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Performance and nitrogen balance in growing-finishing pigs fed restricted or *ad libitum* diet with lowered protein content

Efekty produkcyjne i bilans azotu u tuczników żywionych w systemie dawkowanym lub *ad libitum* paszą o obniżonym poziomie białka

Summary. The objective of the present study was to determine the effect of lowered by 10% feed crude protein level in relation to the requirements for pig feeding standards in mixture concentrates for fatteners fed a restricted or *ad libitum* diet on animal growth, feed conversion ratio and nitrogen balance. The animals (36 pigs) were assigned into 3 groups maintained in pens, 2 animals each. Group I (control) received standard mixture concentrates with a recommended crude protein and amino acids level in compliance with pig feeding standards, whereas the animals from for groups II and III had a diet with a reduced by 10% crude protein and amino acids content. The fatteners from group I and II were fed a restricted diet, while those from group III had free access to feedstuffs (*ad libitum*). The animals were weighed at the beginning of the experiment at 68–70 BW and before slaughter, with regular control of feed intake. The N-balance tests were performed in metabolic cages on 4 porkers from each group at 35, 55, 75 and 95 kg BW. The results, i.e. daily gains (896, 894 and 911 g daily) and feed conversion ratio (2.41; 2.42 and 2.64 kg/kg body-weight gain, respectively, throughout the fattening period from 25 to 110 kg) in groups I, II and III as well as N-excreted in manure (36.5, 31.5 and 34.4 g N daily) indicated the potential to minimize nitrogen emission through feed protein reduction by 10% in relation to the pig feeding standards, in case of free access to feedstuffs.

Key words: pig, crude protein level, performance results, N balance

INTRODUCTION

Recently, one of the major factors reviewed in grower-finisher diets for commercially produced pigs has been the minimized excretion of unused biogenic ingredients, mainly phosphorus and nitrogen. Amount of nitrogen emission in animal faeces and

urine is primarily affected by a feed protein level and amino acid balance, implementation of various feed supplements as well as phase feeding strategy – *ad libitum* or restricted [Kerr *et al.* 1995, Reynolds and O’Doherty 2006, Grela and Semeniuk 2008]. According to Torrallardona [1999], a markedly reduced dietary crude protein content from 19 to 12% in a growing pig diet contributed to the significant decline in nitrogen release with a concurrent decrease of daily bodyweight gains and elevated feed intake. Exogenous amino acid supplementation [Kerr *et al.* 1995, Gomez *et al.* 2002] or use of various feed additives [Bonazii *et al.* 2005, Guingand *et al.* 2005] along with a concomitant partly limited crude protein content in the diet can minimize the excretion of nitrogen. The *ad libitum* feeding system with decreased dietary protein concentration is likely to diminish the disadvantageous effect of feed protein reduction on animal performance parameters and to influence the nitrogen release amount in faeces and urine.

The aim of the study was to evaluate the effect of a lowered by 10% crude protein level in respect to the Polish pig feeding standards [Normy... 1993] in complete mixtures for fatteners fed restricted or *ad libitum* diets, on animal growth rate, feed conversion ratio and nitrogen balance.

MATERIAL AND METHODS

The investigations included 36 growers (PL × PLW) × Duroc crossbreds with the initial body weight of 29 ± 0.5 kg. The animals were divided into 3 groups of 12 units each and housed in pens, 2 pigs each. Fatteners from all groups were fed complete grower (25–70 kg), and finisher diets (71–110 kg); their composition is summarized in Table 1. The animals from group I received feed mixtures with a crude protein level in compliance with the feeding standards [Normy... 1993], whereas the diets for group II and III at both fattening periods had crude protein and exogenous amino acid concentration decreased by 10%. The pigs from group I and II were fed a restricted diet [Normy... 1993], while those from group III had free access to feedstuffs (*ad libitum*). The pig diets provided for the control group during the first and second fattening period were supplemented with lysine, methionine, tryptophan and threonine up to the level recommended in the Polish pig feeding standards [Normy... 1993]. Water was available from automatic drinkers. The pigs were weighed at the beginning of the experiment at 68–70 kg BW and before slaughtering. The zoohygienic conditions, i.e. temperature, relative moisture and cooling were identical for all groups. Feed intake and potential leftovers were checked at each pen.

