THE INFLUENCE OF FABA BEAN SEEDS AND ENZYMES ON NUTRIENT DIGESTIBILITY AND NITROGEN BALANCE IN PIGS

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Summary. The influence of faba bean seeds and enzymes on nutrient digestibility and nitrogen balance in pigs fattening was studied experimentally. The experiment comprised 25 hogs (Polish Large White/Pietrain crosses) – 5 groups of 5 pigs in each. In the experimental diets soybean meal was replaced by faba bean seeds (var. Nadwiślański), in the amount of 21.5 - 22.5% or 33.0-35.0%; diets 3 and 5 were additionally supplemented with feed enzymes (β-glucanase, pentozanase, hemicellulase, pectinase and xylanase). It was estimated that partial substitution of soybean meal by faba bean seeds (21.5 – 22.5%) guaranteed high nutrient digestibility digestibility and ensured a high nutritive value of diets for pigs fattening. Addition of feed enzymes to the diets with faba bean seeds caused an increase of nutrient. Furthermore, they had a favourable effect on nitrogen retention and utilization.

The results of our study confirm the possibility of partial substitution of soybean meal by faba bean seeds. In the case of its complete substitution, diets should be supplemented with feed enzymes.

Keywords: pigs, faba bean, enzymes, digestibility, nitrogen balance.

PENIMŲ KIAULIŲ, Į KURIŲ RACIONUS BUVO ĮTRAUKTOS PUPOS IR FERMENTAI, MAISTO MEDŽIAGŲ VIRŠKINAMUMAS IR AZOTO BALANSAS

Santrauka. Bandymas atliktas su 25 penimomis kiaulėmis (lenkiškos didžiosios baltosios X pjetrenai). Racionuose sojų rupiniai buvo pakeisti pupomis (rūšis ‚Nadwiślański'), atitinkamai mišiniuose sudarė 21,5 – 22,5% ir 33,0–35,0%. Racionai 3 ir 5 buvo papildyti pašariniais fermentais (betagliukanaze, pentozanaze, hemiceliulaze, pektinaze ir ksilanaze). Nustatyta, kad iš dalies sojų rupiniai, pakeisti pupomis (21,5–22,5%), užtikrino aukštą maistinių medžiagų virškinamumą. Racionus su pupomis papildžius pašariniais fermentais, maistinių medžiagų virškinamumas pagerėjo. Sojų rupinius pakeitusios pupos, kurių dalis buvo atinkamai 21,5–22,5%, užtikrino aukštą penimų kiaulių racionų pašarinę vertę ir teigiamą poveikį azotui išlaikyti.

Tyrimų rezultatai patvirtino galimybę dalį sojų rupinių pakeisti pupomis. Sojų rupinius visiškai pakeitus pupomis, racionai turėtų būti papildyti pašariniais fermentais.

Raktažodžiai: penimos kiaulės, pupos, fermentai, virškinamumas, azoto balansas.

Introduction. Well-balanced diets for growing pigs must contain certain amounts of high-quality protein components. The search for animal protein substitutes – to replace meat-bone meals which have been withdrawn from the market due to BSE (Strzetelski, 2001; Urbańczyk, 2001), as well as the need to limit the imports of soybean meal – a standard protein component in pig nutrition, resulted in a growing interest in seeds of leguminous plants. It has been found that they can successfully play the role of a high-protein component (Czarnecki et al., 1991; Flis, 1993; Jacyno et al., 2000). This concerns first of all faba bean, whose high seed yield allows to obtain the highest amount of protein per ha. According to Wiatr (2004), the yields of new faba bean varieties are as high as 50dt/ha. However, faba bean seeds may contain considerable quantities of non-starchy polysaccharides and tannins, which disturb nutrient digestion (Gdala et al., 1995; Gdala and Buraczewska, 1997) and are the reason for restricted use of this kind of feed in animal nutrition. As reported by Bedford (1995, 2000) and other authors, the adverse effects of antinutritional compounds can be reduced by diet supplementation with exogenous enzymes.

