

GROWTH PERFORMANCE, NUTRIENT DIGESTIBILITY AND PROTEIN UTILIZATION IN GROWING PIGS FED NAKED OAT WITH β -GLUCANASE SUPPLEMENTATION AS A SUBSTITUTE FOR WHEAT

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Abstract. A 30-day growth experiment was performed on 44 growing pigs (initial BW 19.3 kg) to determine the effects of diets with a different level of naked oat, and β -glucanase supplementation of a diet with a high oat content, on growth performance. The pigs were fed individually the following diets: a control barley-wheat diet (group BW), a diet containing 23.5% naked oat (BOW), a diet containing 47% naked oat (OB), and a diet containing 47% oat supplemented with 1000 CU/kg β -glucanase (OBG). Nitrogen balance and nutrients digestibility of diets containing 97% wheat or naked oat, with or without 1000 CU/kg β -glucanase, were determined on 20 barrows (initial BW 40.9 kg).

Diet BOW containing 23.5% naked oat as a substitute for wheat had no effect on daily gains and feed efficiency, whereas diet OB with 47% oat improved daily gains from 668 to 713 g ($P < 0.05$) and feed efficiency from 2.31 to 2.17 kg/kg ($P < 0.05$), compared with the control barley-wheat diet. Nutrients digestibility was significantly higher ($P < 0.01$) in the case of oat than wheat, except crude protein digestibility, where this difference was non-significant. Naked oat contained more digestible energy than wheat, i.e. 16.14 vs. 14.36 MJ/kg ($P < 0.01$). It has also a higher biological value, compared with wheat (62.4% vs. 54.8%). In the growth experiment β -glucanase supplementation of a diet containing 47% naked oat had no effect on daily gains and feed efficiency, and in the balance experiment it allowed to increase oat gross energy digestibility ($P < 0.05$).

Keywords: naked oat, wheat, β -glucanase, growth, digestibility, nitrogen balance, pigs.

KIAULIŲ, ŠERIAMŲ LUKŠTENTOMIS AVIŽOMIS SU BETA GLIUKANAZĖS PAPILDAIS BEI KVIEČIŲ PAKAITALAI, PRIESVORIO RODIKLIAI, MAISTO MEDŽIAGŲ VIRŠKINAMUMAS IR BALTYMŲ PANAUDOJIMAS

Santrauka. Buvo atliktas 30 dienų šėrimo bandymas su 44 kiaulėmis (pradinė kūno masė – 19,3 kg), nustatytas raciono su skirtingu lukštentų avižų bei raciono su dideliu avižų kiekiu ir su beta gliukanazės papildais poveikis augimo rodikliams. Kiaulės buvo šeriamos individualiai pagal racionus: kontrolinį miežių ir kviečių (grupė BW), lukštentų avižų 23,5% (grupė BOW), lukštentų avižų 47% (grupė OB), avižų 47%, papildytų 1000 CU/kg beta gliukanazės (grupė OBG). Nustatytas azoto balansas ir maisto medžiagų virškinamumas 20 kuilių (pradinė kūno masė 40,9 kg), kurių racioną sudarė 97% kviečių bei lukštentos avižos su 1000 CU beta gliukanaze.

Racionas BOW, turintis 23,5% lukštentų avižų, kaip kviečių pakaitalas nedarė įtakos paros priesvoriui ir šėrimo efektyvumui. Tuo tarpu racionas OB su 47% avižų paros priaugę padidino nuo 668 iki 713 g ($p < 0,05$) ir pagerino šėrimo efektyvumą nuo 2,31 iki 2,17 kg ($p < 0,05$) palyginti su miežių ir kviečių racionu. Maistinių medžiagų virškinamumas buvo daug geresnis ($p < 0,01$) vietoj avižų duodant kviečių racioną (išskyrus žalių baltymų virškinamumą). Šiuo atveju skirtumas nebuvo reikšmingas. Lukštentos avižos turėjo daugiau virškinamosios energijos nei kviečiai, t. y. (16,14 MJ/kg palyginti su 14,36 MJ/kg) ($p < 0,01$). Jų biologinė vertė taip pat didesnė nei kviečių (62,4% palyginti su 54,8%). Šėrimo eksperimento metu raciono, turinčio 47% lukštentų avižų, papildymas beta gliukanaze neturėjo poveikio paros priaugimi ir šėrimo efektyvumui, tačiau padidėjo avižų bendras energijos virškinamumas.

