing male pigs[1]

	Protein Source		Enzyme		SEM[2]	P-Values		
	Soybean	Canola	None	Added		Protein	Enzyme	P×E
Dry matter (%)	71.2[a]	65.5[b]	67.9	68.9	1.04	0.0001	0.34	0.009
Crude protein (%)	71.5[a]	65.8[b]	67.8	69.4	1.18	0.0005	0.19	0.002
Gross energy (%)	70.8[a]	65.2[b]	67.3	68.7	1.11	0.0003	0.25	0.004

[1] Within main effect, means followed by different letters are significantly different at the P values indicated.
[2] Standard Error of the Mean.

pigs fed the unsupplemented diets but the differences did not reach statistical significance (p>0.05).

There was a significant (p<0.05) interaction between protein source and enzyme supplementation (data not shown). Digestibility coefficients for dry matter, crude protein and energy were 3.1, 4.0 and 3.6 percent higher for pigs fed the unsupplemented soybean meal diet than for pigs fed the soybean meal diet supplemented with enzyme. In contrast, digestibility coefficients for dry matter, crude protein and energy were 6.4, 9.0 and 7.8 percent higher for pigs fed the canola meal diet supplemented with enzyme compared with the unsupplemented canola meal diet.

The main effect means for the effects of protein source, enzyme supplementation and sex on pig performance are shown in table 4. During the growing period (26.2 to 50.3 kg), pigs fed canola meal consumed 8% less feed (p=0.001), gained weight 23% slower (p=0.001 and had a 16.2% poorer feed conversion (p=0.001) than pigs fed soybean meal. Enzyme addition had no significant (p>0.05) effects on weight gain, feed intake and feed conversion during this period. The feed conversion of castrates was 5.1% (p=0.001) poorer than for gilts. Sex of pig had no significant effect on either gain or feed intake.

During the finishing period (50.3 to 77.9 kg), pigs fed canola meal consumed 10.5% less feed (p=0.001), gained weight 19.1% slower (p=0.001) and had a 10.3% poorer feed conversion (p=0.001) than pigs fed soybean meal. Enzyme addition had no significant (p>0.05) effect on weight gain, feed intake and feed conversion during this period. Castrates gained weight 21.1% faster (p=0.001), consumed 12.9% more feed (p=0.001) and had a 9.3% better feed conversion (p=0.001) than gilts.

Over the entire experimental period, pigs fed canola meal consumed 9.4% less feed (p=0.001), gained weight 20.4% slower (p=0.001) and had a 12.9% poorer feed conversion (p=0.001) than pigs fed soybean meal. Growth rate, feed intake and feed conversion were unaffected by enzyme addition (p>0.05). Castrates gained weight 11.4% faster (p=0.001) and consumed 9.3% more feed (p=0.001) and had a 2.6% better feed conversion (p=0.026) than gilts.

There was a significant interaction between protein source and sex for feed conversion during the growing (p=0.01) and finishing (p=0.01) periods as well as through the overall experiment (p=0.05). There were no significant interactions between protein source and enzyme supplementation or between enzyme supplementation and sex of pig for any of the performance traits measured.

The main effect means for the effects of protein source and enzyme supplementation on carcass traits of castrate pigs are shown in table 5. Pigs fed diets based on canola meal had a significantly lower carcass value index (p=0.01), lower lean yield (p=0.007) and lower lean depth over the loin (p=0.001) than pigs fed diets based on soybean meal. Enzyme addition significantly increased lean depth over the loin (p=0.01). There was a significant interaction between protein source and enzyme treatment for carcass value index (p=0.04), estimated lean yield (p=0.05) and fat depth over the loin (p=0.05).

DISCUSSION

The results of this experiment confirm many earlier studies which have demonstrated a decrease in pig performance when canola meal completely replaces soybean meal in diets fed to growing-finishing pigs (Bell et al., 1981, 1987, 1988). The poorer growth of pigs fed canola meal may be attributed to the higher fibre content of the canola meal diets which would result in a lower digestible energy content for these diets (Bell, 1993).

The lysine content of the canola meal diets was lower than the soybean meal diets which could also account for the slower growth rate for pigs fed the canola meal diets. Sauer et al (1982) previously reported a lower lysine content in canola meal compared with soybean meal. In addition, they reported that the digestibility of the lysine in canola meal was approximately 10 percentage units lower than that for soybean meal which would also lead to poorer pig performance.

