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Performance of Growing-finishing Pigs Fed Diets Containing Normal or Low Lignin-high Fat Oat Supplemented or Unsupplemented with Enzyme

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Abstract: The objectives of the following study were to compare a recently developed low lignin- high fat oat with regular oat as an energy source for use in diets fed to growing-finishing pigs and to determine if the performance of pigs fed diets containing oat could be improved through enzyme supplementation. A total of 144 crossbred pigs (26.9±3.5 kg BW) were assigned on the basis of sex, weight and litter to one of six dietary treatments in a factorial design experiment (diet x sex). The control diet was formulated using barley and soybean meal while two experimental diets were formulated in which 40% of either normal or low lignin-high fat oat was substituted for barley. All diets were fed either with or without dietary enzyme (750 units g^{-1} of beta-glucanase and 650 units g^{-1} of xylanase). Enzyme supplementation increased dry matter ($p<0.05$) crude protein ($p<0.05$) and energy ($p<0.05$) digestibility. Digestibility coefficients for dry matter and energy were significantly higher for the barley-based diets than for either the normal oat ($p<0.05$) or low lignin-high fat oat ($p<0.05$) diets. In contrast, digestibility coefficients for crude protein were lower for the barley-based diet than the normal fat ($p<0.05$) or low lignin-high fat ($p<0.05$) diets. For the overall experiment (26.9-111.3 kg), enzyme supplementation had no effect on growth or feed intake ($p>0.05$) but feed conversion was marginally improved ($p<0.10$). Daily gain and feed consumption for pigs fed both normal oat and low lignin-high fat oat were significantly higher than for pigs fed barley ($p<0.05$). Feed conversion was unaffected by the type of cereal fed ($p>0.05$). Barrows gained weight significantly faster ($p<0.05$) and had higher feed consumption ($p<0.05$) than gilts but had poorer feed conversion ($p<0.05$). Enzyme supplementation had no effect on swine carcass traits ($p>0.05$). Pigs fed diets based on low lignin-high fat oat had higher carcass value index ($p<0.10$) than pigs fed normal oat. Lean yield was lower ($p<0.10$) and loin fat higher ($p<0.05$) for pigs fed normal oat than for pigs fed the barley-based diets. Barrows had higher slaughter weights and loin fat than gilts ($p<0.05$) while dressing percentage, carcass value index, lean yield and loin lean were significantly lower ($p<0.05$). The overall results of this experiment indicate that both normal and low lignin-high fat oat can substitute for barley at levels as high as 40% of the diet without hindering pig performance. Since the average yield of oat can be equal or higher than barley with lower input costs, a re-examination of feeding recommendations regarding oat in swine rations seems warranted. There appears to be greater potential to utilize oat, regardless of fat level, in rations fed to growing-finishing pigs than is currently being achieved.

Key words: Swine, low-lignin, high-fat oat, digestibility, growth, carcass composition

INTRODUCTION

Domestic oat (*Avena sativa*) is not widely utilized as an energy source in swine rations[1,2]. The principle reason for this is that approximately one-third of the oat grain is hull resulting in a high dietary fibre content[3]. The fibre itself is not digestible by the pig and its presence also impairs the digestibility of energy and other nutrients contained in the grain[4].

Dietary fibre is defined as the sum of non-starch polysaccharides and lignin[5]. Most non-starch polysaccharides can be degraded to some degree in the digestive tract of the pig[5] whereas lignin is virtually indigestible[6]. Since the lignin content of oat is almost twice that of any of the commonly used cereal grains[5], a reduction in the lignin content of oat may be beneficial in improving its nutritional value for swine. The addition of fat increases the energy content of swine diets[7] and has been shown to improve the feeding value of diets containing 40% oat when fed to growing-finishing pigs[8] . Increasing the fat content of oat may be another way to improve its nutritional value for swine.