The objective of the present study was to determine the effects of enzymes decomposing cell wall carbohydrates, i.e.:

- β-glucanase,
- pentozanase,
- hemicellulase,
- pectinase,
- xylanase,

added to diets containing faba bean seeds, on nutrient digestibility and nitrogen balance in fattening pigs.

Material and Methods. The experiment was performed on 25 young hogs (Polish Large White x Pietrain). The hogs, divided into five groups, were kept and fed individually. In the complete diets they received soybean meal was replaced with faba bean seeds (var. Nadwislański), in the amount of 21.5 - 22.5% or 33.0-35.0%; diets 3 and 5 were additionally supplemented with feed enzymes. The composition of experimental diets is given in Table 1.

The animals were fed twice a day. Each time they were given half of the daily ration, with water (at a ratio of 1:1). They had free access to water over the entire experimental period.

During fattening from 30 to 98 kg nutrient digestibility and nitrogen balance were determined by the simple balance method, at body weights of approx. 50 kg and 75 kg. The basic composition of particular diet components, diets and feces was determined by standard methods (AOAC 1990). Feces and urine were collected during a 6-day period. Urine was collected in containers,

adding sulfuric cid to maintain pH below 2. Nitrogen concentration was determined in feces and urine samples preserved with sulfuric acid. The other components, including gross energy, were determined in partly dried feces samples. At the first stage of the experiment the pigs were fed complete diets PT-1, and at the second – complete diets PT-2. The results were analyzed statistically using the computer program STATISTICA 6.

Table 1. **Composition and nutritive value of concentrates for growing and finishing pigs**

Components, %	Concentrates for growing pigs					Concentrates for finishing pigs				
	1	2	3	4	5	1	2	3	4	5
Ground barley	78.30	66.84	66.76	60.84	60.76	81.48	68.94	68.86	62.43	62.35
Soybean meal	19.00	9.00	9.00	3.50	3.50	16.00	6.00	6.00	-	-
Faba bean seeds	-	21.50	21.50	33.00	33.00	-	22.50	22.50	35.00	35.00
Feed additives[1]	2.70	2.66	2.66	2.66	2.66	2.52	2.56	2.56	2.57	2.57
Ronozyme VP[2]	-	-	0.06	-	0.06	-	-	0.06	-	0.06
Ronozyme WX[3]	-	-	0.02	-	0.02	-	-	0.02	-	0.02
Metabolizable energy, MJ/kg	12.73	12.47	12.60	12.04	12.44	12.98	12.95	12.91	12.44	12.77
Crude protein, g/kg	166.5	165.9	165.3	163.4	164.9	155.8	154.3	154.6	155.9	155.1
Crude fiber, g/kg	41.2	43.7	43.6	47.9	48.3	41.5	44.9	45.3	49.7	49.8

[1] limestone, dicalcium phosphate, NaCl, mineral-vitamin premix, synthetic AA,
[2] β-glucanase, pentozanase, hemicellulase, pectinase,
[3] β-xylanase.

Results. At the first stage of studies the level of crude protein in diets was similar in all groups (16.34% to 16.65%; Table 1) and responded to the needs of experimental animals (Pig Nutrient Requirements, 1993). Different concentrations of faba bean seeds in diets affected crude fiber level. In diet 1, containing soybean meal as the main protein component, crude fiber content was 4.12%. In diets 2 and 3, where soybean was partially replaced with faba bean seeds (21.5%), its amount increased to 4.37 – 4.38%, and diets 4 and 5 (33% faba bean seeds) contained 4.79 to 4.83% crude fiber. The crude fiber content of all experimental diets corresponded with relevant reference values.

At the second stage of studies crude protein level was similar in all groups, ranging from 15.43 to 15.59%, and satisfied the requirements of fattening pigs. Similarly as in the case of PT-1 diets, differences in crude fiber concentration depended on faba bean content. Its highest levels were recorded in diets 4 and 5, containing 35% of faba bean seeds (4.97 and 4.98% respectively). However, it should be stressed that crude fiber content of diets did not exceed the level recommended for this group of animals. Diets 2 and 3 were characterized by lower crude fiber concentration (4.49 – 4.53%), which resulted from their lower faba bean content (22.5%). The lowest amount of crude fiber was recorded in diet 1 (4.15%), which contained soybean meal instead of faba bean seeds.

