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Effect of Pentosanase and Dietary Fat on Growth Performance and Nutrient Utilization of Pigs Fed Diets Containing Whole Maize Plants

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ABSTRACT. *The aim of the experiment was to investigate the effect of a feed enzyme (pentosanase) and dietary fat in diets with high crude fibre content, on growth and metabolism in pigs. The basal diet contained 50% whole maize plants. The four treatments were: C-control (without supplement), E-enzyme (50mg/kg), F-extracted fat (50g/kg), EF-enzyme (50mg/kg) and extracted fat (50g/kg).*

Feed intake, feed conversion ratio (FCR) and daily weight gain were not significantly ($P>0.05$) influenced by either enzyme or fat addition. There was a tendency for lower total feed intake, FCR and higher daily weight gain as an effect of pentosanase. Dietary fat as well as feed enzyme addition positively influenced the digestibility of energy and degradability of neutral detergent fibre (NDF) and acid detergent fibre (ADF). The inclusion of both supplements to the diet did not have additive effects on digestibility of energy and the degradability of NDF and ADF. It seems that dietary fat supplementation inhibits the positive effect of pentosanase.

INTRODUCTION

Pig production in western countries depends upon diets based on grain and high-quality protein supplements, which could also be used directly to provide a nutritious diet for man. The future of feeding pigs on high quality feedstuffs will be increasingly questioned at a time when the world population is increasing, and more than half of the human race is inadequately fed (Low, 1993). Whole maize plants, a cheap, locally grown feed with a high fibre content could be an alternative feedstuff in diets for growing pigs. In general, the higher the crude fibre content in pig diets, the lower was the apparent digestibility of nitrogen, fat and energy in the terminal ileum (Kass *et al.*, 1980; Wenk *et al.*, 1993; Hadorn, 1994). New techniques in biotechnology allow the supplementation of such diets with specific feed enzymes to increase the nutrient digestibility and reduce the negative effects of high fibre content.

The aim of the present study was to investigate the effect of a feed enzyme (pentosanase) and dietary fat in pig diets containing 50% whole maize plants. The interaction of dietary fat with the enzyme was also studied.

MATERIALS AND METHODS

Dietary treatments and animals

The experiment was set up as a 2x2 factorial design (-/+ enzyme; -/+ dietary fat). A total of 28 castrated Swiss Large White male pigs at 24 kg liveweight (LW) were randomly assigned to four treatments. The four treatments were: *C*-control (without supplement), *E*-enzyme[1] (50mg/kg), *F*-extracted fat (50g/kg), *EF*-enzyme (50mg/kg) and extracted fat (50g/kg). The pigs were fed with a basal diet, with or without supplementation of enzyme, dietary fat or both. The enzyme complex Allzyme Pentosanase is reported to contain xylanase (13400 U/g) as the main enzyme activity. Each dietary treatment was tested on 7 animals. Composition of the basal diet and the experimental diets are shown in Tables 1 and 2, respectively.

The pigs were housed in individual pens in a stable with controlled ambient temperature and humidity during the experiment, to facilitate measurement of individual daily feed intake. The animals had *ad libitum* access to feed and water. Liveweight gain and feed consumption of all pigs were recorded weekly. For the calculations of growth parameters three animals were not taken into consideration because they did not reach 90kg LW with the available quantity of feed.

Metabolism study

Faeces were collected once at a LW of 60kg during one day. The samples were dried for 48h at 60°C and ground to pass through 0.5mm sieve. Organic matter digestibility d(OM), energy digestibility d(E) and fibre degradability were estimated using the indicator method (Prabucki *et al.*, 1975). 4N-hydrochloric acid insoluble ash (AIA) was used as the indicator. To increase the concentration of AIA, Celite 545 (acid diatomaceous earth)

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1 Pentosanase, delivered by Alltech Inc.

was added to the diet. Viscosity of the feed was measured as described by Vukic-Vranjes and Wenk (1994).

Table 1. Composition of the basal diet.

Ingredients(g/kg)	
Whole maize plant	500.00
Barley	242.00
Wheat	179.00
Potato protein	20.00
Soybean meal	25.00
Meat-and-bone meal	11.00
L-lysine	0.27
Vitamin / mineral premix[1/2]	10.50
Celite	12.50
Calculated composition	
DE[3] (MJ/kg)	12.89
Crude protein (g/kg)	161.80
Crude fat (g/kg)	16.60
Crude fiber (g/kg)	32.20
Lysine (g/kg)	11.30
Methionine + Cystine (g/kg)	5.40

1 Provided in kg of premix: vitamin A 2000000 IU; vitamin D_3 200000 IU; vitamin E 8000 IU; Ca-pantothenic acid 3g; niacin 4g.