Raktažodžiai: lukštentos avižos, kviečiai, beta gliukanazė, priesvoris, virškinamumas, azoto balansas, kiaulės.

Introduction. Naked oat grain contains more crude protein, crude fat and less fiber compared with husked oat grain (Kosieradzka and Fabijańska, 2001). Due to its composition, especially low fiber content, naked oat nutrients are better digestible by pigs than husked oat (Petkov et al. 2001). Numerous experiments have been performed so far to determine the nutritive value of naked oat as a substitute for maize in pig diets. The results of these experiments show (Brand and van der Merwe, 1996) that the naked oat content of diets for weaners should not exceed 50%, taking into account feed intake

and daily gains. Studies on fatteners (Friend et al., 1989; Brand and van der Merwe, 1996) have demonstrated that even complete replacement of maize with naked oat in diets do not reduce growth performance or carcass slaughter value. The cultivated area of naked oat has been recently increasing in many countries, including Poland. Due to its high fat content and good-quality protein (Kosieradzka and Fabijańska, 2001; Flis et al., 2004), naked oat can be a valuable component of diets for growing pigs, particularly those containing no animal meals. Naked oat contains 3.5 - 5.5% β -glucan

(Conciatori et al., 2000), which is a soluble dietary fiber component, and is able to form highly viscous solutions even at low concentrations (Doublier and Wood, 1995). Therefore β -glucanase supplementation of diets with naked oat seems recommendable, but there are no sufficient data on this topic.

The objective of the present study was to determine the effects of diets with a different level of naked oat and β -glucanase supplementation on the growth performance in young growing pigs. The nutritive value of naked oat and wheat, with and without β -glucanase supplementation, was also investigated on the basis of nutrient digestibility and nitrogen balance.

Material and Methods. Commercial naked oat grain, cv. Akt (13% crude protein, 9.6% crude fat HCl, 2.8% crude fiber, 4.17% β -glucan in DM) was used in the study. A 30-day growth experiment was performed on 44 growing pigs (Polish Large White x Polish Landrace)

with initial body weight of 19.3 kg. The pigs were kept in individual cages and fed a control barley-wheat diet (group BW), a diet containing 23.5% naked oat as a substitute for most of wheat (BOW), a diet containing 47% naked oat substituting all of wheat and half of barley (OB), and a diet containing 47% oat supplemented with 1000 CU/kg β -glucanase (OBG) (Table 1). The diets were given with water (1:1) in daily ration 1.2 to 1.9 kg.

Nitrogen balance and nutrient digestibility of diets containing approx. 97% wheat or naked oat, with or without 1000 CU/kg β -glucanase (groups W, O and WG, OG, respectively) were determined on 20 barrows with initial body weights of 40.9 kg. Cereal diets were supplemented with lysine (to a level of 5.3 g/100 g crude protein), mineral feed, mineral-vitamin premix and chromium oxide as an indicator (Table 1).

Table 1. **Ingredients and nutritional value of feed mixtures used in growth and digestibility experiment on growing pigs, g·kg⁻¹ as-fed basis**

