Legume seeds and rapeseed press cake as substitutes for soybean meal in sow and piglet feed

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The possibility of replacing soybean meal with mixtures of rapeseed press cake (RPC) and legume seeds in sow and piglet diets was evaluated in an experiment on 30 sows and their progeny. Group I (control) received standard feed mixture containing soybean meal as the main protein source, group II – RPC mixed with fodder pea, group III – field bean, group IV – blue lupine, group V – yellow lupine. Weaned piglets received mixtures containing RPC and legume mixtures. Considerable differences were found in amino acid composition of proteins. Differences in the apparent digestibility of essential nutrients were statistically insignificant. Sows fed with field bean and yellow lupine gave birth to heaviest piglets. After weaning piglets receiving field bean were characterized by the best weight gains. It is concluded that mixing rapeseed cake with legume seeds allows for the complete replacement of soybean meal in sow diets and for partial replacement in piglet diets.

Key words: legume seeds, rapeseed press cake, sow, piglet feeding

Introduction

Soybean meal is the most important protein source in pig feeds. Other legumes cultivated in Europe, such as pea, field bean and lupines are used on a smaller scale. About 98% of soybean meal available on the feed market is produced from genetically modified (GM) plants (Sieradzki et al. 2006). According to earlier experiments genetic modification did not influence the nutritive value of feedstuffs (Padgette et al. 1996, Aurlich et al. 2003) and had no effect on animal performance, carcass traits and meat quality (Flachowsky et al. 2005). Also our experiments on feeding pigs with genetically modified soybean and maize proved that these feeds had no effect on animal performance and there was no transfer of transgenic DNA to animal tissues (Swiatkiewicz et al. 2011). However, in some countries there is still strong public opposition against using GM plants in human and farm animal diets and it is thus possible that in some cases other protein sources will have to be used.

Grain legumes are one of the most valuable protein sources for farm animal nutrition. Their cultivation may limit the import of soybean meal into EU countries. They may also replace meat-and-bone meal banned by the European Union. Additionally, their cultivation improves soil structure. Unfortunately, the low content of sulphur amino acids methionine and cystine, and the presence of antinutritive substances limit the nutritive value of legume seed protein. Pea contains relatively small amounts of such substances, although especially its color varieties contain tannins (Canbolat et al. 2007). Field bean also contains tannins, but due to breeding their content was substantially lowered even in color flowering varieties (Jezierny et al. 2010). Lupine seeds do not contain phenolic compounds and alkaloid content in “sweet” varieties was lowered to 0.01% (Ruiz et al. 1977), as a result of which they can be used to replace soybean even in the food industry (Petterson 1998). After lowering the levels of the antinutritive substances, the problem of low methionine content still exists.

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Rapeseed is cultivated mainly as a source of oil but pressed cake remaining after pressing oil can be a good source of protein for farm animals. This protein is relatively rich in sulphur amino acids and thus it should be a good supplement to feed containing legumes. Because of the presence of antinutritive substances (mainly glucosinolates), the amount of rapeseed in pig feed should be limited to about 20% (Partanen et al. 2006), but in new varieties of rapeseed the amount of glucosinolates is substantially lowered. Lipinski et al. (1997) found no negative effect of rapeseed press cake (RPC) fed to piglets but they used it in relatively small amounts (10%).

There are not many papers on feeding pigs with legume and rapeseed mixtures, but experiments on mixtures of rapeseed cake with pea (Turyk et al. 2003) or lupine (Partanen et al. 2006) gave promising results.

The aim of this experiment was to investigate the possibility of replacing soybean meal in pig feed by new varieties of legumes mixed with rapeseed press cake. According to our hypothesis, due to the amino acid composition of protein mixtures of rapeseed meal and grain legumes should have a high nutritive value for sows and piglets, comparable to that of soybean meal.

Material and methods

All methods used in this experiment were accepted by the Second Local Ethics Commission for Experiments on Animals in Krakow, Poland.

