Research Article

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Effects of including raw or extruded field peas (*Pisum sativum* L.) in diets fed to weanling pigs

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Abstract

BACKGROUND: There is limited information about the response to field peas fed to weanling pigs. Two experiments were therefore conducted to investigate effects of including increasing levels of field peas in weanling pig diets.

RESULTS: In Experiment 1, a reduction (linear, $P < 0.05$) in average daily gain (551, 574, 541, 548, 512 and 533 g d^{-1}) was observed in response to increasing levels of raw field peas (0, 120, 240, 360, 480 and 600 g kg^{-1}) in diets fed from day 14 to 42 post weaning. In Experiment 2, the inclusion of raw field peas (0, 245 or 490 g kg^{-1}) in the diets reduced (linear, $P < 0.05$) feed intake from day 14 to 39 post weaning, but average daily gain and gain : feed were unaffected by the use of raw field peas. The response to extruded field peas was not different from that to raw field peas.

CONCLUSION: Up to 360 g kg^{-1} raw field peas may be included in nursery diets without negatively influencing pig growth performance provided that diets are balanced for indispensable amino acids. Results from this work do not support any advantage of extruding the field peas.

Keywords: extrusion; field peas; performance; weanling pigs

INTRODUCTION

Field peas may be included in corn-based diets fed to growing and finishing pigs in quantities sufficient to substitute all soybean meal in the diets without compromising pig performance.[1,2] In diets fed to weanling pigs, field peas may be included in concentrations of up to 200 or 300 g kg^{-1} without affecting pig performance,[3–5] but greater inclusion rates may result in reduced pig performance.[6–8] These conclusions were reached using diets that were fortified with DL-methionine (Met), but not with crystalline tryptophan (Trp). The concentration of Trp in pea protein is lower than in soybean protein,[9] and diets containing more than 30% dietary field peas may be deficient in Trp. It is therefore possible that if diets are fortified with crystalline Trp, greater concentrations of field peas may be used in diets fed to weanling pigs.

Field peas may contain anti-nutritional factors such as protease inhibitors and tannins,[10–12] which may be the reason for the reduction in feed intake sometimes reported when field peas are used. Thermal treatment of field peas may inactivate some of the anti-nutritional factors and extrusion of field peas may increase the digestibility of amino acids (AA), starch, and energy.[13] In previous research, Myer and Froseth[6] reported improvements in pig performance when using extruded field peas compared with raw field peas, but in other reports no effect of extrusion was observed.[3,4] Therefore, the objective of this research was to test the hypothesis that weanling pigs tolerate field peas in larger quantities than those previously shown if diets are fortified with crystalline sources of Trp or if field peas are extruded prior to use.

EXPERIMENTAL

General procedures

Two experiments were conducted. The animal part of both experiments was conducted at South Dakota State University and the protocols for the experiments were reviewed and approved by the Institutional Animal Care and Use Committee at South Dakota State University. Both experiments used pigs that were weaned at 20 days of age and fed a common starter diet for 14 days post weaning. Pigs were then randomly allotted to treatment diets and fed these diets for 28 (Experiment 1) or 25 days (Experiment 2). All pigs were the offspring of SP-1 boars that were mated to Line 13 females (Ausgene International Inc., Gridley, IL, USA). Pigs were housed in 1.2 × 1.2 m pens that were equipped with a fully slatted plastic floor, a two-hole feeder and a nipple drinker. Room temperature was maintained at 26, 25, 24 and 23 °C during weeks 1, 2, 3 and 4 of the experiment. A mixture of smooth, green-seeded and white-flowered varieties of commercial field peas that were grown and harvested in eastern South Dakota in 2006 were used in both experiments (Table 1).

