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THE EFFECT OF FEEDING NATIVE FABA BEAN SEEDS (*VICIA FABA* L.) TO SOWS AND SUPPLEMENTED WITH ENZYMES TO PIGLETS AND GROWING PIGS

Małgorzata Świątkiewicz[1♦], Jerzy Księżak[2], Ewa Hanczakowska[1]

[1]Department of Nutrition Physiology, National Research Institute of Animal Production, 32-083 Balice n. Kraków, Poland
[2]Department of Forage Crop Production, Institute of Soil Science and Plant Cultivation – State Research Institute, 24-100 Puławy, Poland
♦Corresponding author: malgorzata.swiatkiewicz@izoo.krakow.pl

Abstract

The aim of this experiment was to examine the possibility of replacing part of soybean meal in the diets of sows, their piglets and fatteners with two varieties of high- or low-tannin faba bean seed. Twenty-four sows were allocated to 3 groups, 8 animals in each. Control group (C) received standard feed mixture containing soybean meal as the main protein source. Next groups received standard feed mixture in which part of soybean meal was replaced by high-tannin variety Bobas (group HT) or low-tannin variety Kasztelan (group LT). Faba bean was added to diets at the level of 12 and 14% for pregnant and lactating sows, 6% for piglets, and 12 and 16% for fatteners (grower and finisher, respectively). Diets for half piglets and fatteners were supplemented with the enzyme Ronozyme VP. Apparent digestibility of nutrients was evaluated in a parallel experiment, using the same feeds on 18 barrows weighing about 40 kg (grower) and 80 kg (finisher). There was almost no difference in sow reproductive rates, litter weight and body weight of piglets on the first day of life were similar. Until 35 days of age piglets receiving faba bean grew faster than control ones. Control piglets grew fastest from 35 to 84 days of age, but differences were not significant. Enzyme supplement had a positive effect on body weight only from 56 to 84 days of piglet life. Digestibility of nutrients was lower in pigs fed with faba beans, especially in the grower period. Faba bean HT had lower nutrient digestibility in both periods of fattening. Almost all carcass traits were better in control pigs than in those fed with bean variety Bobas. Meat of these pigs had also the lowest content of unsaturated fatty acids and highest atherogenic indices. In sensory evaluation this meat had also the worst smell and taste. It can be stated that faba bean seeds, in moderate amounts, can partially replace soybean meal in feed for pigs, but some lowering of body weight gain and meat quality is possible especially when high-tannin varieties are used.

Key words: pig feeding, feed enzymes, faba bean, pig performance, digestibility, meat quality

Soybean meal is the most important protein source in pig feeds. Other legumes, cultivated in Europe such as the pea, faba bean and lupins are used on a smaller scale.

About 98% of soybean meal present on the feed market is produced from genetically modified (GMO) plants (Sieradzki et al., 2006). According to earlier experiments, genetic modification did not influence the nutritive value of feedstuffs (Aurlich et al., 2003) and had no effect on the animal performance, carcass traits and meat quality (Flachowsky et al., 2005). Likewise, our own experiments on feeding pigs with genetically modified soybean and maize proved that these feeds had no effect on animal performance and that there was no transfer of transgenic DNA to animal tissues (Świątkiewicz et al., 2011). However, there still remains strong public opposition in some countries against using GMO plants in human and farm animal feeding, thus it is possible that in some cases other protein sources will have to be used. In the countries of Europe it could be legumes such as the faba bean, pea or lupins. Faba bean protein has similar amino acid content to that of soybean protein except for a lower level of methionine and tryptophan (Smith et al., 2013) but its digestibility may be lowered by the condensed tannins content (Jezierny et al., 2010), especially in colour-flowering varieties. On the other hand, advancements in plant breeding have resulted in the creation so called zero-tannin faba beans i.e. cultivars containing less than 1% of tannins (Smith et al., 2013). Apart from protein, faba bean may also be a good source of energy (Crépon et al., 2010), although it contains less starch than the pea (Gunawardena et al., 2009).

Buron and Gatel (1992), replacing cereal and soybean meal in standard commercial feed for gestating and lactating sows with faba bean in the amount 15%, found no effect on the number of piglets born and number of litters weaned. In piglet feeding the results are not fully consistent. According to Van der Poel et al. (1992), the protein of a low-tannin line of faba bean was better digested by piglets than that of a high-tannin line, but in the experiment of Pekete et al. (1985) white-flowering tannin-free varieties did not prove to be better than classical colour-flowering ones. Early experiments on the feeding of growing pigs with faba bean did not give satisfactory results (Castell, 1976). More recent research has suggested that a moderate inclusion of faba bean to a barley-soybean diet did not lower pig performance (Gatta et al., 2013). Additionally, the nutritive value of pulses for pigs may be improved by enzyme supplement (Hanczakowska and Świątkiewicz, 2014).

As soybean meal is the main protein source in the different stages of the pig production cycle, i.e. in sow, piglet and growing pigs' nutrition, it seemed interesting to check the faba bean as a possible partial replacer of soybean in the whole production cycle.

The aim of this experiment was to examine the possibility of replacing a part of soybean meal fed to sows, their piglets and fatteners with two varieties of high- or low-tannin faba bean seed. Because faba bean contains indigestible cell walls, an enzyme supplement – Ronozyme VP – was used in the piglet and fattener feed and the enzyme effect was also examined.

Material and methods

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

Animals and diets

Twenty-four Polish Landrace sows were mated with a Polish Landrace boar and kept and fed individually from mating to the end of lactation. After mating, the sows were allocated to 3 groups, 8 animals in each. Group I (control – C) received a standard feed mixture containing soybean meal as the main protein source. The remaining groups received a standard feed mixture in which a part of the soybean meal was replaced by the high-tannin faba bean seeds variety Bobas (group HT) or the low-tannin faba bean seeds variety Kasztelan (group LT). Diets were balanced according to Grela and Skomiał (2015). Thus protein soybean meal was replaced by protein faba bean in 28% (lactating sows) or 66% (pregnant sows). In the case of piglets it was 5%. In diets for fatteners faba bean replaced 24% of protein soybean (grower) or 47% (finisher). The composition of the diets for pregnant and lactating sows is given in Table 1. At 100 d of pregnancy the sows were moved to a farrowing house and kept in individual pens until the weaning of the piglets. The sows received 2.5 kg of mixture per day from mating to 100 d of pregnancy and 3.5 kg from 101 d of pregnancy to farrowing.

