Performance of Growing/Finishing Pigs Fed Hulled and Dehulled Peas With and Without Dietary Enzymes

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ABSTRACT : Eighty crossbred pigs (Large White × Landrace) weighing 9.9 kg were assigned on the basis of sex, weight and litter to one of five dietary treatments in a factorial (5 treatments × 2 sexes) arrangement to compare the nutritive value of hulled and dehulled peas fed with or without enzyme (0.25% Allzyme PF and 0.5% Biogal-S). A barley and soybean meal diet served as a control. Eight castrates and eight gilts were fed each diet. Digestibility coefficients for dry matter, crude protein and energy were higher for diets containing dehulled peas than hulled peas. In addition, enzyme supplementation modestly increased the digestibility of all three nutrients. Over the entire experimental period (9.9 to 103.3 kg), there were no performance differences ($p>0.05$) between pigs fed soybean meal based diets or diets based on any of the pea products. In addition, there were no differences in performance between pigs fed diets containing hulled or dehulled peas or between pigs fed diets with or without dietary enzyme. Castrates gained weight significantly faster, consumed more feed but had a poorer feed conversion than gilts ($p<0.05$). There were no differences in carcass traits between pigs fed diets based on soybean meal or any of the pea products. Carcass traits were similar for pigs fed hulled or dehulled peas while enzyme supplementation also had no effect on carcass data. Castrate pigs had a lower carcass value index, estimated lean yield and loin lean depth ($p<0.05$). Loin fat depth was greater for castrates than gilts ($p<0.05$). The overall results of this experiment provide little support for the need for enzyme supplementation of pea based diets fed to swine. In addition, dehulling did not appreciably improve the nutritive value of peas. Therefore, since the process adds to the cost of the raw product, its use is unlikely to be economical.
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INTRODUCTION

The cereal grains commonly used as feed in livestock production contain insufficient quantities 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 the pig's diet contain a supplementary source of these limiting amino acids.

Soybean meal is the most commonly used source of supplementary protein for swine production and it is generally a consistent, high quality product (Swick, 1994). However, as the transportation cost for feed increases, swine producers will have to maximize the use of locally produced feedstuffs. Therefore, it is important that alternative sources of supplementary protein be developed. One crop that appears to have considerable potential for use in swine diets is the field pea (Castell, 1990).

Field 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 and 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). Fortunately, pea hulls are easily removed from whole peas. Whether or not dehulling is an economical process will be determined by the monetary value of the hulls, as well as the improvement that is obtained in the nutritive value of the peas as a result of this dehulling.

Pectins form substantial amounts of the polysaccharides found in pea hulls and most are very water soluble (Igbasan et al., 1997). Water soluble polysaccharides can produce viscous solutions thereby increasing digesta viscosity and reducing nutrient utilization (Thacker, 1999). Also present in the endosperm of peas are galactosides or oligosaccharides of the raffinose family (Igabasan et al., 1997). Oligosaccharides escape undigested to the lower gastrointestinal tract because of a lack of endogenous galactosidase enzyme which is required to cleave α-linked oligosaccharides. In the chicken, supplementation of pea based diets with enzymes has been shown to improve broiler performance (Brenes et al., 1993; Igbasan et al., 1997). However, to date, there has been little research to determine whether or not enzyme supplmentation of pea-based diets is also beneficial to swine. The objective of the following experiment was to compare the nutritive value of hulled and dehulled peas fed with and without enzyme.

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MATERIALS AND METHODS

Growth trial

Eighty crossbred pigs (Large White × Landrace; Genex Hybrid, Genex Swine Group, Regina, Saskatchewan) weighing 9.9±2.4 were assigned on the basis of sex, weight and litter to one of five dietary treatments in a factorial (5 treatments × 2 sexes) arrangement. A barley and soybean meal diet served as a control. The remaining pigs were fed treatment diets based on either hulled or dehulled peas with or without enzyme.

The field peas used were a spring-seeded, white flowered, smooth variety (cv Espace) grown in the Saskatoon area during the 1998 crop year. The available sample was divided in half with one portion left untreated while the remainder was dehulled using an impact dehuller followed by air aspiration to remove the hull (CSP Foods, Saskatoon, Saskatchewan). The enzyme treatment involved a combination of commercial enzymes. The cocktail included 0.25% Allzyme PF derived from *Aspergillus niger* fermentation (Alltech Biotechnology Center, Nicholasville, Kentucky) and 0.5% Biogal-S derived from a selected strain of *Saccharomyces cerevisiae* (Canadian Bio-Systems Inc; Calgary, Alberta). According to the manufacturer's specificantions, the principal enzyme activities present in Allzyme PF were protease, cellulase, xylanase, α-galactosidase and amylase while Biogal-S provided amylase, β-glucanase, cellulase, pentosanase, protease and α-galactosidase.