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The cell wall of oat contains appreciable quantities of beta-glucan and xylan[9,10]. These compounds have been shown to reduce the nutritional value of cereal grains for poultry by increasing the viscosity of the intestinal fluid[11]. This increase in intestinal viscosity may interfere with the digestive process by impeding enzyme-substrate association or by reducing the rate at which released nutrients approach the mucosal surface for absorption[12] . The negative effects of feeding poultry diets formulated using cereal grains containing beta-glucan and xylan can be largely overcome by enzyme supplementation[10,13].

Efforts to improve the nutritional value of cereal grains for swine through the use of enzyme supplementation have not yielded consistent results. While researchers such as Van Lunen and Schulze[14] and Baidoo *et al.*[15] have reported improvements in pig performance as a result of enzyme supplementation, others have reported little or no benefit[9,17,18].

A breeding project was recently undertaken at the University of Saskatchewan to develop a low acid detergent lignin hull-high fat oat for use in livestock feeding. The following study was conducted to compare this recently developed oat with regular oat as an energy source for use in diets fed to growing-finishing pigs and to determine if the performance of pigs fed diets containing oat could be improved through enzyme supplementation.

MATERIALS AND METHODS

Acquisition of oat samples: The low lignin-high fat oat sample used in the present trial is a breeding line developed at the University of Saskatchewan, Crop Development Centre (CDC). The breeding line was developed from a cross between AC Assiniboia (donor of the low acid detergent lignin hull trait) and a CDC breeding line SA96121 (donor of the high fat trait). A single plant, identified as both low lignin and high fat, was bulked to form the low lignin hull, high fat groat CDC breeding line that was tested in this experiment.

The normal-fat oat variety used was Derby[19]. It is one of the most commonly grown oat varieties on the Canadian Prairies due to its high yield, excellent grain quality, good straw strength and relatively low groat fat. A chemical analysis of the two oat varieties tested as well as that of barley (Table 1).

Table 1: Chemical composition and amino acid content of normal and low lignin-high fat oat (% as fed)

	Barley	Normal oat	Low lignin-high fat oat
Chemical analysis			
Moisture	9.59	7.28	7.87
Crude protein	11.79	12.46	11.08
Ether extract	1.89	3.55	5.74
Neutral detergent fibre	17.46	28.00	27.87
Acid detergent fibre	5.73	14.74	13.34
Lignin	0.79	2.05	1.12
Ash	1.91	2.53	2.95
Amino acid content			
Arginine	0.57	0.92	0.73
Histidine	0.32	0.34	0.30
Isoleucine	0.39	0.39	0.39
Leucine	0.85	0.98	0.86
Lysine	0.48	0.51	0.51
Methionine + Cystine	0.39	0.44	0.44
Phenylalanine	0.48	0.61	0.55
Threonine	0.28	0.30	0.31
Valine	0.38	0.47	0.44

Growth trial: A total of 144 crossbred pigs (Camborough 15 Line female x Canabred sire, Pig Improvement Canada Ltd, Airdrie Alberta) weighing an average of 26.9±3.5 kg were assigned on the basis of sex, weight and litter to one of six dietary treatments in a factorial design experiment. The main effects tested included diet and sex of pig (barrows and gilts).

The control diet was formulated using barley and soybean meal while two experimental diets were formulated in which 40% of either normal or low lignin-high fat oat was substituted for barley. All diets were fed either with or without dietary enzyme. The enzyme used was a commercially available product (Endofeed, GNC Bioferm, Saskatoon, Saskatchewan), which provided 750 units g^{-1} of beta-glucanase and 650 units g^{-1} of xylanase (one unit of activity defined as a change of one in the inverse specific viscosity coefficient; manufacturers specifications). The enzyme was obtained from Aspergillus niger fermentation and the final product contained dehydrated malt sprouts as a carrier. The enzyme cocktail provided lesser quantities of other enzymes including cellulase, amylase, pectinase and arabinofuranosidase.

