EFFECT OF PULSE IN FINISHING PIG FEEDING

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Abstract. The trial was conducted to test the hypothesis that faba bean and peas may replace soybean meal in diets fed to finishing pigs without negatively influencing the pig growth and carcass quality. Forty pigs were allotted to the experiments. The research was done in a pig farm in Latvia. The Yorkshire and Landrace crossbreed pigs were used. Four fattening pig groups were conducted, in each 10 barrows with initial live weight 41.1 ± 0.42 kg. The pig groups received soybean meal 15 % (soybean meal group- SBM group), 20 % of faba bean (faba bean – FB group), 15 % of peas (peas – P15 group) and 28 % of peas (peas – P28 group) blended into a mixture of concentrated feed without crystalline sources of amino acids. The chemical analyses of the soybean meal, peas, faba bean and the prepared pig feed were determined. During the study the live weight of pigs was monitored, and the feed consumed was counted. The pig carcasses were analyzed for the following parameters: the length of the carcass, backfat, ham weight, internal fat, muscle-eye area. The samples of meat were taken from the *Musculus longissimus lumborum et thoracis* 24 hours post mortem and subsequently subjected for the chemical analysis. Inclusion of pea and faba bean without crystalline sources of amino acids, may slightly reduce by 7-9.5 % average daily gain (ADG) in pea fed pig groups, but in FB group pigs have for 2.9 % more ADG then SBM group. The carcass indicators show a tendency to accumulate more fat tissue in pigs, which were fed pea and faba bean in the feed. The internal fat about 0.5 to 1.0 kg was more with significant differences between SBM pig group ($p < 0.001$), the indices of the muscle-eye area and ham weight ($p < 0.05$) also were significant. The pigs which were fed peas and faba bean had a little smaller muscle – eye areas. Pork from SBM, P15, P28 and FB groups contained tryptophan : hydroxyproline ratio from 1.37 till 2.3. The other amino acid content indices were similar in all trial groups. The hypothesis that faba bean and peas may replace soybean meal in diets fed to finishing pigs without negatively influencing the pig growth and carcass quality is true only when finisher pig diets are nutritionally balanced for all nutrients, especially digestible indispensable amino acids.

Keywords: pigs, faba bean, peas, carcass, pork, backfat, fatty acids.

Introduction

To reduce reliance on imported soybean meal in temperate environments, pea and faba bean may be alternative protein sources for pig diets [1]. Both feeds are a potential alternative home-grown protein sources for pig diets. Pigs are able to extract a great deal of energy from peas. Peas have high levels of lysine, which is important for pig growth and peas are very palatable. Since peas are both a good source of energy and amino acids, they tend to displace both cereal grains and protein ingredients when used in pig feeds. They are often used at high inclusion levels, especially in grower-finisher diets. Pea use in the diets of young pigs is limited due to the effects of anti-nutritive components and lower energy digestibility. For growing and finishing pigs, there is no reason to limit pea inclusion levels. Provided that the diets are properly balanced, especially taking into account the low methionine and cystine levels in peas, high levels of performance can be obtained at dietary inclusion levels of 50 percent. Practical inclusion levels in many countries where peas are readily available are in the 20 percent to 40 percent range. A number of studies have illustrated excellent performance when raw peas are used in growing-finishing pig diets [2-6]. The researchers in their results also illustrate the benefit of including canola meal in the diet in combination with peas in order to achieve complementary sources of lysine, methionine and cystine. In recent years it has become more important to look at the effects of dietary ingredients on meat quality, since there are significant premiums for lean and flavourful pork meat. Most researchers have found no significant or consistent effect of feeding peas on the meat quality. Some scientists suggested that feeding peas in corn – barley or hulless oat-based diets had no effect on backfat thickness but may increase intra-cellular fat [4].