Item	Growth experiment				Balance experiment			
	BW	BOW	OB	OBG	W	WG	O	OG
Barley	402.0	407.4	232.9	231.9	-	-	-	-
Wheat	300	60	-	-	967.6	966.6	-	-
Naked oat	-	235	470	470	-	-	969.0	968.0
Soybean meal	230	230	230	230	-	-	-	-
Dry sugar beet pulp	30	30	30	30	-	-	-	-
Minerals and premix ¹	36	35	36	36	26	26	26	26
L-lysine HCl (78%)	1.6	1.2	0.8	0.8	3.4	3.4	2.0	2.0
DL-methionine (99%)	0.4	0.4	0.3	0.3	-	-	-	-
Chromic oxide	-	-	-	-	3	3	3	3
β -glucanase preparation	-	-	-	1	-	1	-	1
Analysed nutrients, g·kg ⁻¹								
crude protein	179.6	172.2	177.8	175.6	106.8	106.6	113.1	112.3
ether extract HCl	23.1	36.8	50.9	50.5	25.4	25.4	82.2	82.2
Calculated nutrients ² , g·kg ⁻¹								
lysine	10.04	10.10	10.13	10.11	5.63	5.63	6.02	6.02
Met + cys	6.24	6.06	6.38	6.38	4.13	4.17	5.02	5.02
threonine	6.30	6.51	6.71	6.71	2.99	2.99	3.83	3.83
tryptophan	2.09	2.17	2.26	2.26	1.07	1.07	1.38	1.38
β -glucan	13.3	20.7	23.9	23.9	5.7	5.7	35.6	35.6
ME ³ , MJ·kg ⁻¹	12.40	12.73	13.27	13.33	13.47	13.22	14.84	14.95

¹ premix on ground limestone carrier and containing flavomycine (4 g/kg)

² calculated on the basis of chemical analysis of feed ingredients

³ metabolizable energy: in growth exp. calculated acc. NRP data (1993), in balance exp. calculated on the basis nutrients content and digestibility

Nutrients content in feeds and feces, and nitrogen in the urine were determined according to AOAC (1990). The results of balance experiment were analyzed by a two-way analysis of variance with the Student-Newman Keul's procedure. The results of the growth experiment were analyzed by a one-way analysis of variance. The calculations were done using the STATISTICA software (ver. 6.0).

Results and Discussion. Diet BOW containing 23.5% naked oat as a substitute for most of wheat had no effect

on growth performance (Table 2). Diet OB with 47% oat substituting all of wheat and half of barley improved daily gains from 668 to 713 g (6.7%; $P < 0.05$) and feed efficiency from 2.31 to 2.17 kg/kg (6.1%; $P < 0.05$). The high nutritive value of this diet resulted from better quality of oat protein, compared with wheat and barley protein, as well as high energy content. After lysine and methionine supplementation, diet OB contained more remaining essential amino acids than the control barley-wheat diet. β -glucanase supplementation of a diet with

47% naked oat had no effect on growth parameters over the entire experimental period (group OBG vs. OB). The fact that β -glucanase supplementation of diet OBG containing 47% naked oat and 23% barley had no influence on the growth performance indicates that β -glucan, at a level of 2.4% of diet, did not decrease nutrient

utilization in pigs weighing 19 to 40 kg. Similar conclusions were formulated by Fortin et al. (2003), who applied diets containing 1.4% to 4.1% β -glucan (mostly from oat) and did not observe reduced daily gains or feed efficiency.

Table 2. Results of growth experiment on weaners

Item	Diet				SE	P level
	BW	BOW	OB	OBG		
Initial body weight, kg	19.41	19.14	19.36	19.41	0.346	NS
Body weight in 30- days of exp., kg	39.45	39.45	40.74	41.05	0.373	NS
Daily body weight gain, g	668 ^a	677 ^{ab}	713 ^{bc}	718 ^c	7.12	< 0.05
Relatively (%)	(100)	(101.3)	(106.7)	(107.5)		
Feed efficiency, kg·kg ⁻¹	2.31 ^a	2.28 ^{ab}	2.17 ^{bc}	2.15 ^c	0.023	< 0.05
Relatively (%)	(100)	(98.7)	(93.9)	(93.1)		

a,b,c – P<0.05; NS –not significant

Oat, compared with wheat, had slightly higher crude protein digestibility, and significantly higher digestibility of crude fat, crude fiber, N-free extractives and gross energy (Table 3). The highest differences between oat and wheat were recorded in the digestibility of crude fat (82.9% vs. 58.4%; P<0.01) and crude fiber (50.2% vs. 35.8%; P<0.01). Oat contained more digestible energy than wheat (16.14 vs. 14.36 MJ/kg; P<0.01). The high nutrients digestibility and energy value of naked oat may

result from its high fat and low fiber content, even lower than in wheat (ADF 3.88% vs. 4.97% DM, NDF 13.08% vs. 15.06% DM; Flis et al., 2004). Similarly as in the present experiment, higher digestibility of oat nutrients as of wheat, was reported by Van Barneveld et al. (1998). β -glucanase supplementation enabled to increase crude fiber digestibility in wheat, and energy digestibility in oat (P<0.05).