During the growing period (26.9 to 56.1 kg), the experimental diets were formulated to supply 0.95% lysine while in the finishing period (56.1-111.3 kg), the diets were formulated to supply 0.75% lysine. These diets would meet the amino acid requirements of pigs with a lean growth potential of 350 g/day[20]. Diets containing oat were supplemented with canola oil to compensate for the expected lower energy of oat vs. barley. All diets were supplemented with sufficient vitamins and minerals to meet or exceed the levels recommended by the National Research Council[20]. The diets were pelleted using low-pressure steam at approximately 60°C.

The pigs were housed in unisex groups of four in 2.7x3.6 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 (08:00 and 15:00 h). Individual body weight, feed consumption and feed conversion were recorded weekly. Twelve 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 five barrows per treatment starting at an average weight of 44.9 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 0.35% chromic oxide as a digestibility marker. 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 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°C for 60 h, followed by fine grinding (0.5-mm screen). Digestibility coefficients were calculated using the equations for the indicator method described by Schneider and Flatt[21].

Carcass measurements: All pigs were slaughtered at a commercial abattoir at an average weight of 111.3 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[22].

Chemical analysis: Samples of barley and the two oat varieties as well as the grower and finisher 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[23]. The calcium and phosphorus content of the growing and finishing rations were also determined according to the methods of the Association of Official Analytical Chemists[23]. Neutral detergent fibre was analysed using the method of Van Soest *et al.*[14]. An adiabatic oxygen bomb calorimeter (Parr; Moline and Illinois) was used to determine gross energy content. Chromic oxide was determined by the method of Fenton and Fenton[24]. An amino acid analysis of the barley and two oat varieties was performed using a Beckman Amino Acid Analyser equipped with a Spherogen 1 IEX Ion Exchange Column. Samples were oxidized with Performic acid and hydrolysed with HCl as described by Llames and Fontaine[25].

Statistical analysis: The data from the performance trial and carcass data were analysed as a 2x6 factorial using the General Linear Model procedure of the Statistical Analysis System Institute, Inc.[26] with the factors in the model consisting of diet and sex of pig as well as their interaction. Digestibility data were analysed as a one-way ANOVA. Treatment means were compared using single degree of freedom orthogonal contrasts. Contrasts tested included a) diets with enzyme vs. without enzyme; b) barley diets vs. all oat diets; c) barley diets vs. normal oat diets, d) barley diets vs. low lignin-high fat oat diets; and e) normal oat diets vs. low lignin-high fat oat diets. Differences were considered significant when $p<0.05$. A $p<0.10$ was taken to indicate a trend. Since pigs were fed individually, pigs were considered the experimental unit for all statistical analysis and pen was never considered in any analytical model.

RESULTS

The breeding program to increase the fat content of oats was successful with the low lignin-high fat oat having 38.1% higher (5.74 vs. 3.55%) ether extract than the normal oat (Table 1). In addition, the lignin content of the selected oat was 45.3% lower (1.12 vs. 2.05%) than the normal oat. The reduction in lignin content was associated with lower neutral detergent fibre and acid detergent fibre. The essential amino acid contents of the two oat varieties were generally higher than those for barley.

The chemical analysis conducted on the growing and finishing rations confirmed that the diets met the specifications called for in the diet formulation. All diets contained approximately the same crude protein and digestible energy content (Table 2 and 3). The ether extract content of the low lignin-high fat oat containing diets was higher and the lignin content lower than the normal oat containing diets reflecting the chemical composition of the two oat varieties.

Enzyme supplementation increased dry matter ($p<0.05$) crude protein ($p<0.05$) and energy ($p<0.05$) digestibility. Digestibility coefficients for dry matter and energy were significantly higher for the barley-based diets than for either the normal oat ($p<0.05$) or low lignin-high fat oat ($p<0.05$) diets. In contrast, digestibility coefficients for crude protein were lower for the barley-based diet than the normal fat ($p<0.05$) or low lignin-high fat ($p<0.05$) oat diets (Table 4).

