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Effect of Enzyme Supplementation on the Performance of Growing-Finishing Pigs Fed Diets Containing Normal or High Fat Oat

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Abstract: The objectives of the following study were to compare a recently developed 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. Sixty crossbred pigs (30.2±2.2 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 high fat oat was substituted for barley. All diets were fed either with or without dietary enzyme (750 units/g of beta-glucanase and 650 units/g of xylanase). Enzyme supplementation significantly increased dry matter ($p<0.10$) and energy ($p<0.10$) 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 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 high fat ($p<0.05$) diets. Pig performance was unaffected ($p>0.05$) by enzyme supplementation. Feed consumption for pigs fed normal oat was significantly higher than for pigs fed barley ($p<0.05$) or high fat oat ($p<0.10$), while daily gain and feed conversion were unaffected by the type of cereal fed ($p>0.05$). Enzyme supplementation had no effect on swine carcass traits. Carcasses from pigs fed diets based on either normal or high fat oat had higher lean yields ($p<0.05$) and lower loin fat ($p<0.05$) than carcasses from pigs fed the barley-based diets. In conclusion, feeding a recently developed 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.

Key words: Swine, High-fat oat, Digestibility, Growth, Carcass composition

Introduction

Domestic oat (*Avena sativa*) provides approximately 10% less digestible energy than barley and about 20% less digestible energy than wheat and corn when fed to pigs (Patience *et al.,* 1995). One of the main reasons for the lower energy content of oat is the fact that approximately one-third of the oat grain is hull resulting in a high fibre content (Pond and Maner, 1984). 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 (Bell *et al.,* 1983). As a result, oat is not widely utilized as an energy source in swine rations (Patience *et al.,* 1995 and Myer, 2000).

The addition of fat is an effective way to increase the energy content of swine diets (Stahly, 1984) and has been shown to improve the feeding value of diets containing 40% oat when fed to growing-finishing pigs (Myer and Combs, 1991). Therefore, increasing the fat content of oat may be an effective way to improve its nutritional value for swine. A breeding project was recently undertaken at the University of Saskatchewan to develop a high-fat oat for use in livestock feeding. The performance of pigs fed diets containing this high fat oat has been shown to be superior to that of pigs fed diets containing normal oat (Thacker *et al.,* 2004).

The cell wall of barley and oat contain appreciable quantities of beta-glucan and xylan (Thacker, 2001and Chesson, 1993). These compounds have been shown to reduce the nutritional value of cereal grains for poultry by increasing the viscosity of the intestinal fluid (Burnett, 1966). 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 (White *et al.,* 1983). The negative effects of feeding poultry diets formulated using cereal grains containing beta-glucan and xylan can be largely overcome by enzyme supplementation (Campbell *et al.,* 1989 and Chesson, 1993).

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 (1996) and Baidoo *et al.* (1998) have reported improvements in pig performance as a result of enzyme supplementation, others have reported little or no benefit (Thacker *et al.,* 1992; Baas and Thacker, 1996 and Thacker, 2000).

There has been little research conducted to determine the effects on enzyme supplementation on the performance of pigs fed oat-based diets. Therefore, the following study was conducted to further compare the recently developed 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.

Materials and Methods

Acquisition of Oat Samples: The high-fat oat sample used in the present trial is a breeding line designated as SA96121. SA96121 was developed at the University of Saskatchewan, Crop Development Centre (CDC) from the cross ND870425 x CDC Boyer, where ND870425 was a breeding line from the North Dakota State University Oat Breeding Program and CDC Boyer is a high milling quality oat variety. Segregating material from the cross was processed through the F2 - F4 generations using Single Seed Descent. A total of 124 F5 selections were grown in hill plots in 1995. Based on selection in the field and subsequent grain quality analysis, which included measurement of groat fat concentration, one of 26 field selections was designated SA96121 and entered in preliminary yield trials in 1996. Subsequent grain quality analysis verified the high groat fat of SA96121 and it was evaluated in Standard Yield Trials at three locations in 1997 where its good physical grain quality, combined with high groat fat, were again verified. Since 1997, SA96121 has

been increased several times in order to produce the larger quantities of material required for feeding trial evaluations.
The normal-fat oat variety used was Derby (Rossnagel and Batty, 1990). 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 is shown in Table 1.