Diets were formulated in both experiments to meet the pigs' expected requirements for all nutrients.[14] Standardized ileal

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Table 1. Analyzed chemical composition of feed ingredients (as-fed basis)

	Ingredient				
Item	Corn	Soybean meal	Extruded soybeans	Raw field peas	Extruded field peas[a]
Trypsin inhibitor (TIU mg^{-1})	–[b]	2.8	9.3	2.9	5.6
Gross energy (kcal kg^{-1})	4090	4429	5353	4050	4584
Composition (g kg^{-1})					
Dry matter	856	887	944	866	936
Crude protein	76	416	364	219	272
Crude fat	22.5	10.6	181.8	5.1	75.5
Neutral detergent fiber	99.2	113.4	89.5	199.2	225.4
Acid detergent fiber	19.0	82.8	64.0	65.5	55.5
Starch	640.4	15.2	17.4	330.3	325.8
Sucrose	8.3	71.2	66.7	17.4	31.6
Raffinose	1.1	8.0	5.8	3.9	7.5
Stachyose	0.5	41.2	39.1	20.4	26.9
Verbascose	0.6	1.2	0.3	28.7	24.0
Indispensable amino acid (g kg^{-1})					
Arginine	3.5	30.8	26.2	18.1	20.5
Histidine	2.1	11.3	9.6	5.2	6.7
Isoleucine	2.7	20.4	17.5	9.4	12.3
Leucine	8.4	33.9	28.4	15.5	20.4
Lysine	2.5	28.4	24.5	16.4	18.8
Methionine	1.5	6.3	5.3	2.1	3.1
Phenylalanine	3.4	21.3	18.0	10.3	13.1
Threonine	2.7	16.8	14.0	8.0	9.7
Tryptophan	0.5	6.0	5.6	1.8	3.3
Valine	3.2	20.3	17.2	9.3	12.4
Dispensable amino acid (g kg^{-1})					
Alanine	5.1	18.8	15.8	9.2	11.6
Aspartic acid	4.9	48.9	41.5	24.2	29.8
Cysteine	1.5	6.4	5.7	3.2	4.0
Glutamic acid	12.6	77.7	65.2	35.6	45.7
Glycine	2.9	18.1	15.4	9.2	11.4
Proline	5.4	21.5	16.8	8.8	10.8
Serine	3.3	20.0	16.0	9.7	11.4
Tyrosine	2.2	15.0	12.7	6.8	8.0

[a] Field peas were mixed with full-fat soybeans before extrusion (700 g field peas and 300 g soybeans kg^{-1}). The data are for the field pea–soybean mixture.
[b] Trypsin inhibitor concentration in corn was not determined.

digestibility values for AA in corn, soybean meal, and field peas that were measured in previous research[9,15] were used in diet formulations. Digestibility values for phosphorus were also based on previously measured data.[15–17] Feed was provided on an *ad libitum* basis throughout both experiments and water was available from nipple drinkers at all times.

Experiment 1

One hundred and sixty-eight pigs were randomly allotted to six treatment groups based on body weight, gender and ancestry in a randomized complete block design. There were four pigs per pen and seven replicate pens per treatment group. Pigs on each treatment group were provided with one of six diets that contained 0, 120, 240, 360, 480 or 600 g kg^{-1} of raw field peas (Tables 2 and 3). Raw field peas mainly replaced corn and soybean meal in the formulas. The concentrations of standardized ileal digestible indispensable AA and digestible phosphorus were kept constant among diets by increasing the inclusion of DL-Met and L-Trp as raw field pea inclusion increased, whereas the inclusion levels of L-lysine and monocalcium phosphate were reduced as the concentration of raw field peas increased.

Individual pig body weights were recorded on the day pigs were allotted to treatments, 2 weeks later, and at the conclusion of the experiment 4 weeks after pigs were allotted to experimental diets. Daily allotments of feed to each pen were recorded, and the amount of feed in each feeder was recorded on the same day as the pigs were weighed. At the conclusion of the experiment, feed disappearance for each pen was summarized, and average daily feed intake (ADFI) was calculated. Average daily weight gains (ADG) and gain : feed (G : F) ratios were also calculated.