Table 2: Ingredient composition and chemical analysis of grower (26.9-56.1 kg) diets formulated to compare the nutrient value of normal and low lignin-high fat oat for swine

	Barley		Normal oat		Low lignin-high fat oat	
	- Enzyme	+ Enzyme	- Enzyme	+ Enzyme	- Enzyme	+ Enzyme
Diet formulation (% as fed)						
Barley (11.79 % CP)	72.10	72.00	30.66	30.56	29.35	29.25
Soybean meal (44.86% CP)	20.09	20.09	19.60	19.60	21.19	21.10
Normal oat (12.46% CP)	0.00	0.00	40.00	40.00	0.00	0.00
Low lignin-high fat oat (11.08% CP)	0.00	0.00	0.00	0.00	40.00	40.00
Canola oil	3.80	3.80	5.64	5.64	5.45	5.45
Vitamin-mineral premix[1]	1.00	1.00	1.00	1.00	1.00	1.00
Dicalcium phosphate	1.46	1.46	1.60	1.60	1.56	1.56
Limestone	1.01	1.01	0.93	0.93	0.94	0.94
Salt	0.50	0.50	0.50	0.50	0.50	0.50
Lysine	0.04	0.04	0.07	0.07	0.01	0.01
Enzyme[2]	0.00	0.10	0.00	0.10	0.00	0.10
Chemical composition (% as fed)						
Moisture	11.43	11.16	11.07	11.76	11.55	12.18
Crude protein	17.08	17.74	17.86	17.65	18.09	18.07
Ash	5.31	4.93	4.99	5.17	5.13	5.28
Ether extract	5.24	5.82	8.01	8.22	8.91	8.77
Neutral detergent fibre	13.60	12.61	17.10	17.25	17.41	16.98
Acid detergent fibre	5.76	5.40	8.21	8.24	7.74	8.05
Lignin	0.70	0.58	0.97	1.00	0.63	0.70
Calcium	0.96	0.89	0.86	0.95	0.90	0.85
Phosphorus	0.58	0.64	0.67	0.63	0.59	0.62
Gross energy (kcal kg^{-1})	4147.0	4097.0	4349.0	4321.0	4358.0	4379.0
Digestible energy (kcal kg^{-1})	3068.0	3194.0	2946.0	3148.0	3127.0	3110.0

[1]Supplied per Kilogram of diet: 8250 IU Vitamin A; 825 IU Vitamin D_3; 40 IU Vitamin E; 4 mg Vitamin K; 1 mg Thiamine; 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]Endofeed (GNC Bioferm, Saskatoon, Saskatchewan), which provided 750 units g^{-1} of β-glucanase and 650 units g^{-1} of xylanase

Table 3: Ingredient composition and chemical analysis of finisher (56.1-111.3 kg) diets formulated to compare the nutrient value of normal and low lignin-high fat oat for swine

	Barley		Normal oat		low lignin-high fat oat	
	- Enzyme	+ Enzyme	- Enzyme	+ Enzyme	- Enzyme	+ Enzyme
Diet formulation (% as fed)						
Barley (11.79% CP)	80.25	80.15	40.26	40.16	40.26	40.16
Soybean meal (44.86% CP)	14.27	14.27	13.46	13.46	13.46	13.46
Normal oat (12.46% CP)	0.00	0.00	40.00	40.00	0.00	0.00
Low lignin-high fat oat (11.08% CP)	0.00	0.00	0.00	0.00	40.00	40.00
Canola oil	2.05	2.05	2.80	2.80	2.80	2.80
Vitamin-mineral premix[1]	1.00	1.00	1.00	1.00	1.00	1.00
Dicalcium phosphate	0.92	0.92	1.06	1.06	1.06	1.06
Limestone	1.01	1.01	0.92	0.92	0.92	0.92
Salt	0.50	0.50	0.50	0.50	0.50	0.50
Enzyme[2]	0.00	0.10	0.00	0.10	0.00	0.10
Chemical composition (% as fed)						
Moisture	11.00	11.71	11.79	11.63	11.79	11.66
Crude protein	16.33	16.05	15.89	15.47	15.43	15.50
Ash	4.61	4.48	4.43	4.64	4.75	4.82
Ether extract	3.43	3.54	5.56	5.14	5.51	6.13
Neutral detergent fibre	13.39	13.63	18.00	17.56	18.40	17.35
Calcium	0.64	0.57	0.50	0.54	0.47	0.58
Phosphorus	0.48	0.46	0.49	0.49	0.47	0.46