Growth Trial: Sixty crossbred pigs (Camborough 15 Line female x Canabred sire, Pig Improvement Canada Ltd, Airdrie Alberta) weighing an average of 30.2±2.2 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 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 of beta-glucanase and 650 units/g of xylanase (one unit of activity defined as a change of one in the inverse specific viscosity coefficient; manufacturers). 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 (30.2 to 62.6 kg), the experimental diets were formulated to supply 0.95% lysine while in the finishing period (62.6-111.4 kg), the diets were formulated to supply 0.70% lysine. These diets would meet the amino acid requirements of pigs with a lean growth potential of 350 g/day (National Research Council, 1998). Diets containing oat were supplemented with tallow 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 (1998). 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. Five castrates and five 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 49.9 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. 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 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 (1975).

Carcass Measurements: All pigs were slaughtered at a commercial abattoir at an average weight of 111.4 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 International, 2000).

Chemical Analysis: Samples of the oat varieties as well as the growing and finished 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 (1990). 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 (1990). Neutral detergent fibre was analysed using the method of Van Soest *et al.* (1991). 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 4) was performed using a LKB-Biochrome 4151 Alpha Plus Amino Acid Analyser after hydrolysis for 22 h with 6 N HCl. Performic acid hydrolysis was not performed.
Lipid was extracted from the oat using a modification of the Folch wash method (Mir *et al.,* 2000). Approximately 7 g of ground feed was placed into a screw-capped tube and 1 ml of chloroform/methanol (2:1 v/v) solution was added. The samples were then homogenized 2 times in 2 ml of the same chloroform/methanol solution. The rinse fluid was combined. The tube was flushed with nitrogen and placed on a test tube rocker for 10 min followed by centrifugation at 3000 rpm for 30 minutes. The supernatant was transferred to a clean screw-capped tube and 7 ml of 0.29% NaCl solution was added. The tube was again flushed with nitrogen and placed on a test tube rocker for a further 10 minutes, followed by centrifugation at 3000 rpm for 30 min. The upper layer was removed by suction leaving the lower chloroform layer containing the lipid. The chloroform was evaporated under nitrogen in a 40°C water bath and the extracted lipid stored at -20°C for later analysis.
Extracted lipid was derivatized using tetramethylguanidine (TMG) and methanol with heneicosanoic acid as the internal standard as described by Shantha *et al.* (1993). About 40 mg of extracted lipid was redissolved in 2 ml of hexane in a test tube and 25 ul of 20 mg/ml heneicosanoic acid was added followed by 400 ul of methanol and 100 ul of TMG. The tubes were flushed with nitrogen, capped and heated in boiling water for 10 min. After cooling, 5 ml of saturated NaCl solution was added, followed by 2 ml of petroleum ether. The organic phase was transferred to a new test tube and evaporated under nitrogen. The contents were then re-suspended in 2 ml hexane.
Fatty acid analysis was carried out in duplicate on a Supelcowax-2340 60m x 0.25m x 0.2 um column (Sigma Aldrich Ont. Canada) installed in an Agilent 6890 Series GC system using a flame ionisation detector with capillary injection system at a split ratio of 1:100. The oven temperature was set at 150°C then raised to 200°C at 1.5°C/min and then finally held for 10 minutes. Helium was used as carrier gas at a flow rate of 1.7 ml/min. Identification of the fatty acids was achieved by comparison to retention times of known standards

(Sigma Aldrich Ont. Canada) and amounts present were determined by calculation based on the internal standard.