2 provided in g/kg of premix : Ca 10, Mg 55, S 5, Cu 2, Fe 6, Zn 20, Mn 8, I 0.2, Se 0.06.

3 Digestible Energy.

Table 2. Chemical composition of the experimental diets.

	Treatment			
	C	E	F	EF
Basal diet %	100	100	95	95
Extracted fat %	-	-	5	5
Pentosanase[1]	-	+	-	+
Dry matter (g/kg)	913	910	919	916
Analyzed chemical composition (per kg dry matter)				
Crude ash (g)	66	64	62	61
Crude protein (g)	132	135	127	127
Crude fat (g)	23	23	86	68
Gross energy (MJ)	18.102	18.129	19.416	19.015
Crude fiber (g)	111	110	105	108
NDF[2] (g)	293	291	274	284
ADF[3] (g)	134	134	127	136
ADL[4] (g)	20	16	20	20
Hemicellulose[5] (g)	160	156	148	148
Cellulose[6] (g)	114	118	107	115
Viscosity (cP)	1.76	1.42	1.49	1.34

[1] Allenzyme pentosanase according to product declaration contains as main enzyme activity: Xylanase (13400 U/g)
[2] Neutral detergent fiber
[3] Acid detergent fiber
[4] Acid detergent lignin
[5] Content of hemicellulose was calculated as difference between NDF and ADF
[6] Content of cellulose was calculated as difference between ADF and ADL

Chemical and statistical analyses

Dry matter (DM), crude fibre and fat (ether extract) analyses of diets and faeces were performed according to standard methods (AOAC, 1990). Gross energy content of diets and excreta were analysed using an isothermic bomb calorimeter (System C, 700 T, IKA Analysentechnik GmbH;

Heitersheim, FRG). Feed and faeces were analyzed for neutral detergent fibre (NDF), acid detergent fibre (ADF) and Lignin (ADL) contents according to Robertson and Van Soest (1981) modified by Zürcher (1992).

Growth performance and metabolism data were analyzed using multifactorial analysis of variance considering enzyme and fat as main factors. Statistical differences between treatment means were assessed by Bonferroni-Test.

RESULTS AND DISCUSSION

The nutrient composition of the whole maize plants is presented in Table 3. The crude fibre, NDF and ADF contents amounted to 19%, 44%, and 23% of the DM, respectively. These values are comparable to the values reported by Wenk et al., (1993).

Table 3. Nutrient composition of whole maize plants.

Dry matter (g/kg)	922
Analyzed chemical composition (per kg dry matter)	
Crude ash (g)	59
Crude fat (g)	18
Gross energy (MJ)	18.197
Crude fiber (g)	188
NDF (g)	437
ADF (g)	227
ADL (g)	29
Hemicellulose (g)	210
Cellulose (g)	198

The crude fibre, crude fat and gross energy contents of treatment diets *C*, and *E* were similar (Table 2) indicating proper mixing of the diet. But, the fibre content, crude fat and gross energy in the diet *EF* failed to meet the expected values. Contents of NDF and ADF in the diet *EF* were 4% and 7% higher than those in the diet F. On the other hand, the content of crude fat and gross energy were 21% and 2% lower than those in the diet F (Table 2). It is difficult to interpret this result, since the content of crude ash, crude protein and crude fibre agree with the corresponding values of diet F.

Addition of pentosanase and fat reduced the viscosity of feed by 15% (treatment *F*) to 24% (treatment *EF*) compared to *C* (Table 2). However, in contrast to broilers, the effect of viscosity is reported to be lower in pigs, because the water content of chime in ileum as well as the volume of ileum in pigs is higher (Campbell and Bedford, 1992).

Feed intake, feed conversion ratio (FCR) and daily weight gain were not significantly influenced by addition of either enzyme and fat (Table 4). However, there was a tendency toward lower total feed intake and FCR and higher daily weight gain as an effect of pentosanase. Compared to control (C), the addition of dietary fat (treatment F) had no positive effect on the growth parameters. The average daily weight gain was lower in treatment F (0.619kg/d) than in treatment E (0.627kg/d) and EF (0.637kg/d), although total feed intake was higher. As a result the FCR increased accordingly (Table 4).

Dietary fat as well as feed enzyme addition positively influenced digestibility of energy. With enzyme or dietary fat supplementation, d(E) was 7% and 11% higher, than in the control diet (Table 5). Pigs receiving both enzyme and dietary fat (treatment *EF*) did not achieve highest d(E). The enzyme to fat interaction indicated that the two effects were not additive.