During lactation, the administered amount of feed depended on litter size. Water was available *ad libitum.* The sows were weighed at mating, farrowing and the weaning of piglets. Before weaning, they were fed a standard prestarter diet, the composition of which is given in Table 2.

The piglets were weaned at 35 d of age and each litter was reared in a separate pen. They were weighed at 35 (weaning), 56 and 84 d of age. After weaning, they received a diet containing faba bean varieties corresponding to the feed for the sows. In each group half the animals (4 litters, selected randomly) received the enzyme Ronozyme VP (DSM Nutritional Products) at 200 $mg\cdot kg^{-1}$ of feed. Ronozyme VP, i.e. carbohydrase complex, is produced by a submerged fermentation of an *Aspergillus aculeatus* strain. It contains endo-1,3(4)-beta-glucanase (min. 50 FBG/g product) and various hemicellulase and pectic-substance hydrolysing activities. It is authorised for use in the EU in piglets and chickens for fattening. The composition of the experimental diet for the piglets is given also in Table 2.

The piglets were raised to 84 d of age and then 20 animals (10 gilts and 10 barrows) from each group were randomly chosen for further fattening, with four animals being kept per pen. They were fed with standard feed mixtures (Table 3) – grower (to 60 kg BW) and finisher (from 60 kg BW to the end of the experiment). In each group half of the animals (5 gilts and 5 barrows) received the enzyme Ronozyme VP (200 $mg\cdot kg^{-1}$of feed). The fatteners were slaughtered at average body mass 110±2 kg. The quality of the carcasses was evaluated according to Tyra and Żak (2012). Twenty-four h after slaughter, the pH of meat was measured and samples of the *longissimus* muscle, obtained from the area of the last thoracic and the first lumbar vertebra, were taken for analysis.

Apparent digestibility was evaluated in the balance experiment in parallel to the fattening, using the same feeds on the 36 barrows weighing around 40 kg (grower) and 80 kg (finisher) not used in the fattening part of the experiment. The scheme of the digestibility trial was the same as that of the fattening experiment. Each subgroup consisted of 6 fatteners. The animals were kept individually in balance cages and fed with the same feeds as in the fattening experiment: 2.0 kg of feed mixture in the grower and 3.0 kg in the finisher period daily. The preliminary period lasted 10 days and the samples collection lasted 5 days. Faeces from each animal were collected daily, weighed and frozen at –20°C. At the end of the collection period, the faeces samples from each animal were mixed and a representative sample was prepared. Protein content in faeces was analysed after subsequent thawing and other components after drying of samples. Digestibility coefficient (DC) was calculated according to the formula:

$$DC = \frac{\text{Amount of ingredient consumed} - \text{amount of ingredient excreted in faeces}}{\text{Amount of ingredient consumed}} \times 100$$

Table 1. Composition and nutrient contents of the diets for sows

Item	Pregnant sows			Lactating sows		
	Group I C	Group II HT	Group III LT	Group I C	Group II HT	Group III LT
Feed mixture composition (g kg^{-1}):						
soybean meal	60	20	20	180	130	130
beans cv. Bobas	–	120	–	–	140	–
beans cv. Kasztelan	–	–	120	–	–	140
wheat bran	100	100	100	50	50	80
wheat, ground	300	300	300	300	300	300
barley, ground	369	289	289	332.5	302	213
beet pulp	150	150	150	100	100	100
rapeseed oil	–	–	–	10	10	10
dicalcium phosphate	5	5	5	7	7	7
calcium carbonate	7	7	7	10	10	10
premix 0.5% [1, 2]	5	5	5	5	5	5
salt	3.5	3.5	3.5	4.5	4.5	4.5
L-lysine	0.5	0.5	0.5	1	1.5	0.5
Mixture contains (per kg, calculated):						
metabolizable energy (MJ[3])	12.5	12.5	12.5	12.8	12.9	12.8
crude protein (g)	134	136	135	176	176	175
Lys (g)	6.00	6.12	6.10	9.24	9.42	9.39
Met + Cys (g)	4.60	4.43	4.33	5.48	5.25	5.13
Trp (g)	1.66	1.55	1.53	2.26	2.10	2.09
Thr (g)	4.49	4.50	4.47	6.04	6.00	5.97

C – control; LT – low tannin faba bean seeds variety Kasztelan; HT – high tannin faba bean seeds variety Bobas.

[1]Vitamin-mineral content in kg of premixes for pregnant sows: A – 200 000 IU; D_3 – 2000 IU; E – 10.0 g; K_3 – 0.4 g; B_2 – 0.8 g; B_6 – 0.4 g; B_{12} – 0.004 g; pantothenic acid – 2.0 g; choline chloride – 50 g; folic acid – 0.2 g; nicotinic acid – 4.0 g; biotine – 0.03 g; magnesium – 8.0 g; manganese – 5.0 g; iodine 0.08 g; zinc – 15.0 g; iron – 18.0 g; copper – 4.0 g; cobalt – 0.08 g; selenium – 0.04 g.

[2]Vitamin-mineral content in kg of premixes for lactating sows: A – 240 000 IU; D_3 – 20000 IU; E –10.0 g; K_3 – 0.4 g; B_2 – 0.8 g; B_{12} – 0.004 g; pantothenic acid – 2.0 g; choline chloride – 50 g; folic acid – 0.4 g; nicotinic acid – 4.0 g; biotine – 0.04 g; magnesium – 8.0 g; manganese – 10.0 g; iodine – 0.2 g; zinc – 14.0 g; iron – 16.0 g; copper – 4.0 g; cobalt – 0.1 g; selenium – 0.04 g.

[3]ME calculated using equation of Hoffman and Schiemann (1980).

Table 2. Composition and nutrient contents of the diets for piglets

Item	All animals	Group I C	Group II HT	Group III LT
	7–35 days of age	35–84 days of age		
Feed mixture composition (g · kg^{-1}):				
soybean meal	250	200	190	190
beans cv. Bobas	–	–	60	–
beans cv. Kasztelan	–	–	–	60
wheat, ground	414	300	300	300
barley, ground	200	365.5	314.5	314.5
milk powder	40	50	50	50
dried whey	50	50	50	50
rapeseed oil	10	–	–	–
premix[1, 2]	5	5	5	5
salt	3.5	3	2.5	2.5
calcium carbonate	8	10	11	11
dicalcium phosphate	12	9	10	10
L-lysine	1	2.5	2	2
DL methionine	1.5	–	–	–
acidifier	5	5	5	5
Mixture contains (per kg, calculated):				
metabolizable energy (MJ[3])	13.1	13.0	13.0	13.0
crude protein (g)	198	193	193	193
Lys (g)	12.00	11.04	11.13	11.12
Met + Cys (g)	8.00	6.04	5.95	5.90
Trp (g)	2.40	2.52	2.45	2.45
Thr (g)	7.30	6.89	6.89	6.88

C – control; LT – low-tannin faba bean seeds variety Kasztelan; HT – high-tannin faba bean seeds variety Bobas.