The digestibility-balance examinations were conducted on 4 animals from each group. The fatteners were kept in individual metabolism cages which allowed to check feed intake as well as faeces and urine sample collection. The digestibility studies were conducted using the Cr_2O_3 indicator method (3 g kg^{-1} feed). The 24-hour faeces and urine collection were performed 4 times and continued through 6 days for fatteners at ca 35, 55, 75 and 95 kg BW. The faeces and urine samples were weighed, then placed in appropriate containers and acidified with a few drops of sulfuric acid. The samples from three consecutive days were mixed up, and a mean sample of ca 0.5 kg faeces and 200 ml urine was taken and transported to the laboratory. Faeces and feed were examined for a Cr_2O_3 content according to the method described by Kimura and Miller [1957]. Dry matter and nitrogen level in faeces as well as nitrogen content in urine were

determined according to AOAC methods [2000]. Exogenous amino acid concentration in feeds was established on the amino acid analyzer with ion-exchange column and UV-VIS detector after the AOAC method [2000]. The energy value of the diets was calculated with the Kirchgessner and Roth equation [1983].

The results were analyzed with variance analysis (ANOVA) to get the mean values for the groups and standard error mean (SEM), whereas significance of differences between the mean values of the studied traits was determined using the Duncan test.

RESULTS AND DISCUSSION

The grower and finisher diets the control group (I) was fed with contained respectively 170.3 and 150.2 g of crude protein and those fed to animals from experimental groups (II and III) contained 154.1 and 136.3 g of crude protein respectively, so they were close to the underlying methodological assumptions of this paper (Tab. 1). Alike, a percentage of exogenous amino acids in these groups was lower by ca 10% in relation to the diets for group I.

Table 1. Composition (%) and nutritive value of mixtures for growing-finishing pigs
Tabela 1. Skład (%) i wartość pokarmowa mieszanek pełnoporcjowych dla tuczników

Components Składniki	Grower (30–70 kg)		Finisher (71–110 kg)	
	100% CP	90% CP	100% CP	90% CP
Wheat – Pszenica	40.0	40.0	20.0	20.0
Barley – Jęczmień	34.0	39.6	60.0	65.0
Fish meal – Mączka rybna	3.0	3.0	-	-
Soybean meal Poekstrakcyjna śruta sojowa	17.0	11.4	15.0	10.0
Soya oil – Olej sojowy	1.5	1.5	1.0	1.0
Mineral feeds – Pasze mineralne	3.5	3.5	3.0	3.0
Mineral vitamin premix Premiks mineralno-witaminowy	1.0	1.0	1.0	1.0
Razem – Total	100.0	100.0	100.0	100.0
Content in 1 kg: – 1 kg zawiera:				
Crude protein, g – Białko ogólne, g	170.3	154.1	150.2	136.3
ME, MJ	12.96	12.95	12.52	12.53
Lizyna – Lysine, g	9.08	8.15	7.55	6.79
Methionine + cystine, g Metionina + cystyna, g	5.48	4.93	4.58	4.12
Tryptophan, g – Tryptofan, g	1.77	1.60	1.45	1.31
Lysine : met. + cys. : tryptophan Lizyna : met. + cyst. : tryptofan	1 : 0.60 : 0.19	1 : 0.60 : 0.20	1 : 0.61 : 0.19	1 : 0.61 : 0.19

Fatteners that were fed restrictively with diets of a reduced by 10% crude protein content compared to the requirements of pig feeding standards [Normy... 1993] (group II) showed slightly lower body weight gains in the initial fattening period (Tab. 2), yet

they remained at a similar level (895 ± 1 g) throughout the whole experiment. Considerably better weight gains during the growing period were recorded for the fatteners from group III, which diets had a decreased crude protein level but were fed *ad libitum*; the differences in this parameter between group II and III proved statistically significant. As for group III, markedly higher feed consumption per 1 kg weight gain in respect to the other two groups was stated (Tab. 2). Carcass meatiness appeared to be high (56.4–57.4%) and it was slightly higher in group II and III compared to the control group (I). Then, it follows that increased feed intake in group III (2.64 kg daily throughout the fattening period and 2.41 kg in group I and II) was to lessen the potential crude protein deficit in diets. However, it seems that the pig feeding standards [Normy... 1993] underestimate the requirement for metabolic energy. The earlier study [Grela *et al.* 2009] showed that a reduced by 10% level of protein digested at the end of small intestine in relation to the DLG standards [2006] with concomitant complementation of amino acids digested to the end of small bowel to the amount provided in the control group diet, allowed to obtain daily bodyweight gains of 799 g, only slightly lower than in the control group (819 g).