Animals and feed

Thirty Polish Landarace sows (at the 3rd–4th reproductive cycle) originating from the same breeding farm were mated with a Duroc ´ Pietrain boar, and kept and fed individually from mating to the end of 28 days lactation. After mating sows were randomly allocated to 5 groups, 6 animals in each. Group I (control) received standard feed mixture containing soybean meal as the main protein source. Next groups received rapeseed press cake (RPC) mixed with fodder pea (*Pisum sativum var.* 'Ramrod') – group II, field bean (*Vicia faba var.* 'Kasztelan') – group III, blue lupine (*Lupinus angustifolius var.* 'Regent') – group IV or yellow lupine (*Lupinus luteus var.* 'Mister') – group V. Rapeseed cake was produced in an on-farm biofuel production plant in the Experimental Station Grodziec Slaski (South-West Poland). Composition of the diets for pregnant and lactating sows is given in Table 1.

At 100th day of pregnancy sows were moved to the farrowing house and kept also in individual pens until weaning piglets. Sows received 2.5 kg of mixture per day from mating to 100th day of pregnancy and 3.5 kg from 100th day of pregnancy to farrowing. During lactation the administered amount of feed depended on litter size: 1.80 kg per sow and 0.40 kg per piglet. Water was available *ad libitum.* Sows were weighed at mating, 100th day of pregnancy, farrowing and weaning piglets.

At about 70th day of pregnancy apparent digestibility of feed mixtures was estimated, using the indicator method with Cr_2O_3 (3.0 g kg^{-1} of feed). The adaptation period lasted 10 days and the balance period 5 days. Feces were collected daily and frozen at -20 ^{o}C. At the end of the experiment mean samples for each sow were prepared. Apparent digestibility coefficients (ADC) were calculated using the following equation:

$$ADC (\%) = 100 – [100 \times (a/b) \times (c/d)]$$

where:
a = chromium content in feed (%)
b = chromium content in feces (%)
c = nutrient content in feces (%)
d = nutrient content in feed (%)

Table 1. Composition and nutrient contents of the diets for experimental sows (g kg $^{-1}$)

	Group I Control		Group II Pea		Group III Field bean		Group IV Blue lupine		Group V Yellow lupine	
	Pregnant	Lactating	Pregnant	Lactating	Pregnant	Lactating	Pregnant	Lactating	Pregnant	Lactating
Soybean meal	50	160	-	-	-	-	-	-	-	-
Pea cv. ‘Ramrod’	-	-	80	200	-	-	-	-	-	-
Field bean cv. ‘Kasztelan’	-	-	-	-	60	140	-	-	-	-
Blue lupine cv. ‘Regent’	-	-	-	-	-	-	50	100	-	-
Yellow lupine cv. ‘Mister’	-	-	-	-	-	-	-	-	40	120
Rapeseed press cake	-	-	50	80	30	80	30	80	30	80
Wheat bran	100	50	100	80	100	80	100	50	100	80
Wheat, ground	-	200	-	200	-	200	-	200	-	200
Barley, ground	397.5	280.8	317.5	104.0	357.5	164.0	367.5	232.5	377.5	212.0
Corn meal	-	100	-	100	-	100	-	100	-	100
Triticale	330	150	330	150	330	150	330	150	330	150
Dried grass	100	30	100	30	100	30	100	30	100	30
Milk powder	-	-	-	30	-	30	-	30	-	-
Dicalcium phosphate	5	7	5	6	5	5.5	5	7	5	6
Calcium carbonate	9	12	9	11	9	11	9	10	9	12
Premix 0.5% *	5	5	5	5	5	5	5	5	5	5
Salt	3.5	4.2	3.5	4	3.5	4	3.5	4	3.5	4
L-lysine	-	1.0	-	-	-	0.5	-	1.5	-	1.0
Mixture contains (per kg):										
Metabolizable energy, MJ	11.6	12.4	11.7	12.6	11.6	12.4	11.6	12.4	11.6	12.3
Crude protein, g	138	156	130	151	139	154	136	151	130	160
Lys, g	5.28	7.98	6.02	8.08	5.61	8.28	5.31	8.32	5.40	8.07
Met + Cys, g	4.47	5.28	4.67	5.36	4.47	5.33	4.58	5.49	4.70	5.85
Thr, g	4.65	5.50	5.03	5.86	4.82	5.90	4.81	5.73	4.80	5.76
Trp, g	1.63	1.85	1.93	2.22	1.77	2.26	1.76	2.19	1.78	2.22
Ca, g	7.09	7.71	6.94	7.74	6.96	7.58	7.01	7.58	6.99	7.83
P, g	5.18	5.48	4.89	5.80	5.07	5.96	4.97	5.81	5.04	5.89