Feed ingredients and diets were analyzed for gross energy using bomb calorimetry (Model 6300, Parr Instruments, Moline, IL, USA) and for dry matter (method 930.15)[18] and crude protein (method 990.03).[18] Corn, soybean meal and field peas were also analyzed for starch (method 979.10),[18] and sucrose, raffinose, stachyose and verbascose.[19] Ingredients and diets were analyzed for ether extract

Table 2. Ingredient composition of diets (as-fed basis), Experiment 1

	Raw field peas (g kg^{-1})					
Ingredient (g kg^{-1})	0	120	240	360	480	600
Ground corn	571.6	495.9	420.0	344.3	268.5	192.8
Soybean meal (44% crude protein)	270.0	230.0	190.0	150.0	110.0	70.0
Raw field peas	–	120.0	240.0	360.0	480.0	600.0
Dried whey powder	100.0	100.0	100.0	100.0	100.0	100.0
Soybean oil	30.0	27.3	24.6	21.9	19.2	16.5
Ground limestone	9.6	9.1	8.6	8.1	7.6	7.1
Monocalcium phosphate	9.3	8.5	7.7	6.9	6.1	5.3
L-Lysine-HCl	2.8	2.2	1.7	1.1	0.6	–
DL-Methionine	0.2	0.5	0.8	1.0	1.3	1.5
L-Threonine	0.5	0.5	0.5	0.5	0.5	0.5
L-Tryptophan	–	–	0.1	0.2	0.2	0.3
Salt	4.0	4.0	4.0	4.0	4.0	4.0
Vitamin premix[a]	0.5	0.5	0.5	0.5	0.5	0.5
Micromineral premix[b]	1.5	1.5	1.5	1.5	1.5	1.5

[a] Supplied per kilogram of complete diet: vitamin A, 10990 IU as vitamin A acetate; vitamin D_3, 1648 IU as D-activated animal sterol; vitamin E, 55 IU as α-tocopherol acetate; vitamin K_3, 4.4 mg as menadione dimethylpyrimidinol bisulfite; thiamine, 3.3 mg as thiamine mononitrate; riboflavin, 9.9 mg; pyridoxine, 3.3 mg as pyridoxine hydrochloride; vitamin B_{12}, 0.044 mg; D-pantothenic acid, 33 mg as calcium pantothenate; niacin, 55 mg; folic acid, 1.1 mg; and biotin, 0.17 mg.
[b] Supplied per kilogram of complete diet: copper, 26 mg as copper sulfate; iron, 125 mg as iron sulfate; iodine, 0.31 mg as potassium iodate; manganese, 26 mg as manganese sulfate; selenium, 0.3 mg as sodium selenite; and zinc, 130 mg as zinc oxide.

(method 920.39),[18] acid detergent fiber (method 973.18)[18] and neutral detergent fiber.[20] Amino acids were analyzed on a Hitachi Amino Acid Analyzer, Model No. L8800 (Hitachi High Technologies America, Inc; Pleasaton, CA, USA) using ninhydrin for post-column derivatization and norleucine as the internal standard. Prior to analysis, samples were hydrolyzed with 6 mol L^{-1} HCl for 24 h at 110 °C (method 982.30 E[a]).[18] Methionine and cysteine were determined as Met sulfone and cysteic acid after cold performic acid oxidation overnight before hydrolysis (method 982.30 E[b]).[18] Tryptophan was determined after NaOH hydrolysis for 22 h at 110 °C (method 982.30 E[c]).[18]

Data were analyzed using the Generalized Linear Model procedure of SAS (SAS Institute Inc., Cary, NC, USA). Data were analyzed for outliers using the UNIVARIATE procedure, but no outliers were identified. The model included diet and replicate as independent variables. Orthogonal polynomial contrasts were used to determine the effects of increasing the concentration of raw field peas in the diets and coefficients for the contrasts were obtained using the Interactive Matrix Language procedure in SAS. Each pen was the experimental unit for all analyses and an alpha value of 0.05 was used to assess significance among treatments.