Statistical Analysis: The data from the performance trial and carcass data were analysed as a 2x6 factorial using the General Linear Models procedure of the Statistical Analysis System Institute, Inc. (SAS 1999) with the factors in the model consisting of diet and sex of pig (barrows and gilts) 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. normal oat diets, c) barley diets vs. high fat oat diets, d) barley diets vs. all oat diets and e) normal oat diets vs. high fat oat diets. Differences were considered to be significant when $p<0.05$. 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 and Discussion

The breeding program to increase the fat content of oats was successful with the high-fat oat having 35.8% higher ether extract than the normal-fat oat (Table 1). Although not the intent of the selection program, the high-fat oat variety appeared to have a higher crude protein content and a lower acid detergent fibre content than the normal-fat oat. The high-fat oat appeared to have an increased content of essential amino acids compared with the normal-fat oat. However, when expressed as a percentage of crude protein, the amino acid content of the two oat varieties are similar and the increase in essential amino acid content was merely due to the increased crude protein content of the high-fat oat. The fatty acid content was similar between the two oats.

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 high fat oat containing diets was higher than the normal oat containing diets reflecting the chemical composition of the two oat varieties.

The effects of enzyme supplementation on digestibility coefficients for pigs fed diets based on normal or high fat oat are shown in Table 5. Enzyme supplementation increased dry matter ($p<0.10$) and energy ($p<0.10$) 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 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 high fat ($p<0.05$) diets. The effects of enzyme supplementation on the performance of pigs fed diets based on normal or high fat oat are shown in Table 6. During the growing period (30.2-62.6 kg), enzyme supplementation had no effect on pig performance (>0.05). There were also no differences in the performance of pigs fed barley diets vs. either normal or high fat oats. In addition, the performance of male and female pigs was also similar.

During the finishing period (62.6-111.4 kg) and the overall experiment (30.2-111.4 kg) pig performance was unaffected ($p>0.05$) by enzyme supplementation. Feed consumption for pigs fed normal oat was significantly higher than pigs fed barley ($p<0.05$) or high fat oat ($p<0.10$). Daily gain and feed conversion were unaffected by the type of cereal fed ($p>0.05$). Males gained weight significantly faster and had higher feed consumption than females.

The amino acid analysis (Table 4) of the grower diets confirmed that the diets met the requirements for pigs with a lean growth potential of 350 g/day. Lysine-HCL was added to the oat diets to ensure that all diets supplied approximately the same level of this first limiting amino acid.

Table 1: Chamical composition, amino acid content and faty acid analysis of normal and high fat oat (% as fed)

	Normal oat	High-fat oat
Chemical analysis		
Moisture	13.30	12.20
Crude protein	11.59	13.77
Ether extract	4.44	6.03
Acid detergent fibre	15.46	12.75
Ash	3.67	3.07
Amino acid content		
Arginine	0.64	0.81
Histidine	0.21	0.26
Isoleucine	0.33	0.48
Leucine	0.67	0.90
Lysine	0.45	0.53
Methionine + Cystine	0.69	0.67
Phenylalanine	0.43	0.60
Threonine	0.40	0.44
Valine	0.53	0.72
Fatty acid content		
Myristic acid (C14:0)	0.23	0.23
Palmitic acid (C16:0)	17.40	17.20
Stearic acid (C18:0)	nd	nd
Oleic acid (C18:1)	43.01	42.80
Linoleic acid (C18:2)	39.20	39.10
Linolenic acid (C18:3)	nd	nd

nd = not detected

Table 2: Ingredient composition and chemical analysis of grower (30.2-62.6 kg) diets formulated to compare the nutrient value of normal and high fat oat for swine.