The feed intake of pigs fed canola meal was significantly lower than that of pigs fed soybean meal

Table 4. The effects of protein source and enzyme supplementation on pig performance[1]

	Protein source		Enzyme		SEM[2]	Sex		SEM	P-Values		
	Soybean	Canola	None	Added		Gilts	Castrates		Protein	Enzyme	Sex
Grower period (26.2-50.3 kg)											
Daily gain (kg)	0.7	0.60^{b}	0.68	0.69	0.017	0.69	0.68	0.012	0.001	0.66	0.63
Daily feed (kg)	1.8	1.72^{b}	1.77	1.82	0.044	1.77	1.83	0.032	0.001	0.30	0.19
Feed conversion	2.4	2.89^{b}	2.64	2.67	0.037	2.58^{a}	2.72^{b}	0.026	0.001	0.39	0.001
Finisher period (50.3-77.9 kg)											
Daily gain (kg)	0.8	0.72^{b}	0.80	0.82	0.022	0.71^{a}	0.90^{b}	0.016	0.001	0.44	0.001
Daily feed (kg)	2.8	2.54^{b}	2.66	2.71	0.065	2.50^{a}	2.87^{b}	0.046	0.001	0.49	0.001
Feed conversion	3.2	3.57^{b}	3.41	3.36	0.054	3.55^{a}	3.22^{b}	0.039	0.001	0.58	0.001
Total experiment (26.2-77.9 kg)											
Daily gain (kg)	0.8	0.66^{b}	0.74	0.75	0.017	0.70^{a}	0.79^{b}	0.012	0.001	0.48	0.001
Daily feed (kg)	2.3	2.13^{b}	2.22	2.27	0.052	2.13^{a}	2.35^{b}	0.037	0.001	0.38	0.001
Feed conversion	2.8	3.24^{b}	3.04	3.03	0.031	3.07^{a}	2.99^{b}	0.022	0.001	0.98	0.026

[1] Within main effect, means followed by different letters are significantly different at the P values indicated.
[2] Standard Error of the Mean.

Table 5. The effects of protein supplement and enzyme addition on carcass traits for castrate pigs [1]

	Protein source		Enzyme		SEM[2]	P-Values		
	Soybean	Canola	None	Added		Protein	Enzyme	P×E
Slaughter weight (kg)	104.6	104.1	103.8	105.0	0.80	0.64	0.31	0.22
Carcass weight (kg)	80.4	78.7	79.5	79.6	0.68	0.09	0.92	0.21
Dressing percentage (%)	76.7	75.6	76.5	75.8	0.53	0.13	0.32	0.84
Carcass value index	105.6^{a}	100.1^{b}	103.2	102.4	1.47	0.01	0.72	0.04
Estimated lean yield (%)	58.5^{a}	57.0^{b}	57.8	57.8	0.38	0.007	0.99	0.05
Backfat depth over loin (mm)	22.7	25.2	24.5	24.5	1.03	0.10	0.42	0.05
Lean depth over loin (mm)	56.7^{a}	46.2^{b}	53.8^{b}	53.8^{b}	1.31	0.001	0.01	0.73

[1] Within main effect, means followed by different letters are significantly different at the P values indicated.
[2] Standard Error of the Mean.

at all stages of growth which would normally be expected to translate into a reduction in growth. Other researchers have reported that canola meal tends to be less palatable than soybean meal (Hill and Lee, 1980), which may be associated with glucosinolates, tannins and sinapine (Bell, 1993).

Addition of the Vegpro enzyme had no beneficial effects on nutrient digestibility, growth rate or feed conversion. These results are somewhat surprising given the fact that the enzyme cocktail was designed specifically to enhance the nutritional value of vegetable protein sources fed to swine through increased utilization of their non-starch polysaccharides. Given that the non-starch polysaccharide content of soybean meal and canola meal has been reported to be 22.7% and 19.6%, respectively (Chesson, 1987), the enzyme cocktail would appear to have ample substrate on which to act. The lack of a beneficial response forces one to conclude that the enzyme is ineffective in breaking down non-starch polysaccharides. Previous work with this enzyme has also reported no beneficial effects in grower-finisher pig performance (Lindemann et al., 1997a) while a modest improvement in feed conversion was reported for weaner pigs (Lindemann et al., 1997b).

In conclusion, the overall results of this experiment confirm previous studies showing inferior performance (reduced nutrient digestibility, slower growth, reduced feed intake and poorer feed conversion) when canola meal is included as the sole protein source in diets fed to growing-finishing pigs. In addition, due to its failure to improve nutrient digestibility, growth performance or carcass traits, there would appear to be little justification for the inclusion of Vegpro enzyme in diets fed to growing-finishing pigs.

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