Experiment 2

One hundred and twenty pigs were randomly allotted to five treatment diets based on body weight, gender and ancestry. There were seven replicate pens per diet (three replicates with four pigs per pen and four replicates with three pigs per pen). The control diet contained corn, soybean meal and 210 g kg^{-1} extruded full-fat soybeans (Tables 4 and 5). Two additional diets were formulated by adding 245 or 490 g kg^{-1} raw field peas to the control diet. The concentration of extruded full-fat soybeans was maintained at 210 g kg^{-1} in these diets, but the concentrations of corn and soybean meal were reduced as raw field peas were included in the diets. The last two diets used 245 and 490 g kg^{-1} extruded field peas rather than raw field peas, but were otherwise similar to the two diets with raw field peas. All diets were formulated to contain similar quantities of standardized ileal digestible AA and of apparently digestible phosphorus as explained for Experiment 1. The full-fat soybeans and the extruded field peas were ground and extruded at 150 °C using a Model 2500 Extruder (Insta Pro, Des Moines, IA, USA) and then cooled to 43 °C using a tumble drum cooler (Insta Pro). Field peas were mixed with full-fat soybeans (700 g kg^{-1} field peas, 300 g kg^{-1} full-fat soybeans) prior to extrusion. In the diet containing 245 g kg^{-1} of extruded field peas, 105 g kg^{-1} of extruded soybeans was added to have the inclusion level of extruded soybeans consistent in all diets.

Individual pig weights were recorded at the start of the experiment, 11 days later and at the conclusion 25 days after initiation of the experiment. Daily feed allotments were recorded as well. All data were summarized at the conclusion of the experiment and ADFI, ADG and G : F were calculated for the initial 11 days, for the final 14 days and for the entire experimental period. Samples of feed ingredients and diets were analyzed as outlined for Experiment 1.

Data were analyzed as explained for Experiment 1. Orthogonal polynomial contrasts were used to determine the effects of increasing raw field peas or extruded field peas in the diets. Data for the control diet were included in both sets of contrasts.

RESULTS

Experiment 1

The ADFI of pigs was not influenced by the concentration of raw field peas in the diets during the initial 2 weeks of the experiment, but ADG, G : F and final body weights were reduced (linear, $P < 0.05$) during this period as the concentration of raw field peas in the diets increased (Table 6). During the following 2 weeks, however, ADFI tended to decrease (linear, $P = 0.07$), but ADG and G : F were not affected as the concentration of raw field peas increased in the diets. For the overall period, ADG was reduced (linear, $P < 0.05$) from 551 g d^{-1} for pigs fed the control diet to 574, 541, 548, 512 and 533 g d^{-1} for pigs fed the diets containing 120, 240, 360, 480 or 600 g kg^{-1} raw field peas. The ADFI and the G : F were not influenced by the inclusion of raw field peas in the diets, but the final body weight was reduced (linear, $P < 0.05$) from 24.36 kg for pigs fed the control diet to 24.99, 24.06, 24.27, 23.31 and 23.85 kg for pigs fed the diets containing 120, 240, 360, 480 or 600 g kg^{-1} raw field peas, respectively.

Experiment 2

During the initial 11 days, no influence of the concentration of raw field peas on ADG or ADFI was observed, but G : F was improved (quadratic, $P < 0.05$) from 538 to 514 and 566 g kg^{-1} for pigs fed diets containing 0, 245 or 490 g kg^{-1} field peas, respectively (Table 7). The body weight after 11 days, however,

Table 3. Energy and nutrient composition of diets (as-fed basis),[a] Experiment 1