Table 2. Productive results of fatteners
Tabela 2. Efekty produkcyjne tuczników

Item Wskaźnik	Fattening period, kg Okres tuczu, kg	Feeding groups – Grupy żywieniowe			SEM
		I	II	III	
Initial BW, kg – Masa początkowa, kg		28.8	29.2	28.5	1.04
BW at slaughter, kg – Masa przy uboju, kg		110.2	110.6	110.6	1.62
Days of fattening – Dni tuczu	30–110	91	91	90	0.20
Daily weight gains, g Przyrosty dzienne, g	30–70	837 ^{ab}	807 ^b	863 ^a	37
	71–110	960	982	957	49
Feed intake, kg Dzienne pobranie paszy, kg	30–110	896	894	911	44
	30–70	1.92 ^b	1.92 ^b	2.15 ^a	0.05
	71–110	2.88 ^b	2.88 ^b	3.09 ^a	0.06
Feed conversion ratio, kg/kg Wykorzystanie paszy, kg/kg	30–110	2.41 ^b	2.42 ^b	2.64 ^a	0.05
	30–70	2.29 ^b	2.38 ^{ab}	2.49 ^a	0.07
	71–110	3.00 ^b	2.93 ^b	3.23 ^a	0.09
Meaty, % – Mięsność, %	30–110	2.69 ^b	2.71 ^b	2.90 ^a	0.09
		56.41	57.27	57.37	1.89

a, b, c – values in the same rows with different letters differ significantly at $p \leq 0.05$

a, b, c – wartości w wierszach oznaczone różnymi literami różnią się istotnie przy $p \leq 0,05$

The results of the balance tests performed on the growing pigs (Tab. 3) indicate substantial reduction of nitrogen release in animal faeces and urine in group I and III. A decrease of protein quantity by 10% according to the [Normy... 1993] increased nitrogen retention in group II by nearly 2.6 % compared to group I with similar N amount retained in daily gains. The studies of Bridges *et al.* [1995] showed that feeding a lower nitrogen diet declined nitrogen excretion in urine and elevated its retention in relation to

nitrogen intake. That was also confirmed in the present research findings. The available literature gives extensive information on production effects and nitrogen balance in fattening pigs fed lower protein diets with or without limiting amino acid supplement. The results of present study and those presented by other authors [Bridges *et al.* 1995, Kerr *et al.* 1995, Kirchgessner and Roth 1991] point out the possibility of minimizing nitrogen emission, without any considerable loss in animal performance (daily gains and feed conversion rate), by reducing dietary crude protein level by 10%. Therefore, such procedures may be applied for fattener feeding, especially the *ad libitum* system.

