ECOLOGICAL CHEMISTRY AND ENGINEERING A

Vol. 17, No. 6 2010

Wiesław SOBOTKA[1], Aleksandra DRAŻBO
and Maria STANEK

EFFECT OF THE SOURCE OF VEGETABLE DIETARY PROTEIN ON NITROGEN EXCRETION TO THE ENVIRONMENT IN GROWING-FINISHING PIGS

WPŁYW ŹRÓDŁA BIAŁKA ROŚLINNEGO NA WYDALANIE AZOTU DO ŚRODOWISKA W TUCZU ŚWIŃ

Abstract: The aim of this study was to determine the effect of different sources of vegetable protein in diets for growing-finishing pigs on total protein digestibility, and on the levels of nitrogen retention, utilization and excretion to the environment. Digestibility and balance trials were conducted twice, on 24 growing-finishing pigs weighing 40 kg (fed grower diets) and 75 kg (fed finisher diets). The animals were placed in individual metabolism cages and were divided into three groups, as follows: SBM (control) group fed a diet in which the only protein source was genetically modified soybean meal, and two experimental groups fed diets containing alternative sources of vegetable protein: RSM+FB group (00-rapeseed meal + faba bean seeds) and RSM+FP group (00-rapeseed meal + field pea seeds).

It was found that 00-rapeseed meal and faba bean seeds (RSM+FB) used as a substitute for soybean meal (SBM) in diets for growing-finishing pigs significantly decreased total protein digestibility, increased fecal nitrogen excretion, and reduced nitrogen retention and utilization. The combination of 00-rapeseed meal and field pea seeds (RSM+FP) improved nitrogen balance parameters in pigs, compared with the RSM+FB group, and the obtained values were similar to those noted in the SBM group. The use of alternative dietary vegetable protein sources in pig production reduced urinary nitrogen excretion. It was estimated that an average pig fed grower and finisher diets with 00-rapeseed meal and faba bean seeds excreted in feces and urine 7.0/3.1 % and 3.6/2.6 % N more, in comparison with an average pig fed control diets with soybean meal and diets with 00-rapeseed meal and field pea seeds, respectively.

Keywords: sources of vegetable protein, protein digestibility, nitrogen balance, nitrogen excretion to the environment, growing-finishing pigs

High production levels and high population density on commercial pig farms constitute a potential threat to the environment, mostly due to high emissions of NH_3, methane and phosphorus. In view of the above, this study investigated the implementa-

[1] Department of Animal Nutrition and Feed Management, University of Warmia and Mazury in Olsztyn, ul. M. Oczapowskiego 5, 10–719 Olsztyn, Poland, email: wieslaw.sobotka@uwm.edu.pl

tion of environment-friendly pig production technologies aimed to reduce the load put on the environment by the unused excess and indigestible nutrients.

From the perspective of pig nutrient requirements, protein contained in rapeseed meal is characterized by a highly desirable amino acid composition. This protein contains less lysine and more methionine, cystine, threonine and tryptophan, compared with protein derived from soybean meal and legume seeds [1, 2]. The ileal and fecal digestibility of protein and lysine derived from rapeseed meal is lower, in comparison with other high-protein feeds [3]. However, rapeseed protein has a high biological value due to good proportions of amino acids [4]. Protein contained in faba bean and field pea seeds has a high lysine content and low concentrations of methionine and tryptophan [5]. The lysine to methionine and cystine ratio in this protein is 1:03 [6], while the proportion between these amino acids in diets for growing pigs should be in the 1:0.65–0.70 range [7]. Therefore, the above feed components cannot be the only source of supplemental protein in pig diets – they should be offered together with high-protein feeds with an increased methionine content or supplemented with crystalline methionine. 00-rapeseed meal may be a good supplement to protein derived from legume seeds in diets for growing-finishing pigs. The combination of rapeseed meal and faba bean or field pea in pig nutrition can be beneficial due to their complementary protein amino acid composition. All of these feed components are also easily available on the domestic market. However, they contain numerous anti-nutritional factors whose presence may exert a negative effect.