Faba beans (*Vicia faba* L.) are a pulse related to the garden beans (the beans consumed by humans). There are two major types of faba beans: those from white-flower varieties and those from colored-flower varieties. Their chemical composition and nutritive value is about the same, but the colored-flower varieties contain more tannins. Tannins (usually about 0.3 to 0.5 percent in faba beans) reduce animal feed intake and depress digestibility of protein and energy. Other major anti-nutritional factors in faba beans include trypsin inhibitors and hemagglutinins. Faba bean is possible to feed up to 20 percent in diets for finishing pigs, but if the faba beans are from colored-flower varieties, the feed

intake will be reduced. Feeding high levels of faba beans creates a large volume of gastrointestinal gases that cause constipation in lactating and gestating sows. In general, faba beans should be introduced gradually in pig diets starting from 5 percent and not exceeding 20 percent. Faba beans have extremely low concentration of methionine and cystine [1]. Differences in standardized ileal digestibility (SID) of crude protein (CP) and amino acid (AA) within faba bean and pea cultivars have been linked to variations in their chemical composition, in particular to varying contents of secondary plant metabolites inherent to different cultivars [1]. For example, the SID of CP and AA in faba beans and peas from white flowered cultivars are higher than those in coloured flowered cultivars due to their higher tannin contents [1]. In temperate environments, grain legumes such as pea and faba bean are potential protein sources that could be considered for pig feed.

The objective of the present research was to test the hypothesis that field peas and faba beans may completely replace soybean meals in diets fed to finishing pigs without negatively influencing the pig performance and the carcass quality of pork.

Materials and methods

Animals and Housing. Forty terminal line finisher pigs were allotted to trial. The research was done in summer time 2014 in a Latvian pig farm. The Yorkshire and Landrace crossbreed pigs were used. Four fattening pig groups were conducted, in each 10 barrows with initial live weight 41.1 ± 0.42 kg. The pigs were previously fed commercial soybean meal (SBM) based diets and balanced for litter and sex. The finisher pigs were housed on concrete floors with shavings and access to drinking water at all times.

Diets and Performance Measures. Commercial sources of pea (Almara), faba bean (colored – flowered spring bean, Fuego) and soybean meal (SBM) were obtained for the experiment (Table 1). Dietary treatments were formulated for finisher pigs in a dose response feeding trial (Table 2).

Table1

Analyzed composition of main variable ingredients in the diets

Item	Pea (Almara)	Faba bean (Fuego)	Soybean meal
ME MJ·kg^{-1} *	14.31	14.14	14.23
Nutrients, %			
Crude protein (CP)	24.31	29.02	39.91
Acid detergent fiber (ADF)	8.5	8.4	15.5
Neutral detergent fiber (NDF)	13.7	11.6	20.5
Calcium (Ca)	0.09	0.34	0.21
Phosphorus (P)	0.24	0.58	0.95
Indispensable AA, %			
Arginine (Arg)	1.98	2.39	2.01
Histidine (His)	0.80	1.09	0.95
Isoleucine (Ile)	0.96	1.14	1.32
Leucine (Leu)	1.52	1.89	1.98
Lysine (Lys)	1.55	1.69	2.51
Methionine (Met)	0.39	0.35	0.52
Phenylalanine (Phe)	0.99	1.08	1.23
Threonine (Thr)	0.82	0.91	1.14
Valine (Val)	1.01	1.22	1.21
Total AA g·kg^{-1}	209.07	243.06	255.92

* Calculated as: digestible energy (DE) MJ·kg^{-1} dry matter DM = 17.47 + 0.0079 × CP + 0.0158 × EEAH – 0.0331 × Ash - 0.0140 ×NDF, where EEAH is ether extraction with an organic solvent after acid hydrolysis [7] and ME averaged 81.9 % of DE for protein feeds [8].

The control diet, with no pea or faba bean included, contained SBM at 15 % for finisher pigs (control group). In the pulse-containing diets, pea or faba bean were included at 15 and 28 % pea in P15 and P28 group and 20 % faba bean in FB group, gradually and completely replacing SBM. The diets were formulated to be isoenergetic for metabolizable energy (ME), with a similar Lysine (Lys)

content, and Ca and P [9]. Pulses replaced SBM on Lys basis. Other ingredients were kept constant and included barley, wheat feed, triticale and trace element-vitamin premix. Each diet was available on an ad libitum basis to finisher pigs.