The trial was run for 119 days and concluded when the pigs reached an average weight of 103.3 kg. The experimental diets contained 17.6 to 18.4% crude protein until the pigs reached a weight of approximately 61.5 kg and then the crude protein level was dropped to between 15.8 and 16.3% for the duration of the trial. All diets were supplemented with sufficient vitamins and minerals to meet or exceed the levels recommended by the National Research Council (1998). The diets were pelleted using low-pressure steam at approximately 60°C.

The pigs were housed in groups of four in 2.7 × 3.6 m concrete floored pens and were provided with water ad libitum. The pens were equipped with four individual feeders. Each pig was allowed access to its own individual feeder for 30-min twice daily (07:00 h and 15:00 h). Individual body weight, feed consumption and feed conversion were recorded on a weekly basis. Eight barrows and eight gilts were fed each diet. Pigs were assigned to feeders in such a way as to minimize the potential for treatment effects to be confounded with environmental effects.

Digestibility determination

Total tract digestibility coefficients for dry matter, crude protein and gross energy were determined using four barrows per treatment starting at an average weight of 40 kg. The pigs were housed under identical conditions as those used in the growth trial and were fed the same diets as those used during the grower trial modified only by the addition of 0.5% chromic oxide as a digestibility marker. The marked feed was provided for a seven day acclimatization period, followed by a three day fecal collection. Fecal collections were made by bringing animals into a clean room immediately after feeding and recovering freshly voided feces. The fecal samples were frozen for storage. Prior to analysis, the samples were dried in a forced air oven dryer at 66°C for 60 h, followed by fine grinding (0.5-mm screen).

Carcass measurements

All pigs were slaughtered at a commercial abattoir at an average weight of 103.3 kg. Carcass weight was recorded and dressing percentage calculated. Carcass fat and lean measurements were obtained with a Destron PG 100 probe between the 3rd and 4th last ribs, 70 mm off the midline. These values were then used in calculating Carcass Value Indices according to the table of differentials in effect at the time of the experiment (Saskatchewan Pork Producers Marketing Board, 1997).

Chemical analysis

Analysis of feed and fecal samples for dry matter, crude protein, acid detergent fibre (ADF), ash, and ether extract (EE) were conducted according to the methods of the Association of Official Analytical Chemists (1980). An adiabatic oxygen bomb calorimeter was used to determine gross energy content. Chromic oxide was determined by the method of Fenton and Fenton (1979).

Statistical analysis

Pig performance and carcass data were analysed as a 5 × 2 factorial using the General Linear Models procedure of the Statistical Analysis System Institute, Inc. (SAS 1999) with the factors in the model consisting of treatment, sex and their two way interaction. The digestibility trial was analysed as a one way ANOVA. Five orthogonal contrasts were also evaluated including soybean meal vs all others; dehulled peas vs hulled peas; enzyme vs no enzyme; hulled peas vs hulled peas plus enzyme; dehulled peas vs dehulled peas plus enzyme.

RESULTS

The chemical analysis of the grower and finisher diets

Table 1. Formulation chemical composition of grower diets (9.9 to 61.5 kg)

	Control	Hulled peas	Hulled peas +enzyme	Dehulled peas	Dehulled peas +enzyme
Diet Formulation (% as fed)					
Barley (9.95% CP)	48.15	23.75	23.75	23.75	23.75
Wheat (13.70% CP)	25.00	25.00	25.00	25.00	25.00
Soybean meal (45.5% CP)	20.45	10.20	10.20	10.20	10.20
Hulled peas (19.58% CP)	----	35.60	35.60	----	----
Dehulled peas (20.09% CP)	----	----	----	35.60	35.60
Tallow	2.45	1.53	1.53	1.53	1.53
Dicalcium phosphate	1.01	1.05	1.05	1.05	1.05
Limestone	1.34	1.32	1.32	1.32	1.32
Salt	0.50	0.50	0.50	0.50	0.50
Vitamin-mineral premix[1]	1.00	1.00	1.00	1.00	1.00
Lysine	0.10	----	----	----	----
Methionine	----	0.05	0.05	0.05	0.05
Enzyme[2]	----	----	+	----	+
Nutrient Levels (% as fed)					
Gross energy (kcal/kg)	4,097	3,993	4,023	3,987	3,957
Moisture	9.97	10.50	9.18	10.44	11.20
Crude protein	18.44	17.66	17.89	18.27	18.22
Ether extract	4.53	3.20	3.24	3.16	3.14
Acid detergent fibre	5.40	5.56	5.63	3.74	3.76
Ash	5.46	5.19	5.30	5.23	5.13