	Raw field peas (g kg^{-1})					
Item	0	120	240	360	480	600
Gross energy (kcal kg^{-1})	4134	4129	4062	4073	4018	4183
Metabolizable energy (kcal kg^{-1})	3384	3384	3384	3384	3384	3384
Dry matter (g kg^{-1})	880.0	874.1	872.0	875.4	873.8	872.6
Crude protein (g kg^{-1})	171.2	164.4	164.6	173.7	177.3	182.1
Ether extract (g kg^{-1})	48.6	48.4	44.3	39.7	33.9	27.5
Neutral detergent fiber (g kg^{-1})	90.5	90.3	96.5	98.3	131.3	131.0
Acid detergent fiber (g kg^{-1})	31.2	34.5	32.6	37.3	43.6	44.2
Calcium (g kg^{-1})	7.0	7.0	7.0	7.0	7.0	7.0
Phosphorus (g kg^{-1})	6.1	5.9	5.7	5.6	5.4	5.3
Digestible phosphorus (g kg^{-1})	3.2	3.2	3.2	3.2	3.2	3.2
Indispensable amino acid (g kg^{-1})						
Arginine	10.1	9.9	10.4	11.1	12.0	12.3
Histidine	4.2	4.0	4.1	4.1	4.2	4.2
Isoleucine	7.4	7.0	7.3	7.5	7.6	7.8
Leucine	14.8	14.0	14.1	13.8	14.0	14.0
Lysine	12.0	11.5	11.6	12.5	12.4	12.2
Methionine	2.8	2.9	3.5	3.5	3.4	3.8
Phenylalanine	7.7	7.3	7.6	7.7	8.1	8.0
Threonine	7.4	7.3	7.0	7.4	7.5	7.7
Tryptophan	2.0	1.8	1.7	1.7	1.7	1.7
Valine	7.6	6.7	7.4	7.7	7.8	7.9
Dispensable amino acid (g kg^{-1})						
Alanine	8.6	8.0	8.0	7.9	8.1	8.1
Aspartic acid	17.0	16.3	16.7	17.4	18.4	18.7
Cysteine	2.7	2.6	2.6	2.6	2.7	2.7
Glutamic acid	29.5	27.7	28.2	28.4	29.6	29.4
Glycine	6.8	6.3	6.5	6.7	7.0	7.1
Proline	8.9	9.8	8.3	7.8	8.7	8.6
Serine	7.8	7.8	7.3	7.2	7.8	7.8
Tyrosine	5.2	5.3	5.0	5.1	5.2	5.3

[a] Values for metabolizable energy, calcium, phosphorus and digestible phosphorus were calculated based on NRC,[14] but all other values were analyzed.

was not influenced by the inclusion of raw field peas in the diet. The ADG of pigs tended to increase from day 1 to 11 of the experiment from 431 g d^{-1} for pigs fed the control diet to 512 and 430 g d^{-1} for pigs fed the diets containing 245 or 490 g kg^{-1} extruded field peas, respectively (quadratic, $P = 0.057$). A tendency for a quadratic response ($P = 0.071$) to extruded field peas was also observed for final body weight of pigs after 11 days from 16.07 kg for pigs fed the control diet to 16.86 and 15.87 kg for pigs fed the diets containing 245 or 490 g kg^{-1} extruded field peas, respectively. However, ADFI and G : F from day 1 to 11 were not influenced by the inclusion of extruded field peas in the diets.

From day 11 to 25, ADFI decreased (linear, $P < 0.05$) from 1174 to 1174 and 1080 g d^{-1}, and the ADG tended to decrease (linear, $P = 0.105$) from 686 to 663 and 621 g d^{-1} as the dietary inclusion of raw field peas increased from 0 to 245 and 490 g kg^{-1}, but G : F was not influenced by the inclusion of raw field peas in the diets. The ADFI also was reduced (linear, $P < 0.05$) from 1174 to 1137 and 1036 g d^{-1} as the inclusion of extruded field peas increased in the diets from 0 to 245 and 490 g kg^{-1}. The dietary concentration of extruded field peas, however, did not influence ADG or G : F from day 11 to 25 of the experiment. For the overall experimental period, ADG and final body weight were not influenced by the inclusion of either raw or extruded field peas in the diets, but, regardless of the source of field peas, ADFI was reduced (linear, $P < 0.05$) as the concentration increased from 0 to 245 and 490 g kg^{-1}.