[1]Vitamin-mineral content in kg of premixes for nursing piglets: A – 2 700 000 IU; D_3 – 400 000 IU; E – 8.0 g; K_3 – 0.5 g; B_1 – 0.5 g; B_2 – 0.8 g; B_6 – 0.8 g; B_{12} – 0.008 g; pantothenic acid – 2.8 g; choline chloride – 70 g; folic acid – 0.2 g; nicotinic acid – 5.0 g; magnesium – 10 g; manganese – 12 g; iodine – 0.1 g; zinc – 30 g; iron – 20 g; copper – 32 g; cobalt – 0.06 g; selenium – 0.04 g; limestone complete to 1000 g.

[2]Vitamin-mineral content in kg of premixes for weaned piglets: A – 2 400 000 IU; D_3 – 300 000 IU; E – 14.0 g; K_3 – 0.3 g ; 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 chloride – 80 g; folic acid – 0.2 g; nicotinic acid – 4.0 g; magnesium – 10 g; manganese – 8 g; iodine – 0.16 g; zinc – 28 g; iron – 20 g; copper – 32 g; cobalt – 0.08 g; selenium – 0.04 g; complete limestone to 1000 g.

[3]ME calculated using equation of Hoffman and Schiemann (1980).

Chemical and physical analyses

The chemical composition of the feeds, faeces samples and nitrogen content were analysed according to AOAC (2005) methods. Tannins content was estimated using the vanillin-sulphuric acid method according to Kuhla and Ebmeier (1981).

Amino acids were determined using HPLC method after acid hydrolysis of samples in 6N hydrochloric acid at 110°C during 22 hours in the colour reaction with the ninhydrin reagent using AAA 400 INGOS automatic analyser. Sulfur amino acids were estimated after initial peroxidation with performic acid to cysteic acid and methionine sulfone. Tryptophan content was estimated after alkaline hydrolysis of samples in BaOH solution and precipitation of bar ions using sulfuric acid (Gąsior et al., 2005).

Table 3. Composition and nutrient contents of the diets for fatteners

Item	Grower			Finisher		
	Group I C	Group II HT	Group III LT	Group I C	Group II HT	Group III LT
Feed mixture composition (g · kg^{-1}):						
soybean meal	210	160	160	150	80	80
beans cv. Bobas	–	120	–	–	160	–
beans cv. Kasztelan	–	–	120	–	–	160
wheat bran	50	50	50	60	60	60
wheat, ground	300	300	300	250	250	250
barley, ground	399.7	330.2	330.2	502	418.5	418.5
rapeseed oil	15	15	15	15	10	10
dicalcium phosphate	6	8	8	3	4	4
calcium carbonate	10	8	8	11	9	9
premix 0.5% [1, 2]	5	5	5	5	5	5
salt	2.8	2.8	2.8	2.5	2.5	2.5
L-lysine	1.5	1.0	1.0	1.5	1.0	1.0
Mixture contains (per kg, calculated):						
metabolizable energy (MJ[3])	13.1	13.1	13.1	13.0	12.9	12.9
crude protein (g)	186	184	183	164	162	161
digestible protein (g[4])	160	150	151	139	130	136
Lys (g)	9.96	9.89	9.87	8.23	8.09	8.06
Met + Cys (g)	5.80	5.55	5.46	5.23	5.03	4.92
Thr (g)	2.43	2.26	2.25	2.14	1.90	1.90
Trp (g)	6.34	6.20	6.18	5.54	5.33	5.30

C – control; LT – low-tannin faba bean seeds variety Kasztelan; HT – high-tannin faba bean seeds variety Bobas.

[1]Vitamin-mineral content in kg of grower premixes: vitamin – A_1 500 000 IU; vitamin D_3 – 300 000 IU; vitamin E – 10.5 g; vitamin K_3 – 0.22 g; vitamin B_1 – 0.22 g; vitamin B_2 – 0.6 g; vitamin B_6 – 0.45 g; vitamin B_{12} – 0.004 g; pantothenic acid –1.5 g; choline chloride – 40 g; biotin – 0.015 g; folic acid – 0.3 g; nicotinic acid – 3.0 g; manganese – 6 g; iodine – 0.12 g; zinc – 15 g; iron – 15 g; copper – 4 g; cobalt – 0.06 g; selenium – 0.03 g.

[2]Vitamin-mineral content in kg of finisher premixes: vitamin A – 1 000 000 IU; vitamin D_3 – 200 000 IU; vitamin E – 7.0 g; vitamin K_3 – 0.15 g; vitamin B_1 – 0.15 g; vitamin B_2 – 0.4 g; vitamin B_6 – 0.3 g; vitamin B_{12} – 0.002 g; pantothenic acid – 1.0 g; choline chloride – 20 g; biotin – 0.01 g; folic acid – 0.2 g; nicotinic acid – 2.0 g; manganese – 4 g; iodine –0.08 g; zinc – 8 g; iron –10 g; copper – 4 g; cobalt – 0.04 g; selenium – 0.02 g.

[3]ME calculated using equation of Hoffman and Schiemann (1980).

[4]Digestible protein calculated on the basis of this experiment.

On the basis of amino acid composition of proteins their nutritive value was estimated. Chemical score (CS) was calculated according to Hidvegi and Bekes (1984) using hen egg protein as a standard. Essential amino acids index (EAAI) was also calculated according to Oser (1951).

The fatty acid profile was determined after two weeks of freezing at –20°C, immediately after thawing, using a CP-Wax 58 capillary column (Varian BV, Middelburg, The Netherlands) (25 m, 0.53 mm, df – 1 μ, carrier gas – helium, 6 ml/min), with a column oven temperature programme from 90 to 200°C, using a Varian 3400 gas chromatograph (Varian Associates Inc., Walnut Creek, USA) equipped with a Varian 8200 CX Autosampler (200°C), FID detector (260°C), and Star Chromatography Workstation software. All the analyses were performed in duplicate and mean values are given.