[1] Supplied per kilogram of diet: 8,250 IU vitamin A; 825 IU vitamin D_3; 40 IU vitamin E; 4 mg vitamin K; 1 mg thiamin; 5 mg riboflavin; 35 mg niacin; 15 mg pantothenic acid; 2 mg folic acid; 25 µg vitamin B_{12}; 0.2 mg biotin; 80 mg iron: 25 mg manganese; 100 mg zinc; 15 mg copper; 0.5 mg iodine; 0.1 mg selenium.

[2] Enzyme cocktail containing 0.25% Allzyme PF and 0.5% Biogal-S.

are presented in tables 1 and 2. As expected, the diets based on dehulled peas were lower in ADF than the diets based on hulled peas. The EE content of the soybean control was higher than any of the diets containing peas regardless if hulled or dehulled. Enzyme supplementation did not appreciably alter the chemical composition of the diet.

The digestibility coefficient for dry matter was significantly lower (p=0.002) for pigs fed the soybean control diet than for any of the pea containing diets (table 3). Hulled peas had a lower digestibility coefficient than dehulled peas (p=0.004) while enzyme supplementation also increased dry matter digestibility (p=0.006). Enzyme supplementation was more effective for dehulled peas (p=0.002) than for hulled peas (p=0.47).

There were no differences (p=0.72) in protein digestibility between the diet containing soybean meal and any of the pea containing diets (table 3). Pigs fed dehulled peas had a higher protein digestibility than pigs fed hulled peas (p=0.003) while enzyme supplementation also increased protein digestibility (p=0.007). Enzyme supplementation was more effective for dehulled peas (p=0.001) than for hulled peas (p=0.63).

Digestibility coefficients for gross energy were higher (p=0.004) for the pea containing diets than for soybean meal (table 3). Dehulled peas produced higher digestibility coefficients than hulled peas (p=0.004) and enzyme supplementation also increased energy digestibility (p=0.009). Enzyme supplementation was more effective for dehulled peas (p=0.002) than for hulled peas (p=0.69).

Over the entire experimental period (9.9 to 103.3 kg), there were no performance differences (p>0.05) between pigs fed soybean meal based diets or diets based on either of the pea products (table 4). In addition, there were no differences (p>0.05) in performance between pigs fed diets containing hulled or dehulled peas or between pigs fed diets with or without dietary enzyme. Castrates gained weight significantly faster (p=0.0028), consumed more feed (p=0.0001) but had a poorer feed conversion (p=0.0125) than gilts (table 6).

There were no differences in carcass traits between pigs fed diets based on soybean meal or either of the pea products (table 5). Carcass traits were similar for pigs fed hulled or dehulled peas while enzyme supplementation also had no effect on carcass data. Castrate pigs had a lower carcass value index (p=0.002), estimated lean yield (p=0.0001) and loin lean depth (p=0.001; table 6). Loin fat

Table 2. Formulation and chemical composition of finisher diets (61.5 to 103.3 kg)

	Control	Hulled peas	Hulled peas + enzyme	Dehulled peas	Dehulled peas +enzyme
Diet Formulation (%)					
Barley (9.95% CP)	48.33	41.00	41.00	41.00	41.00
Wheat (13.70% CP)	37.72	28.88	28.88	28.88	28.88
Soybean meal (45.5% CP)	9.94	4.97	4.97	4.97	4.97
Hulled peas (19.58% CP)	----	21.18	21.18	----	----
Dehuled peas (20.09% CP)	----	----	----	21.88	21.88
Dicalcium phosphate	1.31	1.40	1.40	1.40	1.40
Limestone	1.07	1.07	1.07	1.07	1.07
Salt	0.50	0.50	0.50	0.50	0.50
Vitamin-mineral premix[1]	1.00	1.00	1.00	1.00	1.00
Lysine	0.13	----	----	----	----
Enzyme[2]	----	----	+	----	+
Nutrient Levels (% as fed)					
Moisture	9.67	10.15	9.71	10.52	9.33
Crude protein	16.31	15.84	15.93	15.89	16.04
Ether extract	1.96	1.92	1.83	1.84	1.86
Acid detergent fibre	4.42	4.92	5.23	4.06	4.15
Ash	5.01	5.01	4.97	4.85	4.87

[1] Supplied per kilogram of diet: 8,250 IU vitamin A; 825 IU vitamin D_3; 40 IU vitamin E; 4 mg vitamin K; 1 mg thiamin; 5 mg riboflavin; 35 mg niacin; 15 mg pantothenic acid; 2 mg folic acid; 25 μg vitamin B_{12}; 0.2 mg biotin; 80 mg iron: 25 mg manganese; 100 mg zinc;15 mg copper; 0.5 mg iodine; 0.1 mg selenium.