The aim of this study was to determine the effect of different sources of vegetable protein in diets for growing-finishing pigs on total protein digestibility, and on the levels of nitrogen retention, utilization and excretion to the environment.

Materials and methods

Two digestibility and balance trials were conducted to determine total protein digestibility (by the simple balance method) and nitrogen balance in pigs fed complete grower and finisher diets. A six-day experimental period proper was preceded by an eight-day adaptation period. The experiment was performed on 24 young hybrid (Polish Large White x Polish Landrace) x Duroc) boars with average body weight of approximately 40 kg at the beginning of experiment I, and approximately 75 kg at the beginning of experiment II, divided into three experimental groups. The animals were placed in individual metabolism cages, with free access to water, and were fed a restricted ration of complete grower and finisher diets whose composition is presented in Table 1.

During the experimental period proper, the entire amounts of feces and urine were collected. 5 % samples of the total amount of feces excreted daily were collected, preserved with sulfuric acid and assayed for total nitrogen content. Urine collected into containers was preserved with sulfuric acid, to ensure pH below 2, and 5 % samples were assayed for total nitrogen content [8]. Nitrogen losses to the environment were estimated based on nitrogen intake and fecal and urinary nitrogen excretion.

Table 1

Chemical composition and nutritive value of complete diets grower and finisher [%]

Specification	Diets for growing pigs			Diets for finishing pigs		
	SBM*	RSM +FB	RSM +FP	SBM*	RSM +FB	RSM +FP
Source of vegetable protein						
Soyabean meal	19.50	6.00	6.00	13.50	—	—
Rapeseed meal "00"	—	15.00	15.00	—	15.00	15.00
Field bean var. "Nadwiślański"	—	10.00	—	—	10.00	—
Field pea var. Albatros	—	—	15.00	—	—	15.00
Other raw materials mixtures						
Barley	57.20	45.79	45.69	63.93	52.45	52.45
Wheat	20.00	20.00	20.00	20.00	20.00	20.00
Vitamin and mineral supplement**	3.15	3.15	3.15	2.45	2.45	2.45
L-lysine [HCl, 78 %]	0.15	0.06	0.06	0.12	0.10	0.10
Nutritive value [g/kg]						
Crude protein	171.00	170.80	172.70	153.10	153.70	153.10
Digestible crude protein	141.00	128.00	131.00	129.00	122.00	123.00
Lysine	9.46	9.52	9.44	7.97	8.22	7.97
Methionine + cystine	5.96	6.62	6.65	5.00	6.10	6.16
Threonine	6.25	6.74	6.73	5.43	5.94	5.93
Tryptophan	2.09	2.11	2.09	1.62	1.84	1.44
Metabolizable energy [MJ/kg]	13.05	12.47	12.82	13.26	12.77	12.75
Lysine/metabolizable energy [g/1 MJ ME]	0.72	0.76	0.74	0.60	0.64	0.63

* SBM – postextractive soybean meal – control; RSM+FB – postextractive 00-rapeseed meal + field bean; RSM+FP – postextractive 00-rapeseed meal + field pea.
** Limestone – 1.30/0.90, dicalcium phosphate – 0.60/0.60, salt – 0.25/0.25, mineral-vitamin premix grower/finisher – 1.00/0.70 %.

The digestible protein content of experimental diets was determined based on the digestibility coefficients calculated during digestibility trials. The levels of lysine, methionine, cystine, threonine and tryptophan in diets were calculated based on the concentrations of the above amino acids in feed raw materials used for diet formulation. The amount of metabolizable energy was determined based on the chemical composition of diets, the findings of Sobotka [9], and an equation developed by Hoffman and Schieman and modified by Muller and Kirchgessner [6].

The results regarding protein digestibility and nitrogen balance were verified statistically by a one-factor analysis of variance (ANOVA) and Duncan's multiple range test, using STATISTICA 8.1 software [10].

Results and discussion

As shown in Table 2, the source of dietary vegetable protein affected total protein digestibility and nitrogen balance parameters in pigs.