	Barley		Normal Oat		High Fat Oat	
	- Enzyme	+ Enzyme	- Enzyme	+ Enzyme	- Enzyme	+ Enzyme
Diet formulation (% as fed)						
Barley (12.1 % CP)	71.98	71.96	31.22	31.20	31.22	31.20
Soybean meal (48.5 % CP)	19.91	19.91	18.49	18.49	18.49	18.49
Normal oat (11.59% CP)	0.00	0.00	40.00	40.00	0.00	0.00
High fat oat (13.77% CP)	0.00	0.00	0.00	0.00	40.00	40.00
Tallow	4.40	4.40	6.48	6.48	6.48	6.48
Vitamin-mineral premix[1]	1.00	1.00	1.00	1.00	1.00	1.00
Dicalcium phosphate	1.15	1.15	1.33	1.33	1.33	1.33
Limestone	0.97	0.97	0.87	0.87	0.87	0.87
Salt	0.50	0.50	0.50	0.50	0.50	0.50
Lysine	0.09	0.09	0.11	0.11	0.11	0.11
Enzyme[2]	0.00	0.02	0.00	0.02	0.00	0.02
Chemical composition (% as fed)						
Moisture	10.35	9.86	9.57	9.43	8.97	8.41
Crude protein	18.68	19.19	17.94	17.61	18.81	18.06
Ash	4.57	4.72	4.84	4.87	5.06	5.07
Ether extract	5.73	5.61	9.00	9.18	9.58	9.67
Neutral detergent fibre	14.13	13.68	18.46	18.23	18.09	17.45
Calcium	0.61	0.69	0.64	0.67	0.69	0.71
Phosphorus	0.52	0.55	0.56	0.59	0.62	0.65
Gross energy (kcal/kg)	4178	4155	4361	4410	4427	4466
Digestible energy (kcal/kg)	3275	3276	3176	3296	3268	3358

[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 of beta-glucanase and 650 units/g of xylanase.

Table 3: Ingredient composition and chemical analysis of finisher (62.6-111.4 kg) diets formulated to compare the nutrient value of normal and high fat oat for swine.

	Barley		Normal Oat		High Fat Oat	
	- Enzyme	+ Enzyme	- Enzyme	+ Enzyme	- Enzyme	+ Enzyme
Diet formulation (% as fed)						
Barley (12.1% CP)	80.29	80.27	39.99	39.97	39.99	39.97
Soybean meal (48.5% CP)	12.57	12.57	11.80	11.80	11.80	11.80
Normal oat (11.59% CP)	0.00	0.00	40.00	40.00	0.00	0.00
High fat oat (13.77% CP)	0.00	0.00	0.00	0.00	40.00	40.00
Tallow	3.93	3.93	4.94	4.94	4.94	4.94
Vitamin-mineral premix[1]	1.00	1.00	1.00	1.00	1.00	1.00
Dicalcium phosphate	0.70	0.70	0.85	0.85	0.85	0.85
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	0.02	0.00	0.02	0.00	0.02
Chemical composition (% as fed)						
Moisture	9.85	10.04	10.14	9.81	8.83	8.58
Crude protein	15.16	15.21	14.78	14.57	16.03	15.76
Ash	4.12	4.07	4.46	4.42	4.55	4.59
Ether extract	6.00	4.54	7.05	7.06	7.64	8.21
Neutral detergent fibre	12.65	12.55	16.53	16.17	17.88	18.45
Calcium	0.86	0.88	0.87	0.89	0.87	0.84
Phosphorus	0.45	0.45	0.46	0.46	0.56	0.59

[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 of beta-glucanase and 650 units/g of xylanase.

The effects of enzyme supplementation on carcass traits of pigs fed diets based on normal or high fat oat are shown in Table 7. Enzyme supplementation had no effect on swine carcass traits. Pigs fed diets based on either normal or high fat oat had higher lean yields

($p<0.05$) and lower loin fat ($p<0.05$) than pigs fed the barley-based diets. Males had higher slaughter weights and loin fat than females while carcass value index and lean yield were higher for females than males.

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 pig performance or carcass traits.