[1]Supplied per Kilogram of diet: 8250 IU Vitamin A; 825 IU Vitamin D_3; 40 IU Vitamin E; 4 mg Vitamin K; 1 mg Thiamine; 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]Endofeed (GNC Bioferm, Saskatoon, Saskatchewan), which provided 750 units g^{-1} of β-glucanase and 650 units g^{-1} of xylanase

During the growing period (26.9-56.1 kg), enzyme supplementation significantly increased daily gain ($p<0.10$), feed intake ($p<0.10$) and feed conversion ($p<0.10$). Feed intake was higher ($p<0.05$) for pigs fed barley diets vs. either the normal or low lignin-high fat oat. As a result, feed conversion was improved for both the low lignin-high fat ($p<0.05$) and normal oat ($p<0.05$) fed pigs in comparison with barley fed pigs. Barrows had significantly higher weight gain ($p<0.05$) and feed intake than gilts but poorer feed conversion ($p<0.05$), (Table 5).

Table 4: Effects of enzyme supplementation on digestibility coefficients for pigs fed diets based on normal or low lignin-high fat oat

	Barley		Normal oat		low lignin-high fat oat		
	- Enzyme	+ Enzyme	- Enzyme	+ Enzyme	- Enzyme	+ Enzyme	SEM
Dry matter (%)[a-d]	74.7	78.1	67.4	71.9	71.6	69.5	0.73
Crude protein (%)[a-d]	70.8	75.6	73.1	77.7	77.3	76.8	1.05
Gross energy (%)[a-d]	74.0	78.0	67.7	72.9	71.8	71.9	0.75

[a]Orthoginal contrast for diets with enzyme vs. diets without enzyme significant at p<0.05 , [b]Orthoginal contrast for barley diets vs. all oat diets enzyme significant at p<0.05, [c]Orthoginal contrast for barley diets vs. normal oat diets enzyme significant at p<0.05, [d]Orthoginal contrast for barley diets vs. low lignin-high fat oat diets enzyme significant at p<0.05, [e]Orthoginal contrast for normal oat diets vs. low lignin-high fat oat diets enzyme significant at p<0.05

Table 5: Effects of enzyme supplementation on the performance of pigs fed diets based on normal or low lignin-high fat oat

	Barley		Normal Oat		Low lignin-high fat oat			Sex		
	- Enzyme	+ Enzyme	- Enzyme	+ Enzyme	- Enzyme	+ Enzyme	SEM	Barrows	Gilts	SEM
Growing period (26.9-56.1 kg)										
Daily gain (kg)[h]	0.91	0.97	0.92	0.96	0.93	0.92	0.020	0.96[x]	0.90[y]	0.011
Daily intake (kg)[d,i]	1.87	1.89	1.82	1.87	1.77	1.80	0.043	1.87[x]	1.80[y]	0.026
Feed conversion[h,b-d]	2.07	1.94	1.97	1.95	1.91	1.96	0.022	1.94[x]	1.98[y]	0.013
Finishing period (56.1-111.3 kg)										
Daily gain (kg)[b-d]	1.16	1.15	1.24	1.27	1.20	1.25	0.021	1.26[x]	1.16[y]	0.012
Daily intake (kg)[b-d]	3.11	3.12	3.42	3.38	3.26	3.35	0.056	3.51[x]	3.04[y]	0.033
Feed conversion	2.68	2.72	2.75	2.67	2.72	2.68	0.038	2.78[x]	2.63[y]	0.022
Overall experiment (26.9-111.3 kg)										
Daily gain (kg)[b-d]	1.06	1.08	1.11	1.13	1.09	1.11	0.015	1.14[x]	1.06[y]	0.009
Daily intake (kg)[b,c]	2.62	2.63	2.75	2.73	2.65	2.70	0.040	2.82[x]	2.54[y]	0.023
Feed conversion[h]	2.47	2.43	2.48	2.41	2.44	2.43	0.026	2.48[x]	2.41[y]	0.015