[2] Enzyme cocktail containing 0.25% Allzyme PF and 0.5% Biogal-S.

Table 3. Digestibility coefficients (%) for pigs fed diets based on hulled or dehulled peas with or without dietary enzyme

	Dietary treatments						P values for orthoginal contrasts[2]		
	Control	Hulled peas	Hulled peas +enzyme	Dehulled peas	Dehulled peas +enzyme	SEM[1]	Soybean vs peas	Hulled vs dehullled	Enzyme vs no enzyme
Dry matter	76.85[a]	78.51[a]	79.44[a]	79.69[a]	84.43[b]	0.89	0.002	0.004	0.006
Crude protein	76.11[a]	75.11[a]	74.40[a]	74.73[a]	81.90[b]	1.02	0.720	0.003	0.007
Gross energy	76.32[a]	77.94[a]	78.48[a]	78.92[a]	84.05[b]	0.95	0.005	0.004	0.009

[1] Standard Error of the Mean.

[2] P values for contrasting hulled peas vs hulled peas plus enzyme and dehulled peas vs dehulled peas plus enzyme are not shown.

[3] Means in same line followed by same letter do not differ (p>0.05).

depth was greater (p=0.0001) for castrates than gilts.

DISCUSSION

The overall results of this experiment confirm previous studies which have demonstrated the considerable potential of peas as a feed ingredient for use in growing-finishing pig diets (Bell and Wilson, 1970; Davies, 1984a,b; Grosjean and Gatel, 1986; Castell et al., 1988; Savage and Deo, 1989). Inclusion of 35% peas as a substitute for soybean meal had no detrimental effects on nutrient digestibility, pig performance or carcass traits.

Hull removal had virtually no effect on the nutritive value of peas. Although nutrient digestibility was modestly improved as a result of hull removal, this increased digestibility did not translate into any improvements in pig performance or carcass traits. Experiments with poultry have also indicated little improvement in nutritive value as a result of dehulling peas (Brenes et al., 1993; Igbasan and Guenter, 1996). The lack of improvement can be explained by the fact that the pea hull represents less than 10% of the seed weight (Castell, 1990). In addition, although the pea hull contains up to 75% fiber (Wright, 1985), the crude fiber is 72% digestible, compared with 97% for the nitrogen-free extract portion (Grosjean, 1985) indicating a fairly narrow window of opportunity to improve the

Table 4. Performance of pigs fed diets based on hulled or dehulled peas with or without dietary enzyme

	Dietary treatments						P values for orthoginal contrasts[2]		
	Control	Hulled peas	Hulled peas +enzyme	Dehulled peas	Dehulled peas +enzyme	SEM[1]	Soybean vs peas	Hulled vs dehullled	Enzyme vs no enzyme
Grower period (9.9 to 61.5 kg)									
Daily gain (kg)	0.68	0.64	0.66	0.67	0.70	0.03	0.82	0.27	0.29
Daily feed (kg)	1.39	1.29	0.35	1.35	1.40	0.06	0.55	0.37	0.40
Feed conversion	2.04	2.00	2.05	2.02	1.97	0.04	0.42	0.50	0.95
Finisher period (61.5 to 103.3 kg)									
Daily gain (kg)	1.11	1.09	1.06	1.04	1.00	0.03	0.07	0.09	0.26
Daily feed (kg)	3.13	3.09	3.09	2.99	2.93	0.08	0.24	0.09	0.76
Feed conversion	2.80	2.82	2.94	2.88	2.94	0.06	0.22	0.59	0.15
Total experiment (9.9 to 103.3 kg)									
Daily gain (kg)	0.82	0.80	0.80	0.80	1.80	0.02	0.30	0.95	0.88
Daily feed (kg)	1.95	1.90	1.94	1.92	1.89	0.04	0.40	0.76	0.86
Feed conversion	2.37	2.38	2.44	2.41	2.35	0.04	0.66	0.50	0.90

[1] Standard error of the mean.