After a one week adaptation period, diets were fed for 8 weeks. Weekly body weight (BW) for individual pigs, and pen intakes were recorded to assess average daily gain (ADG), average daily feed intake (ADFI), and gain: feed (G:F). Diets and ingredients were milled through a 1-mm screen before analysis, and all analyses were performed in duplicate. The ADF and NDF contents were determined according to Van Soest et.al., 1991. Analysis of feed samples for dry matter (DM), crude protein (CP), crude fiber, fat, ash, Ca and P were determined in the certified Scientific Laboratory of Agronomic Analysis of Latvia using such methods: for dry matter – forage analyses, USA, met. 2.2.1.1:1993, crude protein LVS EN ISO 5983-2:2009, crude fiber ISO 5498:1981, fat ISO6492:1989, ash ISO5984:2002/Cor1:2005, Ca LVS EN ISO 6869:2002, P ISO 6491:1998. The amino acid composition was analyzed with the methods ISO13903:2005, but tryptophan content by the method EN ISO 13904, HPLC.

Table 2

Composition of experimental diets (as-fed basis) tested on finishing pigs from LW 40 to 100 kg

Item	Soybean meal diet	Pea, (%) diets		Faba bean diet
		15.0	28.0	
Ingredients, %				
Pea (Almara)	-	15	28	-
Faba bean (Fuego)	-	-	-	20
Soybean meal	15	-	-	-
Barley	52.4	41	39.1	56.4
Wheat	-	41.5	-	-
Triticale	30	-	30.3	21
Vitamin- mineral premix (Premium)	2.6	2.5	2.6	2.6
Calculated analysis				
ME MJ, kg	12.92	12.64	13.04	13.04
Lys, %	0.7	0.6	0.7	0.6
Analyzed composition. Nutrients, %				
CP	16.27	14.62	14.98	15.43
Crude fat	1.74	1.67	2.43	2.18
Crude fiber	4.36	4.67	4.46	6.74
Ash	4.57	4.89	4.32	4.87
Ca	0.80	0.79	0.73	0.81
P	0.59	0.56	0.59	0.60

Slaughter and Carcass Quality Measurements. Pigs were slaughtered at a commercial slaughterhouse via electrical stunning, followed by exsanguinations, and carcasses were dehaired via scalding, eviscerated, and split vertically down the midline. Hot carcass weights were obtained and backfat depth was measured at a specific site (i.e., the head of the last rib, 6 cm from the mid back line, using a probe – Introscope Optimal Probe). The length of the carcass was measured in a straight line from the forward edge of the first rib to the forward edge of the aitch bone and muscle-eye area with the planimeter. The internal fat was removed from the carcass and weighed. One side of the carcass was divided into fractions for determination of ham. The samples of meat were taken from the *musculus longissimus lumborum et thoracis* 24 hours *post mortem* and subsequently subjected to the chemical analysis. The amino acid composition of the muscle was analyzed with the methods ISO13903:2005, but the tryptophan content by the method EN ISO 13904, HPLC. The content of each individual amino acid was calculated on $g \cdot (100\ g)^{-1}$ of wet matter basis.

Statistical Analysis. The data were processed with MS Excel mathematical program. The results were compared using the t-test. The t-test was carried out on the data for the growth performance and pork quality. Most data are reported as arithmetic means with the pooled SEM.