Table 2

Digestibility of protein and utilization of nitrogen from grower and finisher concentrates differing in dietary protein source

Specification	Source of vegetable dietary protein					
	Concentrates for growing pigs			Concentrates for finishing pigs		
	SBM* 0+0	RSM+FB 15+10	RSM+FP 15+15	SBM* 0+0	RSM+FB 15+10	RSM+FP 15+15
Digestibility of coefficient [%]						
Crude protein [N × 6.25]	82.4^{Aa}	75.2^{Ba}	79.1^{ABb}	84.1^{A}	79.6^{B}	80.2^{B}
Daily nitrogen balance [g/day]						
N intake	60.2	60.1	60.8	68.6	68.7	68.6
Fecal N excretion	10.6^{B}	14.9^{Aa}	12.7^{Ab}	10.8^{B}	14.2^{A}	13.6^{A}
Fecal N excretion / N intake [%]	17.6	23.7	20.5	15.7	20.6	20.3
N digested	49.6^{a}	45.3^{b}	48.1^{b}	57.8^{b}	54.5^{a}	55.0^{a}
Urinary N excretion	25.3	23.5	24.3	33.2	31.4	30.8
Urinary N excretion /N intake [%]	42.0^{b}	39.1^{a}	39.9^{ab}	48.4^{b}	45.6^{a}	44.9^{a}
Retention	24.3^{b}	21.8^{a}	23.8^{b}	24.4	23.1	24.3
Nitrogen utilization [%]						
Digested / intake	82.4^{Aa}	75.2^{Ba}	79.1^{ABb}	84.2^{A}	79.5^{B}	80.2^{B}
Retention / intake	40.4^{a}	36.2^{b}	39.1^{ab}	35.5^{a}	33.7^{b}	35.4^{ab}
Retention / digested [PVB]**	49.0	48.1	49.5	42.2	42.4	44.2

* See Table 1; ** apparent biological value of protein; a, b – $p \leq 0.05$; A, B – $p \leq 0.01$.

The substitution of 00-rapeseed meal and faba bean seeds for genetically modified soybean meal in RSM+FB grower and finisher diets (in 78 % and 100 % respectively) caused a highly significant decrease in total protein digestibility. The combination of 00-rapeseed meal and field pea seeds (RSM+FP) improved protein digestibility, compared with diets containing 00-rapeseed meal and faba bean seeds, while the values of protein digestibility obtained for diets with soybean meal (SBM) were slightly higher. The above was most probably due to the presence of anti-nutritional factors in the analyzed sources of vegetable protein.

At comparable nitrogen intake, pigs fed grower and finisher diets with 00-rapeseed meal and faba bean seeds (RSM+FB) or with 00-rapeseed meal and field pea seeds (RSM+FP) excreted highly significantly more nitrogen in feces (14.9/14.2 g and 12.7/13.6 g respectively) than pigs fed control SBM diets with genetically modified soybean meal (10.6/10.8 g). It should be stressed, however, that 00-rapeseed meal and field pea seeds proved to be better substitutes for soybean meal protein than 00-rapeseed meal and faba bean seeds. This resulted from differences in total protein digestibility in these feed components. Lower urinary nitrogen excretion (statistically non-significant differences) was noted in pigs fed grower and finisher RSM+FB and RSM+FP diets, compared with animals receiving SBM diets. This suggests that protein derived from rapeseed meal and legume seeds had more desirable proportions of essential amino

acids. Also Gatel and Grosjean [11] and Shriver et al [12] reported that supplementing protein with lysine and methionine in diets for pigs reduced urinary nitrogen excretion.

The results of table Table 3 shows that the source of dietary vegetable protein had little affected on the elimination nitrogen to the environment.