Dietary fat and enzyme had different effects on degradability of NDF and ADF. The addition of fat to the diet increased the degradability of both fractions. Although the inclusion of feed enzymes improved degradability of NDF and ADF, the effect was significant only for ADF (Table 5). Previous experiments by Bee *et al.*, (1995) showed that the ideal digestibility of extracted fat is lower than that of lard. Therefore, undigested fat can be utilized as a substrate by microorganisms in the large intestine which may indirectly contribute to the improved degradability of the fibre fractions.

Based on the results of the metabolism studies, the digestible energy (DE) contents of the four diets were estimated. The DE content of the control diet amounted to 11.580MJ/kg DM. Feed enzyme as well as the dietary fat supplementation caused an increase in the DE content by 0.82 and 2.26 MJ/kg DM, respectively. The improved energy digestibility after fat addition caused a significant increase in DE intake as well as DE efficiency

Table 4. **Growth performance, digestible energy (DE) intake and efficiency.**

	Treatment C n=6	E n=7	F n=6	EF n=6	Pooled SE
Initial body weight (kg)	22.47	21.62	21.05	22.55	0.661
Final body weight (kg)	90.49	89.24	89.25	90.84	0.379
Daily weight gain (kg/d)	0.619	0.627	0.619	0.637	0.0118
Total feed intake (kg)	237.0	226.6	233.6	229.9	2.88
FCR (kg/kg)	3.49	3.35	3.42	3.37	0.038
DE intake (MJ DE/d)	24.98^{a}	25.91^{ab}	29.19^{b}	28.77^{ab}	0.564
DE efficiency (MJ DE/kg gain)	40.42^{a}	41.40^{ab}	47.39^{c}	45.29^{bc}	0.775

	Factorial means: Pentosanase -	Pentosanase +	Dietary fat -	Dietary fat +	Significance of effect: Enzyme	Fat	Interaction
Daily weight gain (kg/d)	0.619	0.631	0.623	0.629	NS	NS	NS
Total feed intake (kg)	235.5	228.1	231.4	231.6	NS	NS	NS
FCR (kg/kg)	3.46	3.36	3.42	3.39	NS	NS	NS
DE intake (MJ DE/d)	26.90	27.23	25.48	28.96	NS	**	NS
DE efficiency (MJ DE/kg gain)	43.59	43.20	40.95	46.25	NS	****	NS

SE- standard error of mean
Values with different superscripts in the same row differ significantly.
** P<0.01, **** P<0.0001 ns- not significant

Table 5. Effect of treatment on organic matter digestibility d(OM), energy digestibility d(E) and fiber degradability.

	Treatment				
	C n=7	E n=7	F n=7	EF n=7	Pooled SE
d(OM)	0.654[a]	0.695[b]	0.722[b]	0.713[b]	0.0062
d(E)	0.638[a]	0.682[b]	0.711[b]	0.702[b]	0.0066
Fiber degradability					
NDF	0.220[a]	0.309[b]	0.368[b]	0.356[b]	0.0145
ADF	0.086[a]	0.206[b]	0.277[b]	0.284[b]	0.0186

	Factorial means				Significance of effect		
	Pentosanase		Dietary fat		Enzyme	Fat	Inter action
	-	+	-	+			
d(OM)	0.688	0.704	0.675	0.718	NS	****	**
d(E)	0.674	0.692	0.660	0.707	*	****	**
Fiber degradability							
NDF	0.294	0.333	0.264	0.362	NS	****	*
ADF	0.182	0.245	0.146	0.281	**	****	*

SE- standard error of mean
Values with different superscripts in the same row differ significantly.
* P≤0.05, ** P≤0.01, **** P≤0.0001 ns - not significant

Pigs receiving diet F consumed significantly more DE per kg weight gain than pigs of the treatment C and E (Table 4). The poorer efficiency of DE and the lower daily weight gain of the pigs fed diet F implied that these animals had a higher fat deposition than animals in the treatments C and E. These values agree with the findings by Campbell and Taverner, (1988) and Bikker (1994), who established a curvilinear increase in lipid to protein deposition ratio with increasing energy intake. This effect caused a curvilinear increase in body lipid content and a curvilinear decrease in body protein content.

CONCLUSIONS

The application of enzymes in rations for growing pigs, in combination with suitable feedstuffs (in our experiment whole maize plants), improved energy digestibility. This mechanism allow us to consider those feedstuffs rich in dietary fiber to be used in diet formulation. Addition of dietary fat to diets with a high crude fibre content improved the d(E) and the degradability of fiber significantly; but no positive effect could be seen in the growth parameters. Significant interaction existed between dietary fat and enzyme supplementation. The combination did not increase the effects on growth or digestibility of nutrients. It implies that the effects of enzyme and fat are not additive.

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