Meat acidity was measured 24 h after slaughter with a pH meter equipped with a Metron OSH 12-00 electrode. Using the CIE (L*a* b*) system, the colour of the fresh meat was estimated with a Minolta colorimeter. On this basis, chroma C* was calculated according to MacDougall (2002):

$$C^* = (a^{*2} + b^{*2})^{1/2}$$

The water-holding capacity of the meat was measured according to Grau and Hamm (1953).

Oxidative stability evaluation

Lipid quality indices i.e. atherogenic index (*AI*) and thrombogenicity index (*TI*) were calculated (Σg/100 g) according to Ulbricht and Southgate (1991):

$$AI = [(4 \times C14{:}0) + C16{:}0] / [n\text{-}6\ PUFA + n\text{-}3\ PUFA + MUFA]$$

$$TI = [C12{:}0 + C14{:}0 + C16{:}0 + C18{:}0] / [(0.5 \times MUFA) + (0.5 \times n\text{-}6\ PUFA) + (3 \times n\text{-}3\ PUFA) + n\text{-}3 / n\text{-}6\ PUFA]$$

The hypocholesterolemic/hypercholesterolemic (*h/H*) ratio was calculated according to Fernández et al. (2007):

$$h/H = (C18{:}1 + C18{:}2 + C18{:}3 + C20{:}4 + C20{:}5 + C22{:}6) / (C14{:}0 + C16{:}0)$$

The peroxidisability index (*PI)* was calculated (Σg/100 g) according to Arakawa and Sagai (1986):

$$PI = (\%\ monoenoic \times 0.025) + (\%\ dienoic \times 1) + (\%\ trienoic \times 2) + (\%\ tetraenoic \times 4) + (\%\ pentaenoic \times 6) + (\%\ hexaenoic \times 8)$$

The iodine value (*IV*) of fat was calculated using the following equation (AOCS, 1998):

$$IV\ (g/100g) = (C16{:}1) \times 0.95 + (C18{:}1) \times 0.86 + (C18{:}2) \times 1.732 + (C18{:}3) \times 2.616 + (C20{:}1) \times 0.785 + (C22{:}1) \times 0.723$$

Sensory analysis

The sensory evaluation of meat after two weeks of freezing at –20°C was made using a 5-point scale (1 = poorest, 5 = best). Samples were thawed at +4°C, cut in about 30 mm thick slices and boiled in 0.6% NaCl solution to an internal temperature +80°C. After cooking, the meat was left for 2 min in order to level the temperature between its layers (Baryłko-Pikielna, 1975). Then, the slices were cut into smaller pieces and presented to the panel. The evaluation board consisted of 6 trained persons. Odour, taste, tenderness and juiciness of the meat were evaluated.

Statistical analysis

Statistical analysis of treatment effect was performed by one-way (sow reproductive rates), two-way (weaned piglets rearing indices and apparent digestibility coefficient) or three-way (fattening results) analysis of variance. Comparison of means was performed using Tukey's multiple range test at P≤0.05 and P≤0.01 levels of significance. All the analyses were conducted using the Statistica 10 package (StatSoft, 2011).

Results

Chemical composition and essential amino acid concentration of seeds

There was no apparent difference in nutrients content between the two varieties of faba bean. Both contained less crude protein, fat and ash but more fibre than soybean meal (Table 4). Cv. Bobas contained almost ten times more tannins than cv. Kasztelan. The protein of both varieties contained slightly less sulphur amino acids (Met + Cys) than the soybean protein (2.48, 2.22 and 1.91%, respectively). They also contained less lysine and especially tryptophan. It resulted in lower EAAI of protein of both varieties of faba bean, especially that of cv. Kasztelan.

Table 4. Chemical composition, tannins content (g kg^{-1}) and amino acids content of proteins (g 100 g^{-1} of protein)

Item	Soybean meal	Faba beans cv. Bobas (HT)	Faba beans cv. Kasztelan (LT)
Dry matter	896.9	851.7	857.4
Crude protein	471.6	241.1	235.5
Ether extract	15.0	10.9	9.4
Crude ash	61.7	31.4	35.4
Crude fibre	37.8	73.8	87.6
Tannins	–	5.86	0.68
Arg	8.86	9.46	9.04
His	2.91	2.41	2.29
Ile	4.60	3.94	3.91
Leu	7.76	7.47	7.01
Lys	7.08	6.64	6.71
Met	1.29	0.87	1.06
Phe	5.87	4.19	4.12
Thr	3.69	3.40	3.40
Trp	1.38	0.87	0.85
Val	4.64	4.31	4.12
Ala	4.39	4.15	4.03
Asp	11.98	10.74	10.40
Cys	1.19	1.33	0.85
Glu	17.88	16.51	16.26
Gly	4.20	4.73	4.25
Pro	4.92	3.94	3.86
Ser	4.77	4.69	4.76
Tyr	3.65	2.78	2.59
CS[1] met +cyst	34.0	30.1	26.2
EAAI[2]	66.4	56.0	53.4

[1] CS – Chemical Score.
[2] EAAI – Essential Amino Acid Index.

Sow reproductive rates and piglet rearing indices

Feeding treatment

There was almost no difference in sow reproductive rates, regardless of the variety that was used. The litter weight and body weight of the piglets at 1 d of age were similar (Table 5). Until 35 d of age, the piglets receiving faba beans grew faster than the control ones in the case of cv. Bobas (P≤0.05). In the later phase of rearing (35–56 d of age) the piglets fed with faba beans grew better than the control ones (Table 6). In the second period of rearing (56–84 d) control piglets grew significantly faster. During the whole rearing this difference decreased, and at 84 d of age it was not statistically significant. There was no significant difference in feed intake or feed conversion.

Table 5. Sows reproductive rates

Item	Group I C	Group II HT	Group III LT	SEM[1]
Number of sows (head)	8	8	8	–
Body weight at mating (kg)	163.6	160.9	163.0	1.63
Body weight after farrowing (kg)	172.6	178.2	180.7	1.54
Body weight at weaning (kg)	142.4	154.3	154.2	2.15
Mean feed consumption during whole cycle (kg)	525.7	511.4	507.6	4.89
Number of piglets weaned per litter	10.00	9.9	9.5	0.47
Litter weight (kg)	13.90	13.96	13.68	0.74
Body weight of piglets at 1 d of age (kg)	1.39	1.41	1.44	0.02
Body weight of piglets at 35 d of age (kg)	7.28 A	8.08 B	7.81 AB	0.11
Average daily weight gain 1–35 d (g)	173 a	196 b	188 ab	3.20
Piglet losses (head)	5	4	4	–

C – control; LT – low-tannin faba bean seeds variety Kasztelan; HT – high-tannin faba bean seeds variety Bobas.

a, b – mean values in the same row with different letters differ significantly at P≤0.05; A, B – mean values in the same row with different letters differ significantly at P≤0.01.