Results and discussion

The pig performance results showed that pig growth intensity was high in all study groups of pigs. The ADG, ADFI, and G:F of the finisher pigs are shown in Table 3. Dietary treatment did not significantly affect finisher ADG, ADFI, and G:F. Soybean meal protein digestibility is higher (87 %) than pulse protein (79 %) [10], and may be because 7-9.5 % higher ADG showed the SBM pig group, but, nevertheless, the faba bean group pigs have for 2.9 % more ADG than the SBM group. The digestibility of most amino acids in field peas and faba beans is similar to that in soybean meal, but pea and faba bean protein has relatively low concentration of methionine, cysteine and tryptophan. It is necessary to pay attention to the concentrations of these amino acids and to include crystalline sources. In our trial these amino acids in the pig diets were not determined. The results obtained for pigs confirm the results from the previous research demonstrating that there are no negative effects of including 36 % field peas in diets fed to finishing pigs [11]. Inclusion of 30 % field peas is also reported not to compromise the pig performance. The research results showed that even higher inclusion rates of peas may be used (66 %) and that peas can substitute all the soybean meal in diets without negatively affecting the performance and feed intake [12], in addition, formulation of the digestible indispensable amino acids in pig diets is obligatory. The other research showed that including pea or faba bean in finisher pigs diets from 7.5-30 % slightly reduced the finisher daily gain [13]. The use of pea and faba bean as an alternative protein source in pig diets has long been considered, though early trials indicated that greater than 20 % inclusion levels reduced the performance [3; 14]. The research before showed [3], that pea and faba bean have relatively low levels of Met and Trp. Today the modern cultivars of pea (Prophet) and faba bean (Fuego) used confirm they remain more deficient in these indispensable AA relative to SBM. Studies using pea diets supplemented with crystalline Met or Trp to correct for this deficiency have shown pig performance comparable to SBM [3]. Thus, greater pea and faba bean inclusion levels may be attainable provided the diets are balanced for the limiting AA. The results of our current study confirm that without supplements of crystalline Met or Trp good pig performance cannot be received (results in pig group P15 and P 28), but FB group got good results, maybe because for using modern cultivar Fuego, which has a similar amino acid content to soybean meal.

Table 3

Effect of dietary treatment on performance of finisher pigs (from 40 to100kg)

Pig group	ADG, g	ADFI, g	G:F, $g \cdot g^{-1}$
Soybean meal (SBM), control group	985±38.1	2770	0.35
Pea			
P15 group	892±8.4	2900	0.30
P28 group	915±10.4	2980	0.31
Faba bean (FB group)	1014±18.3	2730	0.37

Table 4 shows the slaughter measures. The carcass indicators show a tendency to accumulate more fat tissue in pigs, which were fed pea and faba bean in the feed. The internal fat about 0.5 to 1.0 kg was more with significant differences between the soybean pig group ($p < 0.001$). The indices of muscle-eye area and ham weight ($p < 0.05$) also were significant. The pigs which were fed peas and faba bean had a little smaller muscle – eye areas. For pigs the most important amino acid is lysine, which is necessary for building muscle tissue [15], in our research the pigs received lysine as necessary, but other limiting amino acids were not sufficient. Pulse also have relatively high concentrations of oligosaccharides (raffinose and stachyose), which are indigestible but highly fermentable for nonruminant species [16], maybe that also influenced the carcass traits.

In another research dietary treatment did not affect any of the carcass measurements. This is in agreement with a range of studies showing no effect of pea or faba bean diets on slaughter measures [12; 17; 18], but in our experiment the backfat values were greater than 12 mm which is not good for excellent carcass. It can explain that diets were not balanced for amino acids. The amino acids content was determined only in one sample of muscle from each pig group because the price of analyses was very high.

Table 4

Effect of dietary treatment on carcass traits

Indices	Soybean group	Pea		FB group
		P15 group	P28 group	
Carcass lenght, cm	107.1 ± 0.58	108.7 ± 0.88	109.2 ± 0.58	108.2 ± 0.33
Fat thickness on last rib, mm	12.0 ± 0.88	13.3 ± 1.20	13.0 ± 0.57	14.3 ± 0.33
Muscle-eye area, cm^2	52.6 ± 0.68 [a]	50.5 ± 0.21 [a]	51.3 ± 0.16	51.3 ± 0.88
Ham weight, kg	10.5 ± 0.19	10.6 ± 0.06	11.6 ± 0.29 [b]	12.5 ± 0.19 [b]
Internal fat, kg	1.32 ± 0.01 [c]	2.1 ± 0.05 [c]	1.85 ± 0.03 [d]	2.33 ± 0.04 [d]

The values are presented as mean ±standard error. a,b,f $p < 0.05$; c,d,e $p < 0.001$

The measured values of selected amino acids with different feeding in the groups are shown in Fig. 1. The biological value of meat is defined by fully valuable protein [19]. The full value of meat protein is calculating according to the relationship of irreplaceable amino acid tryptophan, which is found only in muscle tissue, and replaceable amino acid hydroxyproline, found only in connective tissue. The higher this ratio, the more biologically valuable meat protein.