Table 3. Apparent total tract digestibility coefficients of nutrients (%) and nitrogen balance results

(g·day⁻¹) in 41- 51kg pigs fed cereal diets with 96.8% wheat or naked oat without (W, O) and with β -glucanase supplementation (WG, OG)

Item	Diet				Cereal (C)		Glucanase (G)		Interaction (C x G) P ≤
	W	WG	O	OG	W	O	-	+	
Digestibility:									
crude protein	80.6	80.6	81.7	82.2	80.6	81.9	81.1	81.4	0.768
ether extract HCl	57.0 ^B	59.8 ^B	82.4 ^A	83.4 ^A	58.4 ^B	82.9 ^A	69.7	71.6	0.572
crude fibre	33.3 ^{cB}	38.4 ^{bB}	50.0 ^{aA}	50.4 ^{aA}	35.8 ^B	50.2 ^A	41.7	44.4	0.167
N free extractives	93.5 ^B	94.1 ^B	95.3 ^A	95.7 ^A	93.8 ^B	95.5 ^A	94.4	94.9	0.794
gross energy	86.8 ^{cB}	87.2 ^{cB}	88.5 ^{bA}	89.5 ^{aA}	87.0 ^B	89.0 ^A	87.7 ^b	88.3 ^a	0.282
DE, MJ·kg ⁻¹ diet	14.33 ^{cB}	14.38 ^{cB}	16.05 ^{bA}	16.23 ^{aA}	14.36 ^B	16.14 ^A	15.19 ^b	15.31 ^a	0.237
N balance results:									
intake	35.88	35.82	38.00	38.07	35.83	38.03	36.93	36.94	
in faeces	6.97	6.94	6.98	6.78	6.96	6.88	6.98	6.86	0.795
in urine	12.75	13.34	11.96	11.46	13.04	11.71	12.36	12.40	0.477
retained	16.16 ^{bB} c	15.54 ^{bC}	19.06 ^{aA} B	19.83 ^{aA}	15.83 ^B	19.44 ^A	17.61	17.67	0.349
retained/absorbed, ¹ %	55.9 ^{ab}	53.8 ^b	61.5 ^a	63.3 ^a	54.8 ^B	62.4 ^A	58.7	58.6	0.418
ADG ² in 16 days, g	691 ^{ab}	650 ^b	744 ^a	731 ^a	671 ^b	738 ^a	717	691	0.551

¹apparent biological value of protein

²average daily gain

a, b, c – P ≤ 0.05; A, B, C – P ≤ 0.01

Despite slightly higher nitrogen intake, pigs fed naked oat excreted less nitrogen in the urine than fed wheat (11.71 vs. 13.04 g; P>0.05) (Table 3). This contributed to higher nitrogen retention and its better utilization in pigs

fed oat (P<0.01). Diets containing naked oat had a significantly higher apparent biological value of protein (N retention/N absorption) than wheat, on average 62.4% and 54.8%, respectively. The supplementation of β -

glucanase, in the amount of 1000 CU/kg (manufacturer's recommendations being 500 - 1000 CU/kg), the diets containing approx. 97% wheat or oat had no effect on nitrogen balance. In a 16-day balance experiment, daily gains of pigs fed oat were significantly higher (738 g) compared with fed wheat (671 g). The apparent biological value of naked oat noted in the present study was slightly higher than its value determined on 45 kg pigs for high-protein naked oat cv. Terra (60.6), also with lysine supplementation (Friend et al., 1989).

Conclusions:

- naked oat (cv. Akt), compared with wheat, was higher nutrients digestibility, digestible energy content and biological value of protein;
- naked oat introduced to diet for 19 - 40 kg pigs in the amount of 23.5% (as a substitute for wheat) did not influence on growth performance, whereas 47% naked oat (as a substitute for wheat and part of barley) significantly improved daily gain and feed efficiency;
- β -glucanase supplementation of a diet containing 97% oat improved gross energy digestibility, whereas β -glucanase supplementation of a diet with 47% oat had no effect on growth performance.

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