***** Vitamin-mineral premix for pregnant sows: vitamin: A - 200000 IU; D_3 – 2000 IU; E –10.0g; K_3 – 0.4g; B_2 – 0.8g; B_6 – 0.4g; B_{12} – 0.004g; pantothenic acid – 2.0g; choline cloride - 50g; folic acid – 0.2g; nicotinic acid – 4.0g; biotine – 0.03g; magnesium – 8.0 g; manganese – 5.0g; iodine 0.08g ; zinc – 15.0g; iron - 18.0g; copper – 4.0g; cobalt – 0.08g; selenium - 0.04g.

***** Vitamin-mineral premix for lactating sows: - vitamin: A- 240000 IU; D_3 –20000 IU; E –10.0g; K_3 – 0.4g; B_2 –0.8g; B_{12} – 0.004g; pantothenic acid – 2.0g; choline cloride - 50g; folic acid – 0.4g; nicotinic acid – 4.0g; biotine – 0.04g; magnesium – 8.0g; manganese – 10.0g; iodine -0.2g; zinc – 14.0g; iron - 16.0g; copper – 4.0g; cobalt – 0.1g; selenium - 0.04g.

Piglets were weaned at 28th day of age. They were kept in group pens, each litter in a separate pen. Before weaning from the 7th day of age they were fed *ad libitum* standard prestarter diets, the composition of which is given in Table 2. From weaning to the end of the experiment (84 days of age), restricted feeding of diets was used. Animals received control diet (group I) or mixtures containing RPC and legume seeds (groups II−V) (Table 2). Each group of piglets received feed with the same legume as the sow from which they originated. The amount of feed was increased every 7 days by 200 g. Half of litters (3 litters) in each group received mixtures supplemented with fibrolytic enzymes Ronozyme VP and Ronozyme WX, both in amounts of 100 mg per kg of mixture. The mixture of NSP enzymes contained endo-1,4-β-xylanase (minimum activity 1000 FXU g^{-1}), endo-1,3(4)-β-glucanase (minimum activity 50 FBG g^{-1}), pentosanase, hemicellulase and pectinase. NSP-hydrolyzing enzymes were kindly supplied by DSM Nutritional Products Ltd. in Mszczonow, Poland. Piglets were weighed at 28 (weaning), 56 and 84 days of age (end of the experiment).

Chemical analyses

Gross composition of feeds and feces was analyzed according to standard methods (AOAC 2005). Chromium content in feed and feces was determined after nitric acid × perchloric acid wet ash preparation (AOAC 2005). Glucosinolates content in rapeseed press cake was determined using HPLC method (PN-EN ISO 91-67-1).

Amino acids were analyzed using the AAA 400 INGOS automatic analyzer.

Statistics

Results were analyzed by two-way analysis of variance (ANOVA/MANOVA). Significance of differences was estimated using the Tukey multiple range test using the STATISTICA 5.1 software package.

Results

Rapeseed press cake contained 23.6 mmol of glucosinolates per kg DM and thus animals received from 0.7 (pregnant sows, weaned piglets) to 1.9 (lactating sows) mmol of glucosinolates in one kg of feed.

Nutrient content in legume seeds used in this experiment varied over a wide range (Tab. 3): for protein from 196 (pea) to 398 g (yellow lupine) per kg, and for fat from 9 (field bean) to 48 g (blue lupine) per kg. Due to these differences various amounts of seeds were used in experimental diets. Protein content of rapeseed cake used was 29.1% and that of fat 13.7%.

Considerable differences were found in amino acid content per kg of examined seeds. RPC contained much more of sulphur amino acids (Met + Cys = 15 g kg^{-1}) than other seeds (4.3–10.2 g kg^{-1}). Significant differences were observed also in the case of some other essential amino acids, i.e. arginine and leucine. On the other hand lysine content of yellow lupine was comparable with its content in RPC and slightly higher than that of other legume seeds (Tab. 3).