These results support earlier work in which enzyme supplementation of barley-based diets produced either no or only slight improvements in pig performance (Thacker *et al.,* 1992; Baas and Thacker, 1996 and Thacker, 2000).

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 (Graham *et al.,* 1989). In addition, viscosities measured in the digestive tract of the pig intestinal tract are almost 100 fold less than have been reported for chickens (Thacker, 2000). 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 oats 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 high fat oat. As such, these findings do not support our previous work in which feeding high-fat oats increased nutrient digestibility as well as improving pig growth and feed efficiency compared with feeding pigs normal fat oats (Thacker *et al.,* 2004). The addition of tallow to both the normal and high-fat oat containing diets in order to balance for energy may have masked the opportunity for the high-fat oat to improve pig performance.

Table 4: Amino acid composition of grower (30.2-62.6 kg) diets formulated to compare the nutrient value of normal and high fat oats for swine

	Barley		Normal Oat		High Fat Oat	
	- Enzyme	+ Enzyme	- Enzyme	+ Enzyme	- Enzyme	+ Enzyme
Arginine	1.05	1.09	1.10	1.11	1.12	1.15
Histidine	0.44	0.45	0.43	0.42	0.44	0.44
Isoleucine	0.70	0.71	0.67	0.69	0.73	0.75
Leucine	1.38	1.39	1.32	1.32	1.40	1.43
Lysine	0.96	0.98	0.96	0.98	1.01	1.02
Methionine and Cysteine	0.61	0.61	0.61	0.61	0.64	0.65
Phenylalanine	0.97	0.96	0.91	0.88	0.97	0.98
Threonine	0.70	0.72	0.67	0.67	0.69	0.70
Valine	0.81	0.85	0.78	0.81	0.86	0.86

Table 5: Effects of enzyme supplementation on digestibility cofficients for pigs fed diets based on normal or high fat oat

	Barley		Normal Oat		High Fat Oat		
	-Enzyme	+ Enzyme	-Enzyme	+ Enzyme	-Enzyme	+ Enzyme	SEM
Dry matter (%)[x,b,c,d,]	79.02	79.62	72.54	74.65	73.13	74.27	0.783
Crude protein (%)[a,b,c,d,]	77.91	79.69	79.14	81.44	79.30	80.80	0.534
Gross energy (%)[x,b,c,d]	78.40	78.84	72.82	74.76	73.83	75.12	0.749

[a,x]Orthoginal contrast for diets with enzyme vs. diets without enzyme significant at $P<0.05$ or $P<0.10$.
[b]Orthoginal contrast for barley diets vs. normal oat diets enzyme significant at $P<0.05$.
[c]Orthoginal contrast for barley diets vs. high fat oat diets enzyme significant at $P<0.05$.
[d]Orthoginal contrast for barley diets vs. all oat diets enzyme significant at $P<0.05$.
[e]Orthoginal contrast for normal oat diets vs. high fat oat diets enzyme significant at $P<0.05$.

Table 6: Effects of enzyme supplementation on the performance of pigs fed diets based on normal or high fat oat

	Barley		Normal Oat		High Fat Oat			Sex		
	-Enzyme	+ Enzyme	-Enzyme	+ Enzyme	-Enzyme	+ Enzyme	SEM	Males	Females	SEM
Growing period (30.2-62.6 kg)										
Daily gain (kg)	0.93	0.92	0.91	0.90	0.99	0.90	0.032	0.93	0.92	0.018
Daily intake (kg)	1.93	1.89	1.88	1.89	1.94	1.84	0.056	1.90	1.89	0.032
Feed conversion	2.07	2.05	2.07	2.10	1.98	2.04	0.046	2.05	2.06	0.027
Finishing period (62.6 – 111.4 kg)										
Daily gain (kg)	1.10	1.17	1.18	1.14	1.13	1.15	0.044	1.21[y]	1.07[z]	0.025
Daily intake (kg)[x]	3.27	3.35	3.49	3.49	3.36	3.31	0.081	3.54[y]	3.22[z]	0.047
Feed conversion	3.00	2.88	2.97	3.09	3.00	2.90	0.075	2.94	3.01	0.044
Overall experiment (30.2 – 111.4 kg)										
Daily gain (kg)	1.02	1.06	1.05	1.03	1.06	1.04	0.030	1.08[y]	1.01[z]	0.018
Daily intake (kg)[x]	2.67	2.69	2.74	2.77	2.71	2.66	0.045	2.78[y]	2.64[z]	0.026
Feed conversion	2.62	2.54	2.60	2.70	2.57	2.57	0.058	2.58	2.62	0.033