At the first stage of fattening nutrient digestibility was considerably different (Table 2). These differences concerned crude protein, crude fiber and gross energy. The highest crude protein digestibility was observed in the control group (75.52%) and slightly lower – in the group fed diet 2 (73.77%); this difference was statistically non-significant. In diet 3, containing 21.0% faba bean and supplemented with feed enzymes, crude protein digestibility was similar as in the control group. The digestibility of this component was adversely affected by faba bean content of 33.0% in group 4 (67.19%); the differences were confirmed statistically. Enzyme supplementation of a diet with a high faba bean content (group 5) enabled a distinct improvement in crude protein digestibility, compared with diet 4 (71.95%).

Table 2. **Apparent digestibility coefficients, % (stage 1 of fattening)**

Item	Groups				
	I	II	III	IV	V
Crude protein	75.52^{A}	73.77^{A}	74.81^{A}	67.19^{Bb}	71.95^{a}
Crude fat	55.49	50.64	53.91	44.17	53.08
Crude fiber	38.75^{A}	23.81^{BD}	28.03^{BC}	21.18^{BDF}	25.42^{BE}
N-free extractives	91.65	90.97	90.88	90.36	91.15
Energy	81.70^{A}	80.49^{a}	80.45^{a}	77.26^{Bb}	79.76^{a}

Means within a row with different superscripts are significantly different: a, b, c, – $P<0.05$,
A, B, C – $P<0.01$

The differences in crude fat digestibility, which varied from 44.17% in group 4 to 55.49% in the control group, were statistically not significant.

The largest differences were found in crude fiber digestibility, which was the highest in the control group (38.75%). In diets 2 and 4, containing faba bean seeds, it

was significantly lower – 23.81% and 21.18% respectively. Feed enzymes added to diets 3 and 5 had a positive effect on crude fiber digestibility. All differences were confirmed statistically.

The smallest differences were observed in N-free extractive digestibility, which raged between 90.36 and 91.65%.

Faba been seeds added to diet 4 in the amount of 33% reduced gross energy digestibility (77.26%), whereas enzyme supplementation enabled its increase to 79.76%. Feed enzymes contained in diet 3 had no influence on energy digestibility in group 2 (80.49 and 80.45% respectively). An analysis of the coefficients of nutrient digestibility in diets PT-2 (Table 3) shows even greater differences between them than those observed at stage 1 of fattening. Partial replacement of soybean meal with faba bean seeds (22.5%) had a positive effect on the digestibility of crude protein, crude fat, N-free extractives and gross energy. Reduced digestibility was observed only in the case of crude fiber, but this tendency was not confirmed statistically. Enzymatic preparations added to diet 3 caused a slight increase in the digestibility of crude protein, crude fiber and energy, and a considerable improvement in crude fat digestibility. Faba bean seeds added to diet 4 in the amount of 35% caused a decrease in the digestibility of all nutrients except crude fat. Such a high faba bean content of diets was disadvantageous, but when a diet was supplemented with feed enzymes, like in group 5, nutrient digestibility improved. In this group crude protein digestibility was at a level of 77.45%, i.e. higher than in the control group fed a diet with soybean meal as the main source of protein (74.98%), and similar to its level recorded in the group receiving a diet with a lower faba bean content (77.66%). Feed enzymes had a beneficial influence on the digestibility of crude fiber and gross energy – the differences were confirmed statistically.

Table 3. **Apparent digestibility coefficients, % (stage 2 of fattening)**

Item	Groups				
	I	II	III	IV	V
Crude protein	74.98^{b}	77.66^{A}	79.25^{Aa}	71.55^{Bb}	77.45
Crude fat	59.03^{BD}	64.59^{B}	73.95^{A}	62.03^{Bb}	70.33^{Aca}
Crude fiber	39.22^{Aa}	35.77^{A}	36.20^{A}	27.94^{B}	34.51^{Ab}
N-free extractives	91.45	92.04	92.09	91.14	91.20
Energy	82.25^{a}	83.09^{A}	83.78^{A}	79.75^{Bb}	82.19^{a}