Differences in the apparent digestibility of nutrients (Tab. 4) were very small and in the case of essential nutrients statistically not significant.

There was no significant difference in the body weight of sows at the 100th day of pregnancy (Tab. 5). From the 100th day of pregnancy sows lost their weight but on the day of farrowing those fed yellow lupine were significantly ($p \le 0.01$) heavier than the others except the control. Taking into account the whole cycle, from mating to weaning piglets, differences in sow body mass were not significant, although those fed with both lupines gained weight while the others lost weight. There was also no significant difference in feed consumption.

Sows receiving blue lupine gave birth to fewer piglets than other sows and the number of dead piglets was high in this group (Tab. 5). The number of weaned piglets was also significantly lower ($p \le 0.05$) than in control animals and those receiving field bean. Sows fed with field bean gave birth to heaviest piglets ($p \le 0.01$). A high number of dead piglets was found also in the case of sows fed with a high level of dietary pea. In this group piglets had also low birth weight.

Table 2. Composition of diets for piglets (g kg $^{-1}$)

	7^{th} – 28^{th} day of age	28^{th} – 84^{th} day of age				
	All animals	Group I Control	Group II Pea	Group III Field bean	Group IV Blue lupine	Group V Yellow lupine
Soybean meal	250	200	150	150	150	100
Pea cv. Ramrod	-	-	100	-	-	-
Field bean cv. ‘Kasztelan’	-	-	-	60	-	-
Blue lupine cv. ‘Regent’	-	-	-	-	50	-
Yellow lupine cv. ‘Mister’	-	-	-	-	-	90
Rapeseed press cake	-	-	30	30	30	30
Wheat, ground	414	300	300	300	300	300
Barley, ground	200	367.5	288	327.7	337.5	347
Milk powder	40	50	50	50	50	50
Dried whey	50	50	50	50	50	50
Rapeseed oil	10	-	-	-	-	-
Premix*	5	5	5	5	5	5
Salt	3.5	3	3	3	3	3
Calcium carbonate	8	9	9	9	9	9
Dicalcium phosphate	12	8	8	8	8	8
L-lysine	1	2.5	2	2.3	2.5	3
DL methionine	1.5	-	-	-	-	-
Acidifier	5	5	5	5	5	5
Mixture contains (per kg):						
Metabolizable energy, MJ	13.1	12.7	12.9	12.8	12.7	12.7
Crude protein, g	196	185	185	184	185	187
Lys, g	12.0	12.0	12.0	12.0	11.9	12.1
Met + Cys, g	8.00	6.14	6.13	6.09	6.20	6.28
Thr, g	7.30	6.84	6.99	6.93	6.93	6.70
Trp, g	2.40	2.27	2.38	2.39	2.38	2.27
Ca, g	8.70	8.60	8.69	8.70	8.75	8.66
P, g	6.70	6.25	6.34	6.44	6.35	6.41

* Premix for nursing piglets: vitamin: A- 2700000 IU; D_3 – 400000 IU; E – 8.0 g; K_3 – 0.5g ; B_1 – 0.5g; B_2 –0.8 g; B_6 –0.8 g; B_{12} –0.008 g; pantothenic acid – 2.8 g; choline cloride- 70g; folic acid – 0.2 g; nicotinic acid –5.0; magnesium -10 g; manganese - 12 g; iodine – 0.1 g ; zinc – 30 g; iron -20g; copper - 32 g; cobalt – 0.06 g; selenium - 0,04 g; limestone complete to 1000 g.
* Premix for weaned piglets: A- 2400000 IU; D3 – 300000 IU; E – 14.0 g; K3 – 0.3g ; B_1 – 0.3 g; B_2 –0.8 g; B_6 –0.6 g; B_{12} –0.005 g; pantothenic acid – 2.0 g; choline cloride- 80g; folic acid – 0.2 g; nicotinic acid –4.0; magnesium -10 g; manganese - 8 g; iodine – 0.16 g ; zinc – 28 g; iron -20g; copper - 32 g; cobalt – 0.08 g; selenium - 0,04 g; complete limestone to 1000 g.