[a]Orthoginal contrast for diets with enzyme vs. diets without enzyme significant at $P<0.05$.
[b]Orthoginal contrast for barley diets vs. normal oat diets enzyme significant at $P<0.05$.
[c]Orthoginal contrast for barley diets vs. high fat oat diets enzyme significant at $P<0.05$.
[d]Orthoginal contrast for barley diets vs. all oat diets enzyme significant at $P<0.05$.
[e,x]Orthoginal contrast for normal oat diets vs. high fat oat diets enzyme significant at $P<0.05$ or $P<0.10$, [y,z]Indicates significant sex effect at $P<0.05$.

Table 7: Effect of enzyme supplementation on carcass traits of pigs fed diets based on normal or high fat oat

	Barley		Normal Oat		High Fat Oat			Sex		
	-Enzyme	+ Enzyme	-Enzyme	+ Enzyme	-Enzyme	+ Enzyme	SEM	Males	Females	SEM
Slaughter weight (kg)	111.2	112.3	110.5	111.1	111.2	112.3	1.22	112.6[y]	110.2[z]	0.70
Carcass weight (kg)	85.1	86.7	85.8	87.1	86.4	87.1	1.07	86.8	85.9	0.87
Dressing percentage (%)	76.5	77.2	77.7	78.4	77.7	77.6	0.62	77.1	77.9	0.36
Carcass value index	109.4	109.0	110.3	111.6	106.4	110.7	1.88	108.2[y]	111.0[z]	1.09
Lean yield (%)[b,c,d]	59.1	58.9	59.9	60.1	60.0	60.0	0.47	59.1[y]	60.2[z]	0.27
Loin fat (mm)[b,c,d]	21.6	21.6	19.3	19.0	19.5	19.1	1.04	21.2[y]	18.8[z]	0.60
Loin lean (mm)	56.9	54.9	54.83	56.55	53.35	54.20	2.79	54.3	56.0	1.61

[a]Orthoginal contrast for diets with enzyme vs. diets without enzyme significant at P<0.05.
[b]Orthoginal contrast for barley diets vs. normal oat diets enzyme significant at P<0.05.
[c]Orthoginal contrast for barley diets vs. high fat oat diets enzyme significant at P<0.05.
[d]Orthoginal contrast for barley diets vs. all oat diets enzyme significant at P<0.05.
[e]Orthoginal contrast for normal oat diets vs. high fat oat diets enzyme significant at P<0.05.
[y,z]Indicates significant sex effect at P<0.05.

Despite the failure of the 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 high-fat oat could play a role in reducing dust levels in pig barns as Chiba *et al.* (1985) 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 of 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 their inclusion should be limited to less than 20% (Holden *et al.,* 1996 and Murphy, 2003). However, these recommendations are based largely on experiments conducted in excess of 25 years ago (Jensen *et al.,* 1959; Meade *et al.,* 1966 and Wahlstrom *et al.,* 1977). 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 high-fat oats 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 (Saskatchewan Agriculture, Food and Rural Revitalization, 2003), a re-examination of feeding recommendations regarding oat in swine rations seems warranted.

In conclusion, feeding a recently developed high-fat oat to pigs did not improve growth rate or efficiency of 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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