Table 4 presents the results of nitrogen balance obtained at the first stage of studies. Nitrogen intake was similar in all groups, varying from 57.52 to 58.61 g. Nitrogen retention was affected by diet composition to a low degree only. The highest level of nitrogen retention was recorded in group 5 fed a diet with a high faba bean content, supplemented with feed enzymes (26.69 g). The amount of nitrogen retained by pigs of the control group and group 3 was similar (26.08 g and 25.90 g respectively), and slightly lower in groups 2 and 4 (24.92 g and 25.17 g). Nitrogen utilization versus its intake ranged from 42.67 to 45.99%, reaching the highest level in group 5 (high faba bean content + enzymes). There were no significant differences between the groups as regards nitrogen retention versus its digestion, which varied between 55.54 and 62.52%.

Table 4. **Daily N balance (stage 1 of fattening)**

Item	Groups				
	I	II	III	IV	V
57.52	58.61	58.40	58.19		58.04
Retained N, g	26.08	24.92	25.90	25.17	26.69
Retained/intake, %	44.49	42.67	44.51	43.77	45.99
Retained/digested, %	56.49	55.54	57.16	62.52	61.41

More distinct differences were observed in nitrogen balance at the second stage of studies (Table 5). Nitrogen intake was similar and varied from 74.06 g to 74.83 g. Nitrogen retention depended on the diet used. Its similar level was noted in groups 2 and 5 (31.36 g and 31.25 g respectively). Lower nitrogen retention was recorded in the experimental pigs fed a diet with 35% of faba bean seeds (group 4 – 30.21 g), and the lowest – in those of groups 1 and 3 (28.73 g and 28.61 g respectively). The differences were confirmed statistically.

The differences in utilization of retained nitrogen more visible than at the first stage of studies. The poorest nitrogen utilization was noted in groups 1 and 3 – 38.42% and 38.55% in relation to its intake. Slightly better nitrogen utilization was observed in group 4 (40.38%), and its highest level (42.34%) – in group 2, fed a diet with 22.5% of faba bean seeds. The above differences were statistically significant. Highly statistically significant differences were found for nitrogen utilization versus its digestion. This index was the highest in group 4 – 54.18%. It was highly statistically higher than that recorded in group 3, receiving a diet with 22.5% of faba bean seeds. In group 2, fed a diet without enzymes, nitrogen utilization was better than in group 3 – 52.33%.

Discussion. The results concerning crude protein digestibility in the control group are partly consistent with reference data. Similar protein digestibility (75.4%) was observed by Chachułowa et al. (1994) in fattening pigs

fed a diet containing 18% of soybean meal. Flis et al (1996) reported higher crude protein digestibility (78.6%) for fatteners fed a diet with 16% of soybean meal.

Faba bean seeds added to diets in the amount of 21.5% resulted in slightly worse digestibility of crude protein, crude fat and gross energy, and significantly worse digestibility of crude fiber. A higher faba bean content (33.0%) caused a further decrease in nutrient digestibility. It seems that the cell wall rich in non-starchy polysaccharides made it difficult for digestive enzymes to get access to nutrients contained in the cell, mostly protein and starch. Diet supplementation with enzymes considerably improved crude protein digestibility, which was especially visible in group 5. It seems that feed enzymes affected non-starchy polysaccharides, thus facilitating digestion of this fraction of carbohydrates, but also crude protein.

Table 5. **Daily N balance (stage 2 of fattening)**

Item	Groups				
	I	II	III	IV	V
N – intake, g	74.78	74.06	74.21	74.83	74.45
Retained N, g	28.73^{bd}	31.36^{a}	28.61^{d}	30.21	31.25^{ac}
Retained/intake, %	38.42^{b}	42.34^{ac}	38.55^{d}	40.38	41.69^{ac}
Retained/digested, %	48.13^{Db}	52.33^{Aa}	46.78^{Bb}	54.18^{AC}	51.70^{a}

The possibility of reducing the adverse effect of high concentrations of non-starchy polysaccharides by diet supplementation with feed enzymes has been reported by e.g. Dierick and Decuypere (1996) Such enzymes change the structure of fiber, in this way increasing nutrient digestibility.