Table 3. Gross composition and amino acids content of seeds (g kg^{-1})

	Pea cv. 'Ramrod'	Field bean cv. 'Kasztelan'	Blue lupine cv. 'Regent'	Yellow lupine cv. 'Mister'	Rapeseed press cake
Dry matter	855	872	878	881	887
Crude protein	196	270	276	398	291
Ether extract	14	9	48	44	137
Crude ash	28	33	32	34	59
N-free extractives	558	488	386	240	281
Crude fibre	59	72	136	165	119
NDF	154	150	211	257	230
ADF	79	98	179	205	172
ADL	6	7	11	14	63
Arg	18.2	21.3	29.4	43.8	17.3
His	4.6	5.4	7.6	9.4	7.3
Ile	8.5	9.2	10.6	13.3	10.2
Leu	14.3	16.5	18	26.2	19.8
Fen	9	9.7	10.2	13.1	12.8
Val	8.8	9.7	10	11.9	14.3
Ala	8.9	9.5	8.6	11.7	12.4
Asp	23.2	24.5	24.7	32.3	22.5
Glu	33	38.3	56.4	78.3	45.7
Gly	8.1	10	11	13.7	15
Pro	8.5	9.1	9.1	11.8	18.8
Ser	9.2	11.2	11.9	15.7	13.6
Tyr	5.1	6.1	9.6	8.5	9.9
Trp	2	2	2.3	3.2	3.5
Thr	7.2	8	8.4	11	12.9
Cys	2.2	2	3.8	7.6	6.7
Met	2.1	2.5	2.9	2.6	8.3
Lys	14.8	15.8	13.2	18.2	18.8

Table 4. Apparent digestibility coefficients of mixture for pregnant sows (%)

	Group I Control	Group II Pea	Group III Field bean	Group IV Blue lupine	Group V Yellow lupine	SEM
Dry matter	87.6^{Bc}	87.1^{ABb}	88.5^{Cc}	85.3^{Aa}	85.9^{ABab}	0.315
Crude protein	83.5^{b}	82.1^{ab}	83.0^{ab}	80.5^{a}	81.5^{ab}	0.475
Crude fat	65.0	66.7	64.9	61.2	63.6	0.934
Crude fiber	53.0^{ab}	54.6^{ab}	58.9^{b}	52.3^{a}	52.1^{a}	0.987
N-free extract	94.7^{ABb}	94.5^{ABab}	95.5^{Bc}	93.8^{ABa}	93.7^{Aa}	0.172

Mean values in the same row with different letters differ significantly at $p \le 0.01$ (A,B) or $p \le 0.05$ (a, b, c).

At weaning (28th day of age) no statistically significant difference was found between piglets. There were also only numerical differences in mean body weight gains and feed consumption of piglets between birth and weaning.

In the further part of the experiment, i.e. between 28th and 84th days of age (Tab. 6) piglets receiving field bean or yellow lupine grew comparably to controls and better than those fed with pea or blue lupine ($p \le 0.01$).

The supplement of enzymes improved piglet growth. Piglets receiving the supplement of enzymes grew numerically better but the differences were not statistically significant. No differences in feed consumption or feed utilization were found.