[a,h]Orthoginal contrast for diets with enzyme vs. diets without enzyme significant at p<0.05 or p<0.10, [b,i]Orthoginal contrast for barley diets vs. all oat diets enzyme significant at p<0.05 or p<0.10, [c,j]Orthoginal contrast for barley diets vs. normal oat diets enzyme significant at p<0.05 or p<0.10, [d,k]Orthoginal contrast for barley diets vs. low lignin-high fat oat diets enzyme significant at p<0.05 or p<0.10, [e,l]Orthoginal contrast for normal oat diets vs. low lignin-high fat oat diets enzyme significant at p<0.05 or p<0.10, [x,y]Indicates significant sex effect at p<0.05

Table 6: Effects of enzyme supplementation on carcass traits of pigs fed diets based on normal or low lignin-high fat oat

	Barley		Normal Oat		Low lignin-high fat oat			Sex		
	- Enzyme	+ Enzyme	- Enzyme	+ Enzyme	- Enzyme	+ Enzyme	SEM	Barrows	Gilts	SEM
Slaughter weight (kg)	112.5	111.2	110.5	111.1	111.6	111.1	0.74	112.0[x]	110.7[y]	0.44
Carcass weight (kg)	87.2	86.7	86.1	86.7	86.9	87.3	0.63	86.9	86.7	0.38
Dressing percentage (%)	77.5	77.9	77.9	78.0	77.9	78.6	0.32	77.6[x]	78.3[y]	0.19
Carcass value index[l]	111.8	111.9	109.3	112.2	112.3	113.5	1.16	110.0[x]	113.7[y]	0.69
Lean yield (%)[j]	61.4	61.4	60.6	61.1	61.3	61.2	0.31	60.1[x]	62.1[y]	0.19
Loin fat (mm)[c]	16.7	16.5	18.6	17.5	17.0	16.7	0.69	19.1[x]	15.3[y]	0.41
Loin lean (mm)	59.4	60.0	59.6	61.5	60.3	58.6	1.46	57.8[x]	61.9[y]	0.87

[a,h]Orthoginal contrast for diets with enzyme vs. diets without enzyme significant at p<0.05 or p<0.10, [b,i]Orthoginal contrast for barley diets vs. all oat diets enzyme significant at p<0.05 or p<0.10., [c,j]Orthoginal contrast for barley diets vs. normal oat diets enzyme significant at p<0.05 or p<0.10, [d,k]Orthoginal contrast for barley diets vs. low lignin-high fat oat diets enzyme significant at p<0.05 or p<0.10, [e,l]Orthoginal contrast for normal oat diets vs. low lignin-high fat oat diets enzyme significant at p<0.05 or p<0.10, [x,y]Indicates significant sex effect at p<0.05

During the finishing period (56.1-111.3 kg) pig performance was unaffected (p>0.05) by enzyme supplementation. Daily gain and feed consumption for pigs fed both normal and low lignin-high fat oat were significantly higher than for pigs fed barley (p<0.05). Feed conversion was unaffected by the type of cereal fed (p>0.05). Barrows gained weight significantly faster (p<0.05) and had higher feed consumption (p<0.05) than gilts but had poorer feed conversion (p<0.05).