DISCUSSION

Ingredient composition

The composition of corn, full-fat soybeans and raw field peas were close to expected values,[9,14,21] but the concentration of crude protein and most AA in soybean meal was slightly lower than expected. Concentrations of ether extract, sucrose and oligosaccharides in soybean meal and full-fat soybeans agree with previous values,[21,22] but the concentration of acid detergent fiber and neutral detergent fiber in the soybean meal used in the present experiment was greater than the values reported by Baker and Stein.[22] The reason for this observation is most likely that a source of soybean meal that was not dehulled was used in the present experiment, whereas dehulled soybean meal was used by Baker and Stein.[22] The concentration of AA in field peas was close to expected values.[2,9,14]

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Table 4. Ingredient composition of diets (as-fed basis), Experiment 2

		Raw field peas (g kg^{-1})		Extruded field peas (g kg^{-1})	
Ingredient (g kg^{-1})	Control	245	490	245	490
Ground corn	568.2	412.0	255.9	412.0	255.9
Soybean meal (44% crude protein)	160.0	80.0	–	80.0	–
Raw field peas	–	245.0	490.0	–	–
Extruded field peas	–	–	–	245.0	490.0
Extruded soybeans	210.0	210.0	210.0	210.0	210.0
Soybean oil	30.0	24.5	19.0	24.5	19.0
Ground limestone	10.0	9.0	8.0	9.0	8.0
Monocalcium phosphate	12.5	10.8	9.0	10.8	9.0
L-Lysine-HCl	2.4	1.2	–	1.2	–
DL-Methionine	0.4	0.9	1.4	0.9	1.4
L-Threonine	0.5	0.5	0.5	0.5	0.5
L-Tryptophan	–	0.1	0.2	0.1	0.2
Salt	4.0	4.0	4.0	4.0	4.0
Vitamin premix[a]	0.5	0.5	0.5	0.5	0.5
Micromineral premix[b]	1.5	1.5	1.5	1.5	1.5

[a] Supplied per kilogram of complete diet: vitamin A, 10990 IU as vitamin A, acetate; vitamin D_3, 1648 IU as D-activated animal sterol; vitamin E, 55 IU as alpha tocopherol acetate; vitamin K_3, 4.4 mg as menadione dimethylpyrimidinol bisulphite; thiamine, 3.3 mg as thiamine mononitrate; riboflavin, 9.9 mg; pyridoxine, 3.3 mg as pyridoxine hydrochloride; vitamin B_{12}, 0.044 mg; D-pantothenic acid, 33 mg as calcium pantothenate; niacin, 55 mg; folic acid, 1.1 mg; and biotin, 0.17 mg.
[b] Supplied per kilogram of complete diet: copper, 26 mg as copper sulfate; iron, 125 mg as iron sulfate; iodine, 0.31 mg as potassium iodate; manganese, 26 mg as manganese sulfate; selenium, 0.3 mg as sodium selenite; and zinc, 130 mg as zinc oxide.

Table 5. Analyzed energy and nutrient composition of experimental diets (as-fed basis), Experiment 2

		Raw field peas (g kg^{-1})		Extruded field peas (g kg^{-1})	
Item	Control	245	490	245	490
Gross energy (kcal kg^{-1})	4477	4421	4388	4478	4441
Dry matter (g kg^{-1})	901.7	894.6	896.2	909.2	920.2
Crude protein (g kg^{-1})	189.8	198.7	205.8	200.0	210.8
Ether extract (g kg^{-1})	97.6	90.2	83.8	92.1	80.7
Neutral detergent fiber (g kg^{-1})	86.8	115.7	168.7	104.8	245.2
Acid detergent fiber (g kg^{-1})	36.5	46.0	45.4	52.8	69.3
Indispensable amino acid (g kg^{-1})					
Arginine	12.1	13.5	14.5	13.4	15.8
Histidine	4.8	5.0	5.0	4.8	5.4
Isoleucine	7.8	8.5	8.5	8.0	9.4
Leucine	15.6	16.0	15.7	15.2	16.8
Lysine	13.5	13.0	13.3	13.6	14.5
Methionine	3.2	4.5	4.2	3.9	4.4
Phenylalanine	8.8	9.3	9.5	9.0	10.4
Threonine	7.8	8.1	8.2	8.2	8.7
Tryptophan	2.7	2.1	2.4	3.0	2.6
Valine	8.1	8.7	8.6	7.7	9.8
Dispensable amino acid (g kg^{-1})					
Alanine	9.0	9.2	9.1	8.8	9.7
Aspartic acid	19.0	20.5	21.3	19.9	23.3
Cysteine	3.0	3.1	3.1	2.9	3.2
Glutamic acid	32.6	34.0	34.1	32.7	37.0
Glycine	7.6	8.1	8.3	7.9	9.1
Proline	10.6	10.6	9.1	10.1	9.5
Serine	8.7	8.9	9.1	9.1	9.5
Tyrosine	6.0	6.1	6.2	6.2	6.3

