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The influence of dietary inclusion of peas, faba bean and lupin as a replacement for soybean meal on pig performance and carcass traits

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Abstract. The effect of peas, faba bean and lupin seed inclusion in growing and finishing pig diets was evaluated. The control diet included soybean meal at 15%, but in the trial groups diets peas were 15 or 28%, faba bean 20 or 25%, lupin seed 12 or 15%, completely replacing soybean meal. Diets formulated to be isoenergetic for ME and with the same crude protein content. The faba bean and, especially, lupin seed meal inclusion in pig diets for growing period significantly reduced ADG *P = 0.02 and 0.01*), and G : F was also significantly influenced (*P = 0.02*) for pigs in lupin seed meal groups. There were no effects on finisher pigs average daily gain, inclusion peas or faba bean, daily gain were, respectively 892 ± 19 and 915 ± 11, 867 ± 12 and 828 ± 11, except lupin seed meal (*P = 0.04*) inclusion. There were no significantly effects on carcass quality and to pork chemical content, but pigs fed the diets with peas 28% and faba bean 25% had less of lean meat content, greater backfat thickness and internal fat than other groups which have a similar results. The muscle chemical content show that inclusion of pulses increased the total fat content in pork. In conclusion, results from this experiment suggest that pigs fed peas and faba bean have equal or slightly lower growth performance and carcass traits than pigs fed soybean meal, except lupin seed meal.

Key words: peas, faba bean, lupin, growing and fattening pigs, nutrition.

INTRODUCTION

The cereal grains commonly used as feed in pig diets contain insufficient of several of the indispensable amino acids such as lysine, threonine and the sulfur containing amino acids to meet the amino acid requirements of the rapidly growing pig (Sauer et al., 1977). Therefore, it is essential that pig's diet contain a supplementary source of these limiting amino acids.

Soybean meal is the most widely used as the main protein supplement in pig feed (Jezierny et al., 2010) and it is generally a consistent, high quality product (Swick, 1994). In temperate environments, soybeans are difficult to cultivate and pig industry relies heavily on imported soybean meal (Fearnside, 2001). Thus, there is need to find a viable alternative protein source for pig diets.

The grain legumes such as pea, faba bean and also lupin are potential protein sources that could be considered for pig feed in temperate regions. The peas and faba beans have been increasingly grown in Europe during the last 15 years. Lupin (*Lupinus spp*.) have been traditionally grown as a nitrogen-fixation crop in rotation with cereals. Grain legumes are used in different quantities as dietary protein sources because the levels of all nutrients can vary depending on the variety, location and growing conditions.

The peas are composed of two major components, the hull, which consists primarily of non-starch polysaccharides, and the kernel, which consists mainly of protein and starch, with some ash, crude fat, fibre and sugars (Castell & Guenter, 1994). The pea hull is largely indigestible fibre which has low nutritional value and may dilute the nutrients in peas thereby lowering their nutritional value. The pea hull also contains tannins which are known to interfere with protein digestion (Gdala et al., 1992). The second grain legume which mostly used in pig diets is faba bean.

There are two major types of faba beans: those from white-flower varieties and those from colourful-flower varieties. Their chemical composition and nutritive value is about the same, but the colourful-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. The other major anti-nutritional factors in faba beans include trypsin inhibitors and hemagglutinins. Faba beans have extremely low concentration of methionine and cystine (Partanen et al., 2003).

The low content of methionine (2.2 g kg^{-1}DM)and tryptophan (3.2 g kg^{-1}DM) also found in lupin cultivars comparison to soybean meal (6.7 and 6.9 g kg^{-1}DM) (Jezierny et al., 2011). The amino acid profile in lupin is characterized also by a lower content of threonine (Simon & Köhn, 2004) and by a much higher content of arginine (43.9 g kg^{-1} DM) which is often deficient in animal diets, comparison to soybean meal (39.8 g kg^{-1} DM) (Jezierny et al., 2011).