For the overall experiment (26.9-111.3 kg), enzyme supplementation had no effect on growth or feed intake (p>0.05) but feed conversion was marginally improved (p<0.10). Daily gain and feed consumption for pigs fed both normal and low lignin-high fat oat were significantly higher than for pigs fed barley (p<0.05). Feed conversion was unaffected by the type of cereal fed (p>0.05). Barrows gained weight significantly faster (p<0.05) and had higher feed consumption (p<0.05) than gilts but had poorer feed conversion (p<0.05).

Enzyme supplementation had no effect on swine carcass traits (p>0.05). Pigs fed diets based on low lignin-high fat oat had higher carcass value index (p<0.10) than pigs fed normal oat. Lean yield was lower (p<0.10) and loin fat higher (p<0.05) for pigs fed normal oat than for pigs fed the barley-based diets. Barrows had higher slaughter weights and loin fat than gilts (p<0.05) while dressing percentage, carcass value index, lean yield and loin lean were higher for gilts than barrows (p<0.05), (Table 6).

DISCUSSION

The overall results of this experiment indicate little benefit from enzyme supplementation of oat or barley-based diets for swine. Although digestibility coefficients for dry matter, crude protein and gross energy were modestly increased as a result of enzyme supplementation, these increases were not reflected in any significant improvements in carcass traits or pig performance over the entire experimental period. These results support earlier work in which enzyme supplementation of barley-based diets produced either no or only slight improvements in pig performance[9,17,18].

The failure of the enzyme cocktail containing beta-glucanase and xylanase to improve pig performance can be explained by the fact that unlike the situation in poultry, beta-glucan and xylan are already extensively degraded in the intestinal tract of pigs even in the absence of enzyme supplementation[27]. In addition, viscosities measured in the digestive tract of the pig intestinal tract are almost 100 fold less than have been reported for chickens[9]. Therefore, based on the results of the current and previous experiments, we conclude that beta-glucan and xylan are not major factors detracting from the nutritional value of barley and oat as feedstuffs for use in swine production. As a consequence, there would appear to be little justification for the routine inclusion of enzymes designed to degrade these compounds in diets fed to swine.

There was little difference in nutrient digestibility, performance or carcass traits between pigs fed diets containing normal or low lignin-high fat oat. As such, these findings do not support our previous work in which feeding high-fat oat increased nutrient digestibility as well as improving pig growth and feed efficiency compared with feeding pigs normal fat oat[28].

Despite the failure of the low lignin-high fat oat to improve pig performance over normal-fat oat, there may still be advantages to its use. It is possible that the use of a high-fat oat could play a role in reducing dust levels in pig barns as Chiba *et al.*[29] reported significant reductions in aerial dust levels in swine units when diets contained additional lipid. The prepackaged fat in high-fat oat may also be of benefit to pig producers who mix their own feed and who may not have sufficient production volume to justify keeping a heated fat tank at their feed mixing facility.

Perhaps the most significant finding of the current experiment was the fact that the performance of pigs fed oats, regardless if normal or high fat, was equal or superior to that of pigs fed barley. Current recommendations regarding the incorporation of oat into rations fed to growing-finishing swine suggest that inclusion should be limited to less than 20%[30,31]. However, these recommendations are based largely on experiments conducted in excess of 25 years ago[32,33]. Considerable improvement has been made in oat varieties during this period, especially in terms of lower % hull (B.G. Rossnagel, Personal Communication, Research Scientist, Crop Development Centre, University of Saskatchewan). The results of the present experiment indicate that both normal and low lignin-high fat oat can substitute for barley at levels as high as 40% of the diet without hindering pig performance. Since the average yield of oat can be equal or higher than barley with lower input costs[34], a re-examination of feeding recommendations regarding oat in swine rations seems warranted.

CONCLUSION

Feeding a recently developed low lignin-high-fat oat to pigs did not improve growth rate or feed conversion when compared with normal-fat oat. Nutrient digestibility and carcass quality were also unaffected by the type of oat fed. In addition, enzyme supplementation had no effect on pig performance or carcass quality. However, there appears to be greater potential to utilize oat, regardless of fat level, in rations fed to growing-finishing pigs than is currently being achieved.

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