Table 5. Sows reproductive rates

	Group I Control	Group II Pea	Group III Field bean	Group IV Blue lupine	Group V Yellow lupine	SEM
Number of sows, head	6	6	6	6	6	
Body weight at mating, kg	237.8	234.0	227.0	217.5	227.0	2.91
Body weight at 100th day of pregnancy, kg	268.4	271.8	270.8	267.2	281.4	3.04
Body weight after farrowing, kg	260.6^{AB}	244.0^{A}	243.4^{A}	249.3^{A}	272.3^{B}	2.63
Body weight at weaning, kg	224.6	216.2	203.8	226.7	232.4	3.75
Mean feed consumption during lactation, kg	129.9	137.3	145.8	125.7	132.3	2.75
Mean feed consumption during whole cycle, kg	426	426	439	419	425	2.90
Number of piglets born alive per litter	12.2	10.8	12.2	9.3	11.1	0.474
Number of piglets weaned per litter	11.3^{b}	9.7^{ab}	11.3^{b}	8.3^{a}	10.3^{ab}	0.331
Body weight of piglet at 1st day of age, kg	1.52^{AB}	1.44^{A}	1.78^{C}	1.62^{ABC}	1.66^{BC}	0.936
Body weight of piglet at 7th day of age, kg	2.65^{ABb}	2.29A^{a}	2.97^{Bb}	2.78^{Bb}	2.83^{Bb}	0.170
Body weight of piglet at 28th day of age, kg	6.70	6.34	7.01	6.84	7.07	0.398
Average daily weight gains 1-28 day, g	192	181	194	193	200	2.743
Average feed intake from 7th to 28th day of life, g day^{-1}	22	24	19	20	17	-
Piglet losses, %	6.8	10.8	6.8	10.7	7.5	-

Mean values in the same row with different letters differ significantly at *p*≤0.01 (A,B,C) or *p*≤0.05 (a, b, c).

Table 6. Weaned piglets rearing indices

	Experimental group					Enzyme supplement			
	Group I Control	Group II Pea	Group III Field bean	Group IV Blue lupine	Group V Yellow lupine	0	200 mg per kg of feed	SEM	Interaction
Body weight of piglets, kg									
28th day of age	6.96	6.40	7.01	6.83	7.07	6.68^{a}	7.03^{b}	0.081	**
56th day of age	11.04^{ab}	10.84^{ab}	11.97^{b}	10.71^{a}	11.31^{ab}	10.92a	11.43^{b}	0.131	-
84th day of age	23.19 ^{Aab}	22.33^{Aa}	25.65^{Bb}	22.61^{Aa}	24.00^{ABab}	23.10	24.02	0.283	**
Average daily gain in periods of life, g									
28th – 56th day	145^{Aa}	158AB^{ab}	177^{Bb}	139^{Aa}	151^{ABa}	151	157	2.967	**
56th - 84th day	433^{ABab}	411^{Aa}	488^{Bb}	425^{ABa}	453^{ABab}	435	450	7.018	**
28th – 84th day	290^{ABa}	284^{Aa}	333^{Bb}	282^{Aa}	302^{ABab}	293	303	4.257	**
Feed intake, g									
28th – 56th day	299	303	304	284	281	298	298	5.977	-
56th - 84th day	834	846	885	837	886	855	872	13.849	-
28th – 84th day	566	572	595	561	584	576	585	8.614	-
Feed conversion ratio in periods of life, kg kg^{-1}									
28th – 56th day	2.17	1.99	1.73	2.19	2.06	2.04	1.98	0.066	-
56th - 84th day	2.05	2.14	1.88	2.05	2.01	2.04	2.01	0.056	-
28th – 84th day	2.08	2.08	1.84	2.06	2.03	2.04	2.00	0.049	-

Mean values in the same row with different letters differ significantly at *p*≤0.01 (A,B) or *p*≤0.05 (a, b).

Discussion

Because RPC was used in this experiment in moderate amounts, glucosinolates should not negatively affect its results. In the experiment of Schöne et al. (2001) 15% of RPC, yielding 3.2 mmol of glucosinolates per kg of feed, had a negative effect on pigs. On the other hand in our previous experiment (Hanczakowska et al. 2012) 15% of RPC originating from the same source as in this experiment and supplying feed with 3.5 mmol of glucosinolates per kg, had no negative effect on sow and piglet performance. Since the highest dose of RPC given in this experiment did not exceed 8%, glucosinolates probably could not have any negative effects.

Pea cultivar used in this experiment had a rather low protein content – about 196 g per kg of dry matter, while in the experiment of Igbasan et al. (1997) protein content of various cultivars of pea ranged from 207 to 264 g kg. In the experiment of Partanen et al. (2001) protein content in pea was 244–279 and 320–347 g per kg in the case of field bean, thus in both these plants it was also higher than in the present experiment. Protein content in blue lupine was in this experiment (276 g kg^{-1}) higher than that found by Partanen et al. (2001), i.e. 220 g kg^{-1}. In yellow lupine we found high protein content (398 g kg^{-1}), higher than that found by Sudzinova et al. (2009), 313 g kg^{-1} or Martinez-Villaluenga et al. (2006), 370 g kg^{-1}. According to these last authors protein content in lupine as well as in other legumes depends on the cultivars and growing conditions. The composition of diets for pigs is in turn based on the protein content of their components and thus results of various experiments are different.