Lupins seeds is use in the animal feed industry was limited because of the high concentration of alkaloids causing unacceptable taste. Consequently, plant breeders have developed low-alkaloid lupins that are suitable for animal feeding.

The sweet lupin are currently utilised as a valuable protein source in pig diets. Lupin seed is classified as a leguminous plant, a crop with high content of crude protein. Its use as an alternative source of protein in pig diets is gradually increasing.

The seeds of sweet lupin contain 28 to 48% of crude protein relative to the variety and climatic conditions (Linnemann & Dijkstra, 2002). However, considerable amounts of anti-nutritional factors, such as non-starch poly-saccharides and oligosaccharides that are known to influence physiological characteristics of digestive tract and nutrient digestibility, are also present.

In the present study, we assessed the effects of including different levels of pea, faba bean and lupin seeds meal in pig diets as a replacements of soybean meal, on performance of pigs in the growing and finishing periods, and carcass quality.

MATERIALS AND METHODS

Animals and housing. A total of 70 local Yorkshire × Landrace growing-finishing pigs with initial body weight 30 kg were selected from a commercial pig herd and used in the experiment.

Pigs were previously fed commercial soybean meal based diets and were allocated to 1 of 7 dietary treatments for both grower (30 to 60 kg) and finisher (60 to 100 kg) periods, balanced for body weight and sex. They were placed by 10 pigs per pen (5female and 5castrated male). Pigs were housed on concrete floors with shavings and access to drinking water at all times. A 2- hole feeder and nipple drinker were installed in each pen. Ambient room temperature in the commercial animal house used ranged between 18 and 22 °C.

Dietary treatments and Performance Measures. Commercial sources of peas ('Almara'), faba bean (colourful-flowered spring bean 'Fuego'), lupin seed ('Sonet') and soybean meal were obtained for experiment (Table 1).

Table 1. Analyzed composition of main variable ingredients in the diets (on dry matter)

Indices	Pea 'Almara'	Faba bean 'Fuego'	Soybean meal	Lupin seed 'Sonet'
ME,[1] MJ kg^{-1}	13.31	12.72	15.85	12.73
Nutrients, &				
DM	92.25	91.84	92.21	92.64
CP	22.83	27.1	29.91	32.8
CF	6.2	7.55	10.89	14.79
Fat	1.02	0.97	19.64	5.32
Ash	1.66	2.43	4.83	3.07
Ca	0.09	0.1	0.21	0.34
P	0.24	0.42	0.95	0.58
Indispensable AA, g kg^{-1}				
Arginine	20.83	19.45	20.05	39.22
Histidine	8.78	9.1	9.47	13.53
Isoleucine	10.31	10.32	13.17	14.29
Leucine	16.47	17.2	19.76	22.82
Lysine	15.92	15.07	19.12	14.03
Methionine	2.86	3.12	5.24	4.15
Phenylalanine	10.66	9.9	12.27	12.46
Threonine	8.6	8.19	11.39	12.0
Tryptophan	1.8	2.3	6.7	7.3
Valine	10.97	10.81	12.1	13.18

[1]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 (Mc Donald et al., 2002) and ME averaged 81.9% of DE for protein feeds (Morgan, 1975).

The seven dietary treatments were formulated for both periods (growing and finishing) in a dose response feeding trial (Table 2). The control diet included soybean meal at 15%, but in the trial groups diets peas were 15 or 28%, faba bean 20 or 25%, lupins 12 or 15%, completely replacing soybean meal. Other ingredients were kept constant and included barley, wheat, triticale, canola oil, salt and trace element – vitamin premix. Diets formulated to be isoenergetic for metabolizable energy (ME) and with the same crude protein (CP) content.