Table 6. Performance of weanling pigs fed increasing levels of raw field peas,[a] Experiment 1

	Raw field peas (g kg^{-1})							*P*-value	
Item	0	120	240	360	480	600	SEM	Linear	Quadratic
Days 0–14									
Initial body weight (kg)	8.94	8.92	8.92	8.92	8.96	8.94	0.027	0.545	0.477
ADG (g d^{-1})	459	458	428	438	388	408	19.4	0.005	0.882
ADFI (g d^{-1})	767	770	771	762	767	781	30.4	0.826	0.789
Gain : feed	0.591	0.593	0.548	0.580	0.514	0.521	0.0168	<0.001	0.695
Final body weight (kg)	15.36	15.33	14.91	15.05	14.40	14.65	0.269	0.006	0.825
Days 14–28									
ADG (g d^{-1})	643	690	654	659	637	657	16.8	0.533	0.597
ADFI (g d^{-1})	1094	1096	1116	1065	1019	1050	34.2	0.070	0.693
Gain : feed	0.589	0.630	0.587	0.627	0.633	0.629	0.0235	0.190	0.906
Final body weight (kg)	24.36	24.99	24.06	24.27	23.31	23.85	0.402	0.025	0.871
Days 0–28									
ADG (g d^{-1})	551	574	541	548	512	533	14.5	0.024	0.835
ADFI (g d^{-1})	930	933	943	913	893	916	27.0	0.295	0.921
Gain : feed	0.592	0.614	0.573	0.606	0.578	0.585	0.0157	0.375	0.861

[a] Each least squares mean represents seven pens of four pigs per pen.
ADG, average daily gain; ADFI, average daily feed intake.

Table 7. Performance of weanling pigs fed diets containing raw field peas (RFP) or extruded field peas (EFP),[a] Experiment 2

	Diet					RFP			EFP		
		RFP (g kg^{-1})		EFP (g kg^{-1})			*P*-value			*P*-value	
	Control	245	490	245	490	SEM	Linear	Quad.	SEM	Linear	Quad.
Days 0–11											
Initial body weight (kg)	11.32	11.25	11.23	11.24	11.15	0.088	0.427	0.814	0.070	0.076	0.860
ADG (g d^{-1})	431	420	456	512	430	20.9	0.364	0.197	32.7	0.970	0.057
ADFI (g d^{-1})	809	818	811	848	760	24.0	0.952	0.985	40.5	0.356	0.175
Gain : feed	0.538	0.514	0.566	0.599	0.575	0.0162	0.197	0.041	0.0343	0.413	0.340
Final body weight (kg)	16.07	15.86	16.25	16.86	15.87	0.258	0.581	0.217	0.377	0.693	0.071
Days 11–25											
ADG (g d^{-1})	686	663	621	640	643	29.3	0.105	0.845	28.2	0.248	0.509
ADFI (g d^{-1})	1174	1174	1,080	1137	1036	33.2	0.047	0.291	39.0	0.017	0.471
Gain : feed	0.583	0.569	0.583	0.564	0.625	0.0145	0.995	0.382	0.0232	0.183	0.176
Final body weight (kg)	25.68	25.15	24.94	25.82	24.87	0.379	0.154	0.512	0.550	0.272	0.402
Days 0–25											
ADG (g d^{-1})	574	556	548	583	549	14.8	0.197	0.540	21.9	0.383	0.384
ADFI (g d^{-1})	1013	1018	962	1010	914	16.9	0.034	0.252	34.4	0.044	0.247
Gain : feed	0.568	0.551	0.576	0.578	0.606	0.0100	0.574	0.060	0.0196	0.160	0.682

[a] Each least squares mean represents seven pens of three or four pigs per pen.
ADG, average daily gain; ADFI, average daily feed intake.