Amino acids content in proteins was similar to that cited by Schumacher et al. (2011). Differences in amino acid composition of protein of various legume cultivars are relatively small because plant breeders are interested mainly in their yield, content of protein and antinutritive substances but protein composition and quality is of secondary interest (Wang et al. 2003).

There is not much information on using legumes and rapeseed mixture in pig diets. Most of it concerns the feeding of growing-finishing pigs. For example, in the experiment of Turyk et al. (2003) a mixture of RPC with pea produced higher body weight gains (though the difference was not significant) than control feed based on soybean meal. On the other hand this mixture was significantly better than RPC alone. Similar results were obtained by Stanek et al. (2007). In their experiment mixture of pea with rapeseed meal significantly ($p<0.05$) increased the body weight gains of fatteners in comparison with soybean meal or pea alone. In the authors' opinion this improvement was due to the better amino acid composition of protein originating from mixed sources.

Rapeseed press cake is rarely used in sow and piglet feeding. According to early opinion of Raj (1992) RPC is not a good protein source for piglets and young pigs. In our previous experiment (Hanczakowska et al. 2012) soybean meal was replaced with RPC and during two reproduction cycles we found no negative effect on performance of pregnant and lactating sows while it improved piglet body weight. We obtained good results also in an earlier experiment using a mixture of rapeseed meal with field bean (Urbanczyk and Hanczakowska 2002).

The main purpose of mixing rapeseed and legume seeds in pig diets is to complement their amino acid composition and reduce the level of antinutritive substances supplied in individual components. In spite of differences in amino acid composition the reproductive performance of sows was similar in all groups. The highest body weight of piglets born to sows receiving field bean could be a result of relatively high lysine content in this protein. On the other hand high body weight of piglets originating from sows fed with yellow lupine, whose protein contained small amounts of this amino acid could be due to the higher digestibility of this and other amino acids (Carbonaro et al. 2000). The poor results of sows fed with blue lupine could be due to the low content of lysine in feed, or perhaps the remainders of alkaloids, although it was a “sweet” variety. On the other hand, the term “sweet” concerns alkaloid content but Stanek et al. (2012), when comparing various blue lupine cultivars found that not remnants of alkaloids but high content of NDF fiber and hemicelluloses had detrimental effect on their nutritive value. According to Kim et al. (2007) higher ileal digestibilities of protein and amino acids in lupines could be partly due to their low level of neutral detergent fibre-bound protein. In the present experiment not ileal but apparent digestibility of protein was estimated, and thus no such interdependence was found. Also Salgado et al. (2002) in the experiment on piglets using soybean, pea, faba bean and blue lupine found differences in the total tract apparent digestibility of dry matter but not of protein.

Negligible differences in digestibility of essential nutrients (protein, fat and fiber) found in this experiment may indicate that no strong antinutritive substances are present in the plants used (Liener 1976).

Piglet average body weight gains from weaning to the end of the experiment, arranged in descending order, were field bean>yellow lupine>other groups. Relatively low body weight gains of piglets receiving pea could be due to its high amount in diets (Stein et al. 2004), which was in turn due to its low protein content. An adverse effect of pea in piglet feed was found also by Valencia et al. (2008). In contrast to these results, Zeman and Šiške (1983) found that sows receiving pea gave birth to more piglets than those receiving field bean.

The supplement of NSP-hydrolyzing enzymes numerically increased piglet body weight. Probably they could help decompose fiber-protein complex during the time when piglet digestive tract is not fully developed (Gdala 1998).

In conclusion, these results show that mixing rapeseed cake with legume seeds allows for the complete replacement of soybean meal in sow diets and for partial replacement in piglet diets. Mixture of rapeseed and field bean gave best results in piglet feeding.

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