Table 2. Composition of experimental diets for both (growing and fattening) periods (as-fed basis)

Indices	Soybean meal, %	Pea, %		Faba bean, %		Lupin seed meal, %	
Ingredients, %							
Pea 'Almara'	-	15	28	-	-	-	-
Faba bean 'Fuego'	-	-	-	20	25	-	-
Lupin seed meal 'Sonet'	-	-	-	-	-	12	15
Soybean meal	15	-	-	-	-	-	-
Wheat	36.7	36.7	23.7	31.7	26.7	39.7	36.7
Barley	30	30	30	30	30	30	30
Triticale	13	13	13	13	13	13	13
Vitamin-mineral premix	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Canola oil	1.7	1.7	1.7	1.7	1.7	1.7	1.7
Salt	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Calculated analysis							
ME[1] MJ kg^{-1}	13.58	13.53	13.39	13.37	13.27	13.75	13.67
Lys, &	0.73	0.65	0.69	0.71	0.70	0.65	0.68
Analyzed composition							
Nutrients, %							
DM	88.2	87.9	87.8	87.8	87.8	88.3	88.2
CP	14.94	14.38	14.08	14.70	15.03	14.43	15.10
CF	4.15	3.01	3.38	3.70	4.05	3.65	3.95
Fat	6.24	3.45	3.27	3.4	3.38	4.37	4.56
Ash	5.26	4.53	4.58	4.88	4.99	4.74	4.61
Ca	0.83	0.81	0.80	0.82	0.87	0.86	0.85
P	0.56	0.55	0.51	0.52	0.6	0.63	0.62

[1] 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 (Mc Donald et al., 2002) and ME averaged 81.9% of DE for protein feeds (Morgan, 1975).

Each diets was available on an ad libitum basis to pens with 10 pigs per pen for period from weaning age till pigs reach 100 kg liveweight.

Every month the bodyweight (BW) for individual pigs and every week pen feed intake recorded to assess average daily gain (ADG), average daily feed intake (ADFI) and liveweight gain from one kg feed (G : F).

Slaughter and Carcass Quality Measurements. The finisher pigs at the 100 kg liveweight, slaughtered at a commercial slaughter house. Hot carcass weights (HCW) 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 (P2), using a probe (Introscope Optimal Probe; SFK, Kolding, Denmark)]. For each individual pig, the percentage of lean meat (% Lean) was calculated as: 66.6708 - 0.3493×P2 (Latvia reg.of the Cabinet of Ministers Nr. 307), and killing out percentage was calculated as: HCW/BW×100%. The length of 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 carcass and weighed. One side of carcass was divided into fractions for determination ham. The pork samples only of one carcass were taken from the *musculus longissimus lumborum et thoracis* 24 hours *post mortem* and subsequently subjected to the chemical analysis to assess water, fat and crude protein content, ph and cholesterol.

Analytical Methods. Diets and ingredients were milled through a 1-mm screen before analysis. The chemical content of feed samples were determined in Scientific laboratory of Agronomic analysis of Latvia. The dry matter (DM), crude protein (CP), crude fibre (CF), fat, ash, Ca and P contents were analysed based on standard methodology, respectively DM with ISO 6496: 1999, CP with LVS EN ISO 5983-2: 2009, Ca with LVS EN ISO 6969: 2002, P with ISO 6491: 1998, crude fibre (CF) with ISO 5498: 1981, fat ISO 6492: 1999, ash with ISO 5984: 2002/Cor1: 2005. The metabolizable energy (ME) were calculated according to equation (Morgan, 1975; Mc Donald et al., 2002).The amino acids contents in pea, faba bean, lupin seed and soybean meal were determined by near infrared reflectance spectroscopy (NIRS). The chemical analysis in pork were determined by LVS ISO 1442:1997 for water, LVS ISO 1443:1973 for fat and LVS ISO 937:1978 for crude protein content, LVS ISO 2917:2004 for ph and BIOR-T-012-132-2011 for cholesterol content in laboratory of Food and Environmental Investigations (BIOR) in Latvia.