[1]Standard error of the mean.

Enzyme supplementation

Supplementation of enzymes resulted in lowering of body weight gains in the first period of rearing. In the second period (56–84 d) this supplement increased body weight gains by about 12% (P≤0.05). For the whole rearing period this difference amounted to about 4%. Significant interaction was found between the treatment (the type of feed mixture used) and supplementation of enzymes in the both rearing periods (P≤0.01).

Digestibility experiment

Feeding treatment

In the first period of fattening (grower), total apparent digestibility coefficients of dry matter, protein, fibre and N-free extractives of feed mixtures containing faba bean was significantly (P≤0.01) lower than that in control group (Table 7). Digestibility of fat was lower in pigs receiving faba bean Bobas than in control and fed with faba bean Kasztelan (P≤0.01). In the second period (finisher) total apparent digestibility coefficients of dry matter, protein, fat and N-free extractives was lower in pigs fed with bean cv. Bobas when compared to control and cv. Kasztelan (P≤0.01). Digestibility coefficients of fibre was higher in both groups receiving beans (P≤0.01).

Table 6. Weaned piglets rearing indices

Item	Feeding treatment (T)			Enzyme supplement (E)		I[1]	SEM[2]
	Group I C	Group II HT	Group III LT	200 mg per kg of feed	0		
Number of piglets	75	75	72	108	114	–	–
Body weight of piglets (kg)							
35 d of age	7.28 a	8.04 b	7.97 b	7.63	7.90	TxE*	0.11
56 d of age	11.25 Aa	12.72Bb	12.29 ABb	11.78 a	12.39 b	NS	2.25
84 d of age	22.13	21.68	21.80	22.04	21.70	TxE**	2.86
Average daily gain in periods of life (g)							
35–56 d	189 A	223 B	206 AB	198	214	TxE**	4.67
56–84 d	388 Bb	320 Aa	340 Aba	366 b	332 a	TxE**	7.57
35–84 d	303	278	282	294	282	TxE*	4.72
Feed intake (g)							
35–56 d	474	506	503	465 a	524 b	NS	15.79
56–84 d	986	891	906	953	901	NS	37.24
35–84 d	767	726	733	744	739	NS	20.96
Feed conversion ratio in periods of life (kg kg^{-1})							
35–56 d	2.51	2.27	2.45	2.35	2.45	NS	0.07
56–84 d	2.54	2.78	2.67	2.60	2.71	NS	0.09
35–84 d	2.53	2.61	2.60	2.53	2.62	NS	0.06

C – control; LT – low-tannin faba bean seeds variety Kasztelan; HT – high-tannin faba bean seeds variety Bobas.

a, b – mean values in the same row with different letters differ significantly at P≤0.05; A, B – mean values in the same row with different letters differ significantly at P≤0.01.

[1] Interaction.

[2] Standard error of the mean.

NS – not significant P>0.05.

Enzyme supplementation

In the first period of the experiment (grower), the enzyme supplement improved the digestibility of dry matter and fibre (P≤0.01), and that of protein although to a lesser degree (P≤0.05) but lowered fat digestibility (P≤0.01). The digestibility of fat depended on type of the mixture and enzyme supplement (P≤0.05). In the second period (finisher), enzyme supplement improved both fat and fibre digestibility (P≤0.01). Significant interactions between factors were found in the case of protein (P≤0.05), fat and fibre (P≤0.01).

Table 7. Apparent digestibility coefficients of grower and finisher feed mixtures (%)

Item	Feeding treatment (T)			Enzyme supplement (E)		I[1]	SEM[2]
	Group I C	Group II HT	Group III LT	200 mg per kg of feed	0		
Number of pigs	12	12	12	18	18	–	–
Grower mixtures							
dry matter	85.3 B	79.7 A	80.4 A	82.4 B	81.2 A	NS	0.49
crude protein	86.0 B	81.3 A	82.6 A	84.0 b	82.5 a	NS	0.49
ether extract	56.8 B	37.3 A	50.5 B	42.9 A	53.6 B	TxE*	2.19
crude fibre	29.7 B	17.5A	18.1 A	24.5 B	19.1 A	NS	1.43
N-free extractives	90.2 B	87.3 A	87.8 A	87.1 A	89.8B	NS	0.32
Finisher mixtures							
dry matter	84.3 B	81.0 A	82.4 AB	82.1	83.0	NS	0.41
crude protein	84.6 B	79.9 A	84.2 B	83.3	82.5	TxE*	0.53
ether extract	63.5 B	50.0 A	66.8 B	64.8 B	55.4 A	TxE**	2.08
crude fibre	23.3 A	31.2B	31.3 B	31.7 B	25.5 A	TxE**	1.19
N-free extractives	87.9 B	85.9 A	86.4 AB	86.5	87.0	NS	0.30

C – control; LT – low-tannin faba bean seeds variety Kasztelan; HT – high-tannin faba bean seeds variety Bobas.

a, b – mean values in the same row with different letters differ significantly at P≤0.05; A, B – mean values in the same row with different letters differ significantly at P≤0.01.

[1]Interaction.

[2]Standard error of the mean.

NS – not significant P>0.05.

Fattening results and carcass quality indices

Feeding treatment

There was no significant difference in BWG in the first and second period of fattening, though pigs fed with the faba beans grew slightly worse than the control ones (Table 8). But when the whole experiment was calculated, it turned out that the animals fed soybean meal grew significantly faster than those fed both varieties of bean [737, 670 and 658 g, respectively (P≤0.01)]. There was also no significant difference in feed conversion. Significant interaction was found in feed conversion between treatment (mixture type) and enzyme supplementation. Almost all carcass traits, except backfat thickness of 5 measurements, were higher (P≤0.01) in the control pigs than in those fed with faba bean seeds cv. Bobas. Meat of ham, primal cuts and carcass meatiness were better in pigs receiving the Kasztelan variety than in those fed with Bobas (P≤0.05). Gilts had better slaughter value than barrows. Meatiness of their carcasses was significantly higher (P≤0.01).