Experiment 1

Field peas contain relatively low levels of sulfur containing AA and Trp,[9] and when field peas are included in diets fed to pigs diets may become deficient in these AA. Inclusion of DL-Met may ameliorate poor performance of pigs fed diets containing up to 300 g kg^{-1} field peas,[23] but inclusion of greater levels of field peas in diets fed to weanling pigs have resulted in reduced performance.[6,8] We hypothesized that this reduction in performance might be caused by a Trp deficiency. The diets we formulated were therefore balanced for concentrations of Trp by inclusion of crystalline Trp in diets containing 240, 360, 480 or 600 g kg^{-1} raw field peas. Analyzed values for Trp and all other AA were very close to calculated values. However, the linear reduction in ADG and final body weight as the level of raw field peas in the diets increased indicates that factors other than Trp are responsible for the reduction in performance. The linear reduction in ADG and body weight was mainly caused by the diets containing 480 and 600 g kg^{-1} raw field peas, and pigs fed diets containing 120, 240 or

360 g kg^{-1} raw field peas had performance that was very close to that of pigs fed the control diet. This observation agrees with data showing that inclusion of 200 g kg^{-1} field peas[4,5,24] or 300 g kg^{-1} field peas[3,23] in diets fed to weanling pigs from around 2 weeks post weaning results in performance that is not different from that of pigs fed corn–soybean meal diets. Based on the results from Experiment 1, it was concluded that weanling pigs tolerate up to at least 360 g kg^{-1} dietary raw field peas, but if 480 or 600 g kg^{-1} raw field peas is included in the diets growth performance may be reduced even if diets are balanced for sulfur-containing AA and Trp. It is therefore likely that factors other than AA imbalances are responsible for the reduction in performance observed at high inclusion rates of raw field peas.

Experiment 2

It was hypothesized that the reduction in pig growth performance that was observed in Experiment 1 at high inclusion levels of raw field peas could have been caused by anti-nutritional factors. The presence of anti-nutritional factors in field peas is well documented,[11,12] and some of these anti-nutritional factors may be inactivated if heated. To investigate whether thermal treatment might alleviate the negative effects of including 480 g kg^{-1} raw field peas in diets fed to weanling pigs as observed in Experiment 1, field peas were extruded to reduce a possible negative impact of anti-nutritional factors in the peas. The results of Experiment 2, however, did not support this hypothesis because the overall response to feeding extruded field peas was not different from that of feeding raw field peas and the reduction in ADFI that was observed for pigs fed diets containing 490 g kg^{-1} field peas compared with pigs fed the control diet was similar for the extruded and the raw field peas. The response to inclusion of dietary raw field peas obtained in Experiment 2 is similar to the response observed in Experiment 1 and shows that weanling pigs fed a diet containing 490 g kg^{-1} field peas will not perform as well as pigs fed a diet containing lower levels of raw field peas. It was, however, surprising that extrusion of field peas had no impact on pig performance because Myer and Froseth[6] reported an increase in pig performance when field peas were extruded compared with performance of pigs fed raw field peas. In contrast, other experiments showed no differences in performance between pigs fed raw and extruded field peas.[3,4] It is not clear why different responses to extrusion have been reported, but the different results may have been caused by differences in the level of anti-nutritional factors in the field peas that were used because relatively large differences in the concentration of anti-nutritional factors among varieties of field peas have been observed.[11]

CONCLUSIONS

Results of this research indicates that from 2 weeks post weaning pigs may be fed diets containing at least 360 g kg^{-1} raw field peas without negatively affecting growth performance if diets are balanced for concentrations of Trp and other indispensable AA. Inclusion of 480 or 600 g kg^{-1} raw field peas in the diets may, however, reduce growth performance of the pigs even if diets are fortified with crystalline AA. Feeding extruded field peas does not result in improved performance compared with feeding raw field peas. The current data suggest that the reduction in pig growth performance that is observed if field peas are included at 480 g kg^{-1} or more in diets fed to weanling pigs is caused by factors other than Trp deficiency or the presence of heat-labile anti-nutritional factors.

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