Table 3

Nitrogen excretion levels as dependent on the source of vegetable dietary protein in the growing-finishing pigs [g]*

Specification	SBM** 0+0	RSM+FB 15+10	RSM+FG 15+15
Diets for growing pigs [40 kg BW]			
N intake	842.8	841.7	851.1
Fecal N excretion	148.4	208.6	177.8
Urinary N excretion	354.2	329.0	340.2
Total N excretion	502.6	537.6	518.0
Nitrogen excretion levels as dependent on the source protein			
[g]	*0.0*	*+35*	*+15.4*
[%]	*100*	*107.0*	*103.1*
[g]	—	*0.0*	*–19.6*
[%]	—	*100*	*96.4*
Diets for finishing pigs [75 kg BW]			
N intake	960.2	964.0	960.2
Fecal N excretion	151.2	198.8	190.4
Urinary N excretion	464.8	439.6	431.2
Total N excretion	616.0	638.4	621.6
Nitrogen excretion levels as dependent on the source protein			
[g]	*0.0*	*+22.4*	*+4.4*
[%]	*100*	*103.6*	*101.0*
[g]	—	*0.0*	*–16.8*
[%]	—	*100*	*97.4*

* Analysis performed during digestibility and balance trials; ** see Table 1.

Increased fecal nitrogen utilization in pigs receiving vegetable protein sources alternative to soybean meal resulted in slightly lower nitrogen retention and worse nitrogen utilization in relation to nitrogen intake. It was estimated that an average pig fed grower and finisher diets with 00-rapeseed meal and faba bean seeds excreted in feces and urine 7.0/3.1 % and 3.6/2.6 % N more, in comparison with an average pig fed control diets with soybean meal and diets with 00-rapeseed meal and field pea seeds respectively.

Conclusions

1. 00-rapeseed meal and faba bean seeds used as a substitute for genetically modified soybean meal in diets for growing-finishing pigs negatively affected total portein digestibility, fecal nitrogen excretion, nitrogen retention and utilization.

2. The combination of 00-rapeseed meal and field pea seeds improved nitrogen balance parameters in pigs, compared with diets containing 00-rapeseed meal and faba bean seeds.

3. The use of alternative dietary vegetable protein sources in pig production reduced urinary nitrogen excretion.

4. It was estimated that an average pig fed grower and finisher diets with 00-rapeseed meal and faba bean seeds excreted in feces and urine 7.0/3.1 % and 3.6/2.6 % N more, in comparison with an average pig fed control diets with soybean meal and diets with 00-rapeseed meal and field pea seeds respectively.

References

[1] Nasi M.: *Digestibility and protein utilization responsens od soybean and rape seed meal to physical and enzymatic treatments in diets for growing pigs.* J. Agric. Sci. Finland 1992, **63**, 465–474.

[2] Sobotka W., Tywończuk J. and Lewicki Cz.: *Wpływ stosowania mieszanek pełnoporcjowych typu PT-1 z udziałem poekstrakcyjnej śruty rzepakowej, bobiku i grochu na strawność składników pokarmowych i bilans azotu u tuczników.* Acta Acad. Agricult. Tech. Olst. 1995, **44**, 71–82

[3] Buraczewski S. and Buraczewska L.: *Współczesne zasady żywienia świń. Normowanie białka dla świń na podstawie aminokwasów strawnych.* XXVII Sesja Żywienia KNZ PAN. Jabłonna 3–4 czerwca 1997, pp. 23–40.

[4] Lipiński K., Tywończuk J., Flis M. and Sobotka W.: *The effect of low-glucosinolate rapeseed meal, cake and seeds on nutrient digestibility and nitrogen and energy utlization in growing pigs.* Acta Acad. Agricult. Tech. Olst. 1997, **46**, 169–180.

[5] Flis M., Sobotka W., Purwin C. and Zduńczyk Z.: Nutritional *value of diets containing field bean* (*Vicia faba L.) seeds with high or low proanthocyanidin levels for pigs*. J. Anim. Feed Sci. 1999, **8**, 171–180.

[6] Normy Żywienia Świń. Wartość pokarmowa pasz. Omnitech Press, Warszawa 1993.

[7] Grela E.: *Żywienie tuczników*, [in:] Żywienie zwierząt i paszoznawstwo. Podstawy szczegółowego żywienia zwierząt, vol. 2, Jamroz D., Potkański A. (eds.), Wyd. Nauk. PWN, Warszawa 2001.