Table 8. Fattening results and slaughter value of pigs

Item	Feeding treatment (T)			Enzyme supplement (E)		Sex (S)		I[1]	SEM[2]
	Group I C	Group II HT	Group III LT	200 mg per kg of feed	0	gilts	barrows		
				Number of pigs					
	20	20	20	30	30	30	30	–	–
Initial body mass (kg)	22.1	22.5	21.0	22.3	21.4	21.7	22.1	TxE**	0.49
Final body mass (kg)	110.5	109.9	109.4	110.5	109.3	110.9	108.7	TxS* SxE**	0.87
Average daily weight gain (g)									
22–60 kg	695	661	642	644	687	652	680	NS	12.58
60–110 kg	790	692	716	748	708	730	735	NS	19.45
22–110 kg	737 B	670 A	658 A	690	686	684	693	NS	9.31
Feed conversion ratio (kg)									
23–60 kg	3.03	3.14	3.19	3.16	3.09	3.18	3.06	TxE*	0.06
60–110 kg	3.06	3.14	3.12	3.05	3.19	3.11	3.14	NS	0.07
23–110 kg	3.04	3.14	3.17	3.11	3.13	3.13	3.11	TxE**	0.04
				Number of pigs					
	14	14	14	21	21	21	21	–	–
Cold dressing yield (%)	79.01	77.13	77.76	78.23	77.70	77.73	78.20	NS	0.04
Meat of ham (%)	79.08 Bc	73.63 Aa	76.51 ABb	76.69	76.13	77.19	75.62	NS	0.49
Loin eye area (cm²)	52.17 B	45.17 A	48.61 AB	49.35	47.95	50.02	47.28	NS	0.84
Meat of primal cuts (kg)	22.09 Bc	18.61 Aa	20.18 ABb	20.28	20.31	20.63	19.96	NS	0.49
Meatiness of carcass (%)	53.19 Bb	47.06 Aa	49.75 Ab	50.46	49.51	51.37 B	48.60 A	NS	0.32
Backfat of 5 measurements (cm)	2.15	2.14	2.05	2.05	2.18	2.04	2.19	NS	0.57
Backfat in point C (cm)	0.96 a	1.20 b	1.04 ab	1.03	1.10	0.99	1.14	NS	0.09

C – control; LT – low-tannin faba bean seeds variety Kasztelan; HT – high-tannin faba bean seeds variety Bobas.
a, b – mean values in the same row with different letters differ significantly at $P \leq 0.05$; A, B – mean values in the same row with different letters differ significantly at $P \leq 0.01$.
[1]Interaction.
[2]Standard error of the mean.
NS – not significant $P>0.05$.

Enzyme supplementation

The enzyme supplement and sex had no significant effect on pig BWG. The enzyme supplement had no effect on carcass traits.

Meat quality

Feeding treatment

Intramuscular fat of pigs receiving beans contained more caprylic (P≤0.01) and oleic acids but less (P≤0.01) linoleic acid (Table 9). Both faba beans lowered PUFA *n-3* and PUFA *n-6* content in meat (P≤0.01). Generally, the intramuscular fat of pigs fed with faba bean Bobas contained more saturated and less unsaturated fatty acids (P≤0.01) than the fat of the pigs of the other two groups. As a result of these differences atherogenic (AI) and thrombogenicity (TI) indexes were also higher in the Bobas group, while h/H, PI and iodine value indices were lower (P≤0.01).

Both varieties of faba bean significantly (P≤0.01) improved the water holding capacity of the meat (Table 10). Meat of pigs fed with the faba bean Bobas was significantly (P≤0.05) brighter than that of the pigs from the other two groups. Its yellowness was higher when compared to controls (P≤0.01). Meat of these pigs also had the worst odour and taste.

Sex had only a small effect on meat quality but higher content of PUFA *n-3* in gilts than in barrows (P≤0.05) was found. It resulted in better (lower) PUFA *n-6* to PUFA *n-3* ratio (P≤0.01). This ratio depended on type of mixture, enzyme supplement and sex (P≤0.01).

Enzyme supplementation

Enzyme supplement had only a small effect on meat fatty acid pattern but lowering of PUFA *n-3* content and worse PUFA *n-6* to PUFA *n-3* ratio (P≤0.01) were noted. The enzyme supplement significantly worsened the meat taste (P≤0.05) and juiciness (P≤0.01).

Discussion

The protein content of both varieties of faba bean used in this experiment was similar to that reported by Duc et al. (1999). Their composition was also comparable to that of other varieties given in most recent literature (Milczarek and Osek, 2016; Smith et al., 2013). Also, the tannin content of both the low- and high-tannin cultivars was very similar to those found in other experiments in the corresponding varieties (Van der Poel et al., 1992; Crépon et al., 2010). This similarity also applies to the amino acid composition of proteins (Duc et al., 1999), whose nutritive value is limited by the low content of sulphur amino acids. The low essential amino acids index (EAAI) when compared to soybean protein was due also to the low content of some other amino acids, especially that of tryptophan.

Table 9. Fatty acids profile of intramuscular fat (g/100 g of estimated acids), hypocholesterolemic/hypercholesterolemic (h/H) ratios, atherogenic index (AI), thrombogenicity index (TI) and peroxidizability index (PI) in *Longissimus thoracis*