According to Lipiec and Pisarski (1994), worse crude protein digestibility may result from the presence of tannins in faba bean seeds. Due to their affinity to protein, these compounds may form hard to access complexes in the alimentary tract, reducing digestibility of this nutrient. Their presence may cause low digestibility of faba bean protein (approx. 70%) till the end of the small intestine in the pig. Studies on tannin concentration in faba bean seeds have been conducted, among other, by van der Poel et al. (1992) and Flis et al. (1999). These authors reported reduced digestibility of crude protein and energy, as well as worse body weight gains, in pigs fed a tannin-rich diet.

The results of nitrogen balance at the first stage of studies partly agree with those obtained by Flis and Lewicki (1992). They found that daily nitrogen retention did not differ significantly (17.54 to 20.26 g) despite the fact that experimental diets contained various amounts of faba bean seeds. Also nitrogen intake (35.3 – 40.7%) and digestion (46.9 – 53.6%) were similar in all groups. No significant differences were noted in nitrogen intake and digestion at stage 2 of fattening, either, in pigs fed diets rich in faba bean seeds (27%). The observations concerning nitrogen balance correspond with the findings by Lettner et al. (1986) and Burgstaller et al. (1990), indicating the possibility of adding faba bean seeds to diets for fattening pigs, in the amount of 22 - 33%.

According to Sokół (2001), faba bean seeds should not constitute more than 10-15% of the ration for pigs. However, this level of faba bean in complete diets for fatteners does not guarantee meeting their requirements if not accompanied by other high-protein feed components (soybean meal, animal meals).

In most experiments performed by other authors a high faba bean content, as an alternative to soybean meal or other high-protein feed components, usually results in a slight, linear decrease in body weight gains and worse feed conversion, especially at stage 1 of fattening (Aherne et al., 1977; Kracht et al., 1973, 1979; Onaghise and Bowland, 1977). Therefore, complete soybean meal replacement with faba bean seeds is not recommended in this period. The optimum solution seems to be its 50% substitution, corresponding to faba bean content of the ration at a level of 15 to 20%. At stage 2 of fattening the amount of faba bean seeds can be increased to 30%.

The research results confirm the possibility of partial substitution of soybean meal by faba bean seeds. In the case of its complete substitution, diets should be supplemented with feed enzymes.

References

1. Aherne F.X., Lewis A.J., Hardin R.T. An evaluation of faba beans as protein supplement for swine. Can. J.Anim. Sci. 1977. Vol. 57 (2). P. 321-328.

2. AOAC. Official methods of analysis of the association of official analytical chemists, 15 th edition. 32. 1990.

3. Bedford M.R. Mechanism of action and potential environmental benefits from the use of feed enzymes. Anim. Feed Sci. Techn. 1995. Vol. 53. P. 145-155.

4. Bedford M. R. Exogenous enzymes in monogastric nutrition - their current value and future benefits. Anim. Feed Sci. Techn. 2000. Vol. 86. P. 1-13.

5. Burgstaller G., K. Lang, G. Rohrmoser, M. Kuhn. Ackerbohnen im Mastfutter für Schweine unter besonderer Berücksichtingung der Methioninergänzung durch OO-Rapsextractionsschrot. Wirtschafts. Futter. 1990. N. 36 (2). S. 143-157.

6. Chachułowa J., Sokół J.L., Sawosz E., Skomiał J. Lupin seeds instead of soybean meal in the fattening pig mixtures. Ann. Warsaw Agricult. Univ. – SGGW, Anim. Sci. 1994. Vol. 30. P. 21 – 28.

7. Czarnecki R., K. Petkov, E. Jacyno, R. Lubowicki, D. Owsianny, M. Kawęcka, B. Delikator, A. Delecka. Ocena przydatności nasion bobiku w żywieniu knurków i loszek. Zesz. Nauk. PTZ. 1991. N. 1. S. 169-178.

8. Dierick N., Decuypere J. Mode of action of exogenous enzymes in growing pig nutrition. Pig News and Information. 1996. Vol. 1. P. 41-48.