[2] P values for contrasting hulled peas vs hulled peas plus enzyme and dehulled peas vs dehulled peas plus enzyme are not shown.

Table 5. Carcass traits of pigs fed diets based on hulled or dehulled peas with or without dietary enzyme

	Dietary treatments						P values for orthoginal contrasts[2]		
	Control	Hulled peas	Hulled peas +enzyme	Dehulled peas	Dehulled peas +enzyme	SEM[1]	Soybean vs peas	Hulled vs dehullled	Enzyme vs no enzyme
Slaughter weight (kg)	102.9	103.7	103.1	104.5	102.1	0.74	0.60	0.91	0.05
Carcass weight (kg)	79.1	78.8	79.7	80.0	79.9	0.75	0.52	0.38	0.60
Dressing percentage (%)	76.8	76.0	77.2	76.5	78.2	0.66	0.76	0.24	0.04
Carcass value index	107.9	108.3	107.9	111.2	107.9	1.64	0.64	0.40	0.25
Estimated lean yield (%)	60.3	60.5	59.7	60.5	59.5	0.40	0.56	0.81	0.03
Loin fat depth (mm)	18.4	17.7	19.3	18.0	20.2	0.84	0.67	0.50	0.03
Loin lean depth (mm)	54.3	52.9	51.5	55.7	54.0	1.47	0.64	0.08	0.30

[1] Standard error of the mean

[2] P values for contrasting hulled peas vs hulled peas plus enzyme and dehulled peas vs dehulled peas plus enzyme are not shown.

nutritive value through dehulling.

Enzyme supplementation improved nutrient digestibility for pigs fed dehulled peas but not for pigs fed hulled peas. The improvements in dry matter and crude protein digestibility were of a similar magnitude to those reported by Baucells et al. (2000) for pigs fed cereal-soybean-pea diets supplemented with α-galactosidase. However, in the present experiment, there were no improvements in growth rate, feed intake or feed conversion as a result of enzyme supplementation of either hulled or dehulled peas. Carcass traits were similarly unchanged as a result of enzyme supplementation. These results are therefore contrary to those reported by Baucells et al. (2000) who reported improvements in gain and feed conversion as a result of α-galactosidase supplementation. A potential explanation for this discrepancy may be the lower level of peas (25 vs 35%) and higher level of soybean meal (20 vs 10%) present in the diets used by Baucells et al. (2000). Since the average content of α-galactosides are 32 to 46 g/kg for peas (Bach Knudsen, 1997) and 43 to 53 g/kg for soybean meal (Trugo et al., 1995), it is likely that the improved performance observed by Baucells et al. (2000), may have had more to do with breaking down deleterious compounds in soybean meal than those compounds in peas.

In conclusion, the overall results of this experiment provide little support for the need for enzyme supplementation of pea based diets fed to swine. In addition, dehulling did not appreciably improve the nutritive value of peas and therefore, since the process adds to the cost of the raw product, its use is unlikely to be economical.

Table 6. Performance and carcass traits of castrates and gilts fed diets based on hulled or dehulled peas with or without dietary enzyme

	Castrates	Gilts	SEM[1]
Performance data			
Grower period (9.9 to 61.5 kg)			
Daily gain (kg)	0.69	0.66	0.02
Daily feed (kg)	1.41	1.30	0.04
Feed conversion	2.06[a]	1.97[b]	0.02
Finisher period (61.5 to 103.3 kg)			
Daily gain (kg)	1.13[a]	1.00[b]	0.03
Daily feed (kg)	3.33[a]	2.77[b]	0.04
Feed conversion	2.97[a]	2.79[b]	0.04
Total experiment (9.9 to 103.3 kg)			
Daily gain (kg)	0.83[a]	0.78[b]	0.01
Daily feed (kg)	2.01[a]	1.83[b]	0.02
Feed conversion	2.44[a]	2.34[b]	0.03
Carcass traits			
Slaughter weight (kg)	103.4	103.2	0.47
Carcass weight (kg)	78.7[a]	80.2[b]	0.48
Dressing percentage (%)	76.2[a]	77.7[b]	0.42
Carcass value index	106.3[a]	111.0[b]	1.03
Estimated lean yield (%)	59.2[a]	61.0[b]	0.25
Loin fat depth (mm)	20.4[a]	17.0[b]	0.53
Loin lean depth (mm)	50.6[a]	56.7[b]	0.93

[1] Standard Error of the Mean. [2] Means followed by same or no letter do not differ ($p>0.05$).

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