Item	Feeding treatment (T)			Enzyme supplement (E)		Sex (S)		I[1]	SEM[2]
	Group I C	Group II HT	Group III LT	200 mg per kg of feed	0	gilts	barrows		
Number of meat samples	14	14	14	21	21	21	21	–	–
C10:0	0.00 A	0.49 C	0.31 B	0.25	0.28	0.27	0.26	TxExS*	0.32
C12:0	0.29	0.31	0.18	0.26	0.25	0.28	0.23	NS	0.33
C14:0	1.72 B	1.60 B	1.33 A	1.59	1.51	1.57	1.53	NS	0.36
C16:0	24.81 A	26.98 B	24.73 A	25.27	25.75	25.39	25.63	NS	0.25
C16:1	3.34 A	3.94 B	3.38 A	3.65	3.46	3.57	3.54	TxS**	0.07
C18:0	11.27	10.97	11.42	11.12	11.32	10.87 A	11.57 B	NS	0.13
C18:1	40.63 A	42.61 AB	44.27 B	42.02	43.00	42.04	42.97	TxE**;TxS**	0.57
C18:2	10.18 B	7.34 A	7.94 A	8.95	8.02	8.81	8.16	TxE**;TxS**	0.41
C18:3	1.10 B	1.15 A	0.18 A	0.29 A	0.66 B	0.52	0.43	TxE**	0.07
C18:3γ	0.16 B	0.09 A	0.09 A	0.12	0.10	0.12	0.10	TxE**	0.01
C20:0	0.24 A	0.37 B	0.31 AB	0.28	0.33	0.30	0.31	NS	0.02
C20:4	4.84 B	3.18 A	3.80 B	4.43 b	3.45 a	4.19	3.69	TxE**;TxS	0.29
C20:5	0.23 a	0.36 b	0.33 ab	0.29	0.31	0.35 b	0.26 a	NS	0.02
C22:0	0.06	0.04	0.04	0.04	0.05	0.06	0.04	NS	0.01
C22:1	0.03	0.01	0.02	0.02	0.02	0.02	0.02	NS	0.01
C22:6	0.26 b	0.14 a	0.13 a	0.20	0.15	0.22 B	0.13 A	TxS*	0.02
SFA	38.38 A	40.90 B	38.39 A	38.87	39.58	38.81	39.64	ExS*	0.30
UFA	60.77 B	57.81 A	60.13 B	60.00	59.17	59.84	59.30	ExS*	0.30
MUFA	44.00 A	46.56 AB	47.67 B	45.68	46.47	45.62	46.53	TxE**;TxS**	0.61
PUFA	16.77 B	11.25 A	12.47 A	14.29	12.70	14.22	12.77	TxE**;TxS**	0.74
PUFA*n-6*	15.17 B	10.60 A	11.82 A	13.50	11.57	13.12	11.95	TxE**;TxS**	0.69
PUFA*n-3*	1.59 B	0.64 A	0.64 A	0.79 A	1.13 B	1.10 b	0.81 a	NS	0.08
PUFA/SFA	0.44 B	0.27 A	0.33 A	0.37	0.32	0.37	0.33	TxE*; TxS*	0.02
PUFA*n-6/n-3*	11.74 A	18.18 B	19.17 B	18.15 B	14.57 A	14.02 A	18.70 B	TxE**;TxS**;TxExS*	0.77
h/H	2.17 B	1.89 A	2.18 B	2.11	2.05	2.10	2.07	ExS*	0.03
Indices									
AI	0.52 A	0.58 B	0.50 A	0.53	0.54	0.53	0.54	ExS*	0.01
TI	1.24 A	1.39 B	1.26 A	1.27	1.31	1.27	1.31	ExS*	0.02
PI	36.59 B	24.92 A	27.91 A	32.00	27.61	31.92	27.69	TxE*;TxS*	1.74
Iodine value	58.66 Bc	53.50 Aa	5.51 ABb	55.88	55.90	56.19	55.60	NS	0.39

C – control; LT – low-tannin faba bean seeds variety Kasztelan; HT – high-tannin faba bean seeds variety Bobas.
a, b, c – mean values in the same row with different letters differ significantly at P≤0.05; A, B, C – mean values in the same row with different letters differ significantly at P≤0.01.
SFA – sum of saturated fatty acids; UFA – sum of unsaturated fatty acids; MUFA – sum of monounsaturated fatty acids; PUFA – sum of polyunsaturated fatty acids;
[1]Interaction, [2]Standard error of the mean, NS – not significant P>0.05.

Table 10. Meat quality traits (*longissimus* muscle)

Item	Feeding treatment (T)			Enzyme supplement (E)		Sex (S)		I[1]	SEM[2]
	Group I C	Group II HT	Group III LT	200 mg per kg of feed	0	gilts	barrows		
Number of meat samples	14	14	14	21	21	21	21	–	–
pH after 24 h cooling	5.51 a	5.54 ab	5.65 b	5.61 b	5.52 a	5.54	5.59	TxS*	0.02
Water holding capacity index (%)	22.91 B	19.26 A	18.29 A	20.11	20.20	19.95	20.35	NS	0.41
Meat colour									
lightness L*	50.78 ABa	52.38 Bb	50.31 Aa	50.97	51.34	50.49 A	51.82 B	NS	0.25
redness a*	16.35	16.21	16.45	16.64 b	16.03 a	16.38	16.29	NS	0.13
yellowness b*	2.49 A	3.20 B	2.73 AB	2.88	2.70	2.64	2.94	NS	0.09
chroma calculated C	16.54	16.53	16.68	16.90 b	16.27 a	16.60	16.56	NS	0.13
Sensory evaluation of meat:									
odour	4.71 B	4.25 A	4.59 B	4.48	4.55	4.43	4.60	ExS*;TxExS*	0.07
taste	4.67 AB	4.51 A	4.82 B	4.58 a	4.75 b	4.62	4.72	NS	0.05
tenderness	4.66	4.44	4.60	4.48	4.65	4.58	4.55	NS	0.04
juiciness	4.71	4.61	4.70	4.57 A	4.77 B	4.67	4.67	ExS*	0.04

C – control; LT– low-tannin faba bean seeds variety Kasztelan; HT – high-tannin faba bean seeds variety Bobas.
a, b – mean values in the same row with different letters differ significantly at P≤0.05; A, B – mean values in the same row with different letters differ significantly at P≤0.01.
[1]Interaction.
[2]Standard error of the mean.
NS – not significant P>0.05.

The data concerning utilization of faba bean in sow feeding are scarce. In an early experiment Nelsen and Kruse (1974) replaced sow feed protein mixture (soybean, fish meal and meat bone meal) by one half or in full with faba bean. The increase in dietary faba bean significantly reduced the protein content in colostrum but its fat content was not influenced. The field bean at both levels had a negative effect on milk yield, but its effect on milk composition was insignificant. Etienne et al. (1975) replaced soybean meal in diet for lactating sows with whole faba bean supplemented with methionine. The similarity of their results allows for the conclusion that such a supplemented faba bean can be used as the sole protein concentrate in the diets of lactating sows. Moreover, Neil and Sigfriedson (2011) found no differences in litter number and mass in sows fed with a mixture replacing soybean meal with 10% of white flowering faba bean.