Statistical analysis. All data were statistically processed to determine the differences between protein sources. Statistical analysis was performed according to the General linear Model procedure of SAS/STAT 9.22 software package (2010). Most data was reported as arithmetic means with the pooled SEM. The treatment means were compared using Student's *t-test.* Statements of statistical significance were based upon $P < 0.05$.

RESULTS AND DISCUSSION

The mean of ADG, ADFI and G:F for pigs in growing period were 532 ± 37 g, 1947 ± 69 and 0.27 ± 0.02 g g^{-1}, but for pigs in finishing period were 854 ± 64, 2681 ± 178 and 0.32 ± 0.02, respectively (Table 3). The faba bean and, especially, lupin seed meal inclusion in pig diets for growing period significantly reduced ADG (*P = 0.02 and 0.01*), and G : F was also significantly influenced (*P = 0.02*) for pigs in lupin seed meal groups. There were no effects on finisher pigs average daily gain, inclusion peas or faba bean, daily gain were, respectively 892 ± 19 and 915 ± 11, 867 ± 12 and 828 ± 11, except lupin seed meal (*P = 0.04*) inclusion (Table 3). The use of peas and faba bean as an alternative protein source in pig diets in early trials indicated that greater than 20% inclusion levels reduced performance. (Castell, 1976; Gatel & Grosjan, 1990). In other research (Smith et al., 2013) the ADG for grower and finishing pigs were more higher than in our research, respectively in growing period 869 ± 41 g and in finishing 1,000 ± 40 g. It should be noted that the diets in our studies were not formulated to ensure deficiencies of methionine or tryptophan. In previous studies using pea diets supplemented with crystalline methionine or tryptophan to correct for this deficiency have shown pig performance comparable to soybean meal (Gatel & Grosjan, 1990). Similarly, a small number of trials supplementing faba bean diets with crystalline amino acid demonstrate improved performance (Crepon, 2006). Thus, better peas, faba bean and lupin seed inclusion results may be attainable provided diets are balanced for the limiting amino acids. The results of our current study confirm this.

Table 3. Effect of dietary treatment on performance of pigs

Dietary treatment	In growing period			In finishing period		
	ADG, g	ADFI, g	G:F, g g^{-1}	ADG, g	ADFI, g	G:F, g g^{-1}
Soybean meal	555	1,848	0.300	897	2,560	0.351
Pea						
15%	550	1,970	0.279	892	2,900	0.347
28%	554	1,831	0.303	915	2,980	0.335
Faba bean						
20%	545	1,975	0.275	867	2,630	0.330
25%	540	1,995	0.270	828	2,580	0.321
Lupine seed meal						
12%	528	2,000	0.264	853	2,680	0.318
15%	450	2,011	0.223	726	2,440	0.298
SEM	37	69	0.0246	64	178	0.0168
P-value						
Soybean meal vs. pea	0.39	0.17	0.48	0.26	0.13	0.15
Soybean meal vs. faba bean	0.02	0.82	0.21	0.06	0.11	0.09
Soybean meal vs. lupine seed meal	0.01	0.57	0.02	0.04	0.36	0.07

Table 4. shows the slaughter measures: P2, lean meat , killing out , the length of carcass, muscle-eye area, internal fat and ham weight. Dietary treatment did not significantly affect carcass traits. The mean of backfat, lean meat, killing out, the length of carcass, muscle-eye area, internal fat and ham weight were 12.7 ± 2.3 mm, 62.2 ± 0.71%,76.0 ± 4.17%, 101.7 ± 12.11 cm, 52.5 ± 1.54 cm^2, 1.72 ± 0.37 kg, 11.31 ± 0.97 kg, respectively.