9. Flis M. Wartość odżywcza nasion nowych odmian bobiku i łubinu żółtego stosowanych w żywieniu tuczników. Acta Acad. Agric. Tech. Olst. Zoot. 1993. N. 38. Suppl. A (rozprawa habilitacyjna)

10. Flis M., Cz. Lewicki. Zastosowanie bobiku łuskanego i nie łuskanego w żywieniu tuczników. Acta Acad. Agricult. 1992. N. 36. P. 113-121.

11. Flis M., Sobotka W., Meller Z. The use of dehulled or fat-supplemented yellow lupin seeds in feeding growing pigs. J. Anim. Feed Sci. 1996. Vol. 5. P. 49 - 61.

12. Flis M., Sobotka W., Purwin C., Zduńczyk Z. Nutritional value of diets containing field bean (Vicia faba L.) seeds with high or low proanthocyanidin levels for pig. J. Anim Feed Sci. 1999. Vol. 8. P. 171-180.

13. Gdala J., Buraczewska L. Chemical composition and carbohydrate content of several varieties of faba bean and pea seeds. J. Anim. Feed Sci. 1997. Vol. 6. P. 123-135.

14. Gdala J., Buraczewska L., Wasilewko J. Koncentraty białkowe i energetyczne w mieszankach treściwych i dawkach pokarmowych. Próby zwiększenia strawności białka bobiku u świń przez odłuszczenie nasion i dodatek enzymów. XXV Sesja Naukowa Komisji Żywienia Zwierząt KNZ PAN Poznań 8-9 listopad 1995. S. 123-126.

15. Jacyno E., Czarnecki R., Kawęcka M., Owsianny J., Delikator B., Kołodziej A., Fiałkowska B. Nasiona łubinu żółtego i grochu w żywieniu młodych knurów. Folia Univ. Agric. Stetin, Zoot. 2000. N. 39. S. 55-62.

16. Kracht W., Schroder H., Bennewitz D.,Wunsche J., Bock H.D. Zum Eimsatz von Ackerbolmen (Vicia faba L.), und weisen Susslupinen (Lupinus albus L.) als pflanzliche Eiweissfuttel in der Schweinemast. Arch.Tierern. 1973. 239/19. S. 801-812.

17. Kracht W., Marz W., Franke M., Busse L. Erbsen als Ersatz furFischmel und Extraktionsschrote im Schweinemastfutter. Tierernahrung u. Futterung. 1979. N. 11. S. 159-166.

18. Lettner F., Preining F., Bachlechner W. Einsatz von Ackerbohnen in der Schweinemastration. Frderungsdients. 1986. N. 34(4). S. 94-98.

19. Lipiec A., Pisarski R.K. Substancje antyżywieniowe w paszach. Med. Wet. 1994. N. 50 (4). S. 152-155.

20. Oanghise G.T.U., Bowland J.P. Influence of dietary faba beans and cassava on performance, energy and nitrogen digestibility and thyroid activity of growing pigs. Can. J. Anim.Sci. 1977. Vol. 57 (1). S. 157-167.

21. Normy żywienia świń. Wartość pokarmowa pasz. Instytut Fizjologii i Żywienia Zwierząt im. J. Kielanowskiego, Jabłonna. 1993. 120 s.

22. Poel van der A.F., Delaert l.M., van Norel A., Helsper J.P., The digestibility in piglets of faba bean (Vicia faba L.) as affected by breeding towards the absence of condensed tannins. Brit.J. Nutr. 1992. Vol. 68. (3). P. 793-800.

23. Sokół J.L. Nasiona strączkowe, Trzoda chlewna. 2001. N. 4. S. 54-56.

24. Strzetelski J. Żywienie zwierząt przeżuwających mieszankami treściwymi bez udziału mączek mięsnych i mięsno-kostnych. Mat. Konf. Pt.,, Choroba szalonych krów (BSE), Balice. 2001. S. 35-37.

25. Urbańczyk J. Zamienniki białka zwierzęcego w żywieniu świń. Mat. Konf.,, Choroba szalonych krów (BSE)", Balice. 2001. 39-50.

26. Wiatr K. Wyniki porejestrowych doświadczeń odmianowych. Rośliny strączkowe. 2003. N. 23. 25 s.