Table 3. Nitrogen balance in pigs
Tabela 3. Bilans azotu u tuczników

Item Wskaźnik	Body weight, kg Masa ciała	Groups – Grupy			SEM
		I	II	III	
Nitrogen intake, g day ⁻¹ Pobranie azotu w paszy, g d ⁻¹	35	43.52 ^a	39.42 ^b	43.86 ^a	0.19
	55	54.43 ^a	49.28 ^b	54.45 ^a	0.38
	75	62.48 ^a	56.16 ^c	58.11 ^b	0.43
	95	72.09 ^a	64.81 ^b	66.53 ^b	1.52
	\bar{x}	58.13 ^a	52.42 ^c	55.74 ^b	0.46
Urinary nitrogen excretion, g day ⁻¹ Azot wydalony w moczu, g d ⁻¹	35	18.66 ^a	16.59 ^b	18.36 ^a	0.12
	55	23.92 ^a	21.08 ^b	22.25 ^{ab}	0.21
	75	26.88 ^a	24.22 ^b	25.81 ^{ab}	0.27
	95	34.82 ^a	29.73 ^c	31.78 ^b	0.42
	\bar{x}	26.07 ^a	22.91 ^c	24.55 ^b	0.27
Faecal nitrogen excretion, g day ⁻¹ Azot wydalony w kale, g d ⁻¹	35	10.24 ^a	8.82 ^b	10.08 ^a	0.15
	55	9.78 ^a	8.56 ^b	10.66 ^a	0.27
	75	9.89 ^a	7.89 ^b	8.48 ^{ab}	0.24
	95	11.92 ^a	9.08 ^c	10.14 ^b	0.28
	\bar{x}	10.46 ^a	8.59 ^b	9.84 ^a	0.36
Total nitrogen excretion, g day ⁻¹ Azot wydalony w odchodach, g d ⁻¹	35	28.90 ^a	25.41 ^b	28.44 ^a	0.21
	55	33.70 ^a	29.64 ^b	32.91 ^a	0.38
	75	36.77 ^a	32.11 ^c	34.29 ^b	0.29
	95	46.74 ^a	38.81 ^c	41.92 ^b	0.43
	\bar{x}	36.53 ^a	31.49 ^c	34.39 ^b	0.34
N retention, g day ⁻¹ Azot zatrzymany, g d ⁻¹	35	14.62 ^b	14.01 ^b	15.42 ^a	0.18
	55	20.73 ^b	19.64 ^c	21.54 ^a	0.22
	75	25.71 ^a	24.05 ^b	23.82 ^b	0.26
	95	25.35 ^{ab}	26.00 ^a	24.61 ^b	0.25
	\bar{x}	21.60	20.93	21.35	0.17
N retention, % of N intake Azot zatrzymany, % azotu pobranego w paszy	35	33.59 ^b	35.54 ^a	35.16 ^a	0.19
	55	38.09 ^b	39.85 ^a	39.56 ^a	0.16
	75	41.15 ^b	42.82 ^a	40.99 ^b	0.21
	95	35.16 ^c	40.12 ^a	36.99 ^b	0.34
	\bar{x}	37.00 ^c	39.58 ^a	38.17 ^b	0.23

a, b, c, d – values in the same rows with different letters differ significantly at $p \leq 0.05$

a, b, c, d – wartości w wierszach oznaczone różnymi literami różnią się istotnie przy $p \leq 0,05$

CONCLUSION

The obtained production effects and N balance indices have shown the potential reduction of nitrogen release through lower by 10% protein diets as compared to the pig feeding standards [Normy... 1993] in case of *ad libitum* feeding system.

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Streszczenie. Celem podjętych badań było określenie wpływu obniżonej o 10% zawartości białka ogólnego w stosunku do zaleceń norm żywienia świń w mieszankach pełnodawkowych dla tuczników żywionych systemem dawkowanym lub *ad libitum* na wzrost zwierząt, zużycie paszy i bilans azotu. Zwierzęta (36 sztuk) podzielone na 3 grupy, utrzymywane były w kojcach, po 2 sztuki w każdym. Grupa I (kontrola) otrzymywała standardowe mieszanki pełnoporcjowe

o poziomie białka ogólnego i aminokwasów zgodnie z zaleceniami norm żywienia świń, zwierzęta zaś grupy II i III – otrzymywały mieszanki o obniżonym o 10% poziomie białka ogólnego i aminokwasów. Tucznie w grupie I i II żywiono w systemie dawkowanym, w III zaś miały swobodny dostęp do karmideł z paszą (żywienie *ad libitum*). Zwierzęta były ważone na początku badań, przy masie ciała ok. 68–70 kg oraz przed ubojem, przy systematycznej kontroli pobrania paszy. Badania bilansowe wykonano w klatkach metabolicznych na 4 wieprzkach z grupy przy masie ciała 35, 55, 75 i 95 kg. Uzyskane efekty produkcyjne: przyrosty dzienne (896, 894 i 911 g) i zużycie paszy (2,41; 2,42 i 2,64 kg/kg przyrostu), odpowiednio za cały okres tuczu (25–110 kg) w grupach I, II i III oraz ilości azotu wydalanego dziennie w odchodach (36,5; 31,5 i 34,4 g) wskazują na możliwość ograniczenia wydalania składników azotowych do środowiska poprzez zmniejszenie poziomu białka w paszy o 10% w stosunku do zaleceń norm żywienia świń, nawet przy dowolnym pobraniu mieszanki.

Słowa kluczowe: świnie, poziom białka ogólnego, efekty produkcyjne, bilans azotu