Table 4. Effect of dietary treatment on carcass traits

Dietary treatment	P2, mm	Lean, %	Killing out, %	Carcass length, cm	Muscle-eye area, cm^2	Internal fat, kg	Ham weight, kg
Soybean meal	10	63.1	79.0	89	54.8	1.3	10.5
Pea							
15%	15	61.4	83.6	109	51.9	2.3	11.6
28%	12	62.5	75.6	110	50.8	2.0	10.3
Faba bean							
20%	14	61.8	70.7	114	52.2	1.5	12.5
25%	11	62.8	73.2	90	53.8	1.4	10.4
Lupine seed meal							
12%	16	61.1	72.1	115	50.4	2.1	12.9
15%	11	62.8	78.0	85	53.9	1.5	11.0
SEM	2.3	0.71	4.17	12.11	1.54	0.37	0.97
P-value							
Soybean meal vs. pea	0.22	0.28	0.18	0.22	0.19	0.10	0.34
Soybean meal vs. faba bean	0.49	0.42	0.13	0.49	0.37	0.19	0.44
Soybean meal vs. lupine seed meal	0.25	0.31	0.39	0.44	0.39	0.41	0.25

The chemical composition of meat was shown in Table 5. The values of water content in trial groups were in the range of 69.4–75.7%, the highest value of water was found in pork which received 12% lupine seed meal in diet. The other authors also presented the same water content in pork from 72.0–74.0% (Correa et. al., 2006). The fat content were higher in pork samples of all pig groups which received pulses in diets, especially with 28% pea and 25% of faba bean, respectively 1.9 and 1.8 times more than of soybean meal pig group. The content of crude protein also was very different in the groups (20.1–24.1%) and also the cholesterol concentration of pigs ranged in large, from 60.6 till 108.3 mg 100 g. In the researchers Kim et al. (2016) studies, a higher protein content resulted in pork lower pH $_{24h}$ value, pH 5.7 (n = 90) 24.37%, but pH 6.1 (n = 56) 23.16% crude protein content (Kim et al., 2016). A number of previous studies reported levels of cholesterol in *longissimus* muscle with 57 mg 100 g (Dorada et al., 1999) and 59 mg 100 g (Moss et al., 1983). Similarly Bohac & Rhee (1988) reported cholesterol content of 55.7 mg 100 g. These figures are considerably lower than our current results. Apparently, the obtained figures depended on the feeding of pigs, breed and rearing environment.

Table 5. The chemical analyses of the *musculus longissimus lumborum et thoracis*

Item	Soybean meal	Pea		Faba bean		Lupine seed meal	
		15%	28%	20%	25%	12%	15%
Water, &	72.4	70.1	69.4	71.7	70.1	75.7	72.2
Fat content, &	3.8	6.5	7.2	5.3	6.7	3.6	4.4
Crude protein content, &	24.1	23.6	22.4	21.8	22.8	20.1	22.4
pH	5.48	5.38	5.41	5.49	5.28	5.62	5.47
Cholesterol, mg 100g	108.3	105.7	78.0	77.6	103.3	60.6	69.1

The pH of muscle in the living pigs is around 7.0 till 7.2. After slaughter, it drops to around 5.5. Pork already reaches its lowest pH value of 5.4 to 5.8 at 6–10 hours after slaughter. Glycogen is broken down to lactic acid when muscle turns into meat. The pH of pork can range from 5.2 to 7.0. The highest quality products tend to fall in the range of 5.7 to 6.0 (Kim et al., 2016). The pH of pork muscle in our research was from 5.28–5.62.

CONCLUSIONS

The results from the present study indicate that 20% and 25% faba bean, 12% and 15% lupine seed meal inclusion without crystalline amino acids may for pigs in growing period significantly reduced average daily gain. The liveweight gain from one kg feed was also significantly influenced for pigs in lupine seeds meal groups in growing period. There were no effects of inclusion of peas or faba bean on pigs average daily gain in finishing period, except lupine seed meal inclusion. There were no significantly effects on carcass quality and to pork chemical content. But pigs fed the diets with peas 28% and faba bean 25% had less of lean meat content, greater backfat thickness and internal fat than other groups which have a similar results. The muscle chemical content show that inclusion of pulses increased the total fat content in pork.

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