Weaned piglets are particularly sensitive to low digestible protein, antinutritive substances and high fibre content in feed, therefore new sources of plant proteins have to be used with caution. On the other hand, the results of the experiments remain inconclusive. According to Emiola and Gous (2011), as much as 30% of faba bean in weaner pig diet caused no deleterious effect but they used dehulled seed and tannins are contained mainly in hulls. While Grala et al. (1993) found lower ileal digestibility of protein and amino acids and growth rate of young pigs fed faba beans with a higher content of tannins, Flis et al. (1999) found no such interdependence. Also in the present experiment, no significant effect of tannin content on piglet BWG was confirmed. Perhaps some other factors – not only tannins – are responsible for the lower growth of pigs fed with faba bean. For example, Gunawardena et al. (2009) found reduced feed intake of pigs fed faba bean starch concentrate.

It is usually assumed that tannin content limits digestibility of nutrients in diets with faba bean (Jezierny et al., 2010). On the other hand, Vilariño et al. (2004) did not find such an effect. Our results in the grower period are in accordance with this earlier paper, but in the finisher period digestibility of protein of cv. Kasztelan was the same as that of soybean, which is in accordance with these aforementioned authors. The presence of tannins in the gastrointestinal tract may induce complexes with dietary protein or digestive enzymes, or both, thereby reducing the digestibility of the protein (Marquardt, 1989). Also, possible interactions between tannins and proteins in the basal diet or between tannins and the mucosa of the intestinal wall may lead to an increased secretion of endogenous protein. These phenomena may explain the observed reduction in DM and N digestibility of the high tannin variety in the present experiment. Probably the effect of tannins depends on the type of protein fed to the animals. According to Jansman et al. (1995), tannins from faba beans showed some preference to interact with proteins with a high content of proline and histidine. The protein of the faba bean used in the present experiment was not rich in these amino acids when compared to soybean protein.

The enzyme supplement had a significant effect on fibre digestibility but only a negligible one on protein digestibility. These results are only partially in accordance with those of Stanek et al. (2005), who found no improvement in protein digestibility when an enzyme (also Ronozyme VP) was added, and the digestibility of fibre was significantly lowered.

Non-significant differences in pig BWG in the grower and finisher period gave significant differences when the whole fattening is taken into account. Soybean meal proved to be better than faba bean, which is in accordance with the results of Castell (1976). On the other hand Sirtori et al. (2015) observed no difference in pig performance when comparing diets containing soybean, faba bean and pea. Perhaps the new varieties of bean are better than the older ones, although a not significant difference between varieties was also found in the present experiment. The results also depend on the amount of faba beans used. Partanen et al. (2003) replaced rapeseed meal with faba bean in 0, 25, 50, 75 and 100%. Higher doses of bean lowered performance but the best results were obtained when half of the rapeseed was replaced. These positive effects of mixing faba bean with rape, which were probably due to the higher content of sulphur amino acids in the rape protein, were encountered by us in our earlier experiment (Hanczakowska and Świątkiewicz, 2014).

In the present experiment faba bean, especially cv. Bobas, also lowered carcass traits. The meatiness of the carcass and loin eye area was significantly better in pigs fed the control diet. Although Castell (1976) found improved Carcass Value Index in pigs fed with faba beans, it was rather a result of reduction in backfat thickness than an increase of the areas of lean tissue. In addition, Leikus et al. (2004) found lower backfat thickness in pigs fed with faba bean. Degola (2015), on the contrary, reported higher fat content in the carcasses of pigs receiving faba bean. In the present experiment there was only small difference in backfat thickness. When comparing the results of animals fed both varieties of faba bean, it can be seen that cv. Bobas resulted in poorer carcasses, probably due to a higher tannin content.

Both faba bean varieties had a negative effect on the fatty acid profile of the meat from the point of view of consumer health. Polyunsaturated fatty acids (PUFA) content was low, especially that of PUFA *n-3*. Also, the ratio of PUFA *n-3* to PUFA *n-6* was high (about 19). Such a ratio cannot be recommended from a health perspective (Kuhnt et al., 2012). According to the recommended optimum, this ratio should be 1:1 to 4:1 (Simopoulos 2004), although in European diets it ranges from 15:1 to about 17:1 (Fernández et al., 2007). Thus, in the meat of the animals from both experimental groups, the *n-6/n-3* ratio is considerably above this limit. Lower iodine value, the effect of higher content of saturated fatty acids, suggests lower dietetic value of meat from pigs fed high tannins variety of faba bean (Benz et al., 2011). On the other hand, lower iodine value suggests lower susceptibility to fat oxidation and thus longer shelf life. There were also differences between the faba bean varieties: both atherogenic and thrombogenicity indexes were higher in the meat of pigs fed with Bobas, which suggests that this meat may not be recommended as dietetic. The effect of low-protein diet, especially when supplemented with crystalline lysine, on the decrease of altherogenic and thrombogenic indices of pork *longissimus* muscle fat was earlier found in the experiment of Fiedorowicz et al. (2016). They found that meat from pigs fed with lower protein diet had insignificantly higher intramuscular fat content and higher α-linolenic acid level and provided more atherogenic and thrombogenic properties.

The main significant difference in the physical traits of the meat was the lower water holding capacity index of the meat from the pigs fed with faba beans. This is a positive feature as consumers do not like dry meat and, according to Huff-Lonergan and Lonergan (2005), unacceptable water holding capacity costs the meat industry millions of dollars annually.

The differences in sensory evaluation of the meat could be due to its fatty acid profiles, especially saturated and unsaturated fatty acids. According to Wood et al. (2008) the varying fatty acid composition of adipose tissues and muscles has a profound effect on meat quality. The poor odour of the meat of pigs fed with faba bean Bobas could be due to the presence of capric acid (C10:0) which is known for its bad smell (Oprean et al., 2011). However, according to the opinion of the evaluation team, the meat of the pigs fed with faba bean Kasztelan was as good as the meat of the pigs fed with soybean meal.

Conclusions

No differences were found between both bean varieties in the seeds' chemical composition, except in the tannin content and lower degree of sulphur amino acids content. The results obtained suggest that faba bean seeds may be, in moderate amounts, partial replacers of soybean meal, especially in sow and weaned piglet feeding. Both a low- and high-tannin variety, given at a level of 6% of feed, produced comparable results to that of soybean meal in piglet feeding. Body weight gains and feed utilization may be, in some degree, improved by enzymes supplementation.

It can be stated that faba bean seeds, in moderate amounts, can be partial replacers of soybean meal in feed for pigs, but some lowering of body weight gain and meat quality is possible especially when high-tannin varieties are used. Supplementation of feed for fatteners with enzymes gives no positive effect.

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