[8] Official Methods of Analysis of the Association of Official Analytical Chemists. 15th Edition, Darlington 1990.

[9] Sobotka W.: *Poekstrakcyjna śruta rzepakowa "00" i nasiona strączkowych jako źródła białka w tuczu świń*. Wyd. UWM, Olsztyn. Rozprawy i Monografie 2004, **93**, 1–98.

[10] Stanisz A.: Przystępny kurs statystyki z wykorzystaniem programu STATISTICA PL na przykładach z medycyny, vol. 2, Wyd. StatSoft Polska, Kraków 2000, pp.1–401.

[11] Gatel F. and Grosjean F.: *Effect of protein content of the diet on nitrogen excretion by pigs.* Livest. Prod. Sci. 1992, **31**, 109–120.

[12] Shriver J.A. Carter S.D., Sutton A.I., Richert B.T., Senne B.W. and Pettey L.A.: *Effects of adding fiber sources to reduced crude protein, amino acids suplemented diets on nitrogen excretion, growth performance and carcass traits of finishing pigs*. J. Anim. Sci. 2003, **81**, 492–502.

WPŁYW ŹRÓDŁA BIAŁKA ROŚLINNEGO NA WYDALANIE AZOTU DO ŚRODOWISKA W TUCZU ŚWIŃ

Katedra Żywienia Zwierząt i Paszoznawstwa
Uniwersytet Warmińsko-Mazurski w Olsztynie

Abstrakt: Celem badań było określenie wpływu różnych źródeł białka roślinnego w mieszankach paszowych dla tuczników na strawność białka ogólnego, retencję azotu i jego wykorzystanie oraz na ilość azotu wydalonego do środowiska. Badania strawnościowo-bilansowe przeprowadzono dwukrotnie, na 24 tucznikach utrzymywanych indywidualnie w klatkach metabolicznych, przy masie ciała 40 kg (mieszanki grower) i 75 kg (mieszanki finiszer), przydzielonych do trzech grup doświadczalnych: SBM (kontrolna) – żywiona

mieszanką wyłącznie z białka pochodzącego z genetycznie modyfikowanej poekstrakcyjnej śruty sojowej i doświadczalnych żywionych mieszankami zawierającymi alternatywne źródła białka roślinnego: RSM+FB (poekstrakcyjna śruta rzepakową "00" + nasiona bobiku), oraz RSM+FP (poekstrakcyjna śruta rzepakowa "00" + nasiona grochu).

Stwierdzono, że użycie w mieszankach paszowych dla tuczników poekstrakcyjnej śruty rzepakowej "00" i nasion bobiku (RSM+FB) jako alternatywnego źródła białka roślinnego w odniesieniu do poekstrakcyjnej śruty sojowej (SBM), statystycznie istotnie obniżyło strawność białka ogólnego, zwiększyło wydalanie N w kale, zmniejszyło retencję N i jego wykorzystanie. Połączenie poekstrakcyjnej śruty rzepakowej z nasionami grochu (RSM+FP) poprawiło analizowane parametry gospodarki azotowej w organizmie świń w porównaniu do grupy RSM+FB i były to także wartości zbliżone do wyników bilansu azotu uzyskanych w grupie SBM. Stosowanie alternatywnych źródeł białka w tuczu świń zmniejszyło wydalanie azotu w moczu. Oszacowano, że tucznik żywiony mieszanką grower/finiszer z udziałem poekstrakcyjnej śruty rzepakowej "00" i bobiku wydalał w kale i moczu o 7,0/3,1 % więcej N do środowiska niż tucznik z grupy z poekstrakcyjną śrutą sojową i o 3,6/2,6 % w porównaniu do tucznika otrzymującego w dawce poekstrakcyjną śrutę rzepakową łącznie z grochem.

Słowa kluczowe: źródła białka roślinnego, strawność białka, bilans azotu, wydalanie azotu do środowiska, tuczniki