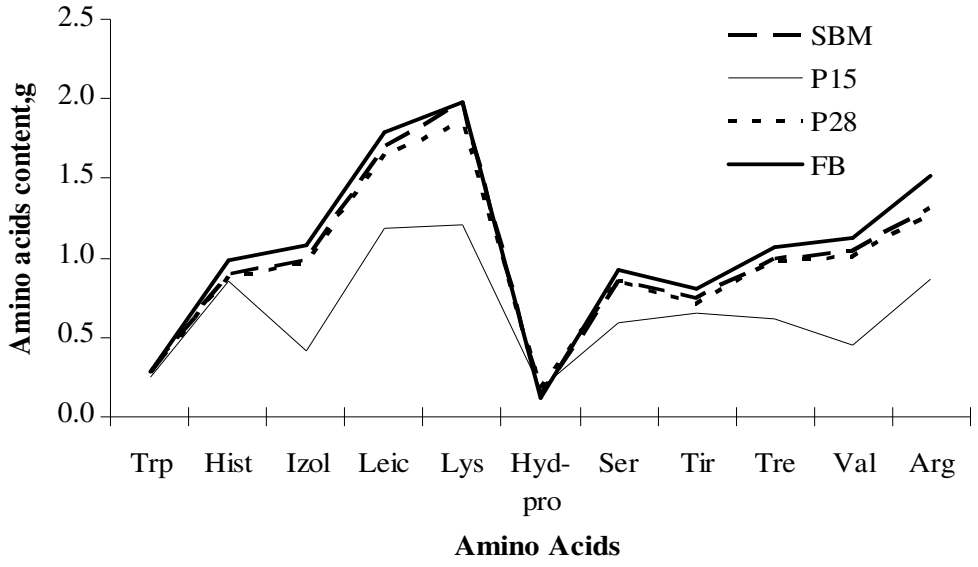

Fig. 1. **Amino acid composition in *m. longissimus lumborum*, g·(100 g)$^{-1}$**

The ratio tryptophan: hydroxyproline in pork was 7.9 [20], our data in Fig. 1. demonstrate different results, pig pork in soybean meal (SBM), peas (P15, P28) and faba bean (FB) groups contained tryptophan: hydroxyproline ratio from 1.37 till 2.3, but we had only one pork sample from each group. The other amino acid content indices were similar in all trial groups.

Conclusions

1. Inclusion of pea and faba bean without crystalline sources of amino acids, may slightly reduce by 7-9.5 % ADG in the pea fed pig groups, but in the faba bean group pigs have for 2.9 % more ADG than the SBM group.
2. The carcass indicators show a tendency to accumulate more fat tissue in pigs, which were fed pea and faba bean in the feed. The internal fat about 0.5 to 1.0 kg was more with significant differences between the soybean pig group ($p < 0.001$). The indices of muscle-eye area and ham weight ($p < 0.05$) also were significant. The pigs which were fed peas and faba bean had a little smaller muscle-eye areas.
3. Pork from soybean meal (SBM), peas (P15, P28) and faba bean (FB) groups contained tryptophan: hydroxyproline ratio from 1.37 till 2.3. The other amino acid content indices were similar in all trial groups.
4. The hypothesis that faba bean and peas may replace soybean meal in diets fed to finishing pigs without negatively influencing the pig growth and carcass quality is true only when finisher pig

diets are nutritionally balanced for all nutrients, especially of digestible indispensable amino acids.

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