SHORT COMMUNICATION

Apparent and true total tract digestibility of phosphorus in field peas (*Pisum sativum* L.) by growing pigs

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Stein, H. H., Boersma, M. G. and Pedersen, C. 2006. **Apparent and true total tract digestibility of phosphorus in field peas (*Pisum sativum* L.) by growing pigs**. Can. J. Anim. Sci. **86**: 523–525. The apparent (ATTD) and true (TTTD) total tract digestibility of P in field peas were measured using growing pigs. Two diets based on field peas without or with microbial phytase were formulated. A P-free diet was also formulated to measure endogenous losses of P. Results of the experiment showed that the ATTD and TTTD of P in field peas with microbial phytase (65.9 and 72.3%, respectively) were greater ($P < 0.01$) than in field peas without microbial phytase (55.0 and 60.8%, respectively). The addition of microbial phytase to field peas also reduced ($P < 0.01$) the excretion of P in the feces (from 5.77 to 4.09 g/5 d).

Key words: Digestibility, endogenous losses, field peas, phosphorus, pig

Stein, H. H., Boersma, M. G. et Pedersen, C. 2006. **Digestibilité apparente et réelle totale du phosphore présent dans le pois de grande culture (*Pisum sativum* L.) chez les porcs en croissance**. Can. J. Anim. Sci. **86**: 523–525. Les auteurs ont déterminé la digestibilité apparente et réelle du phosphore (P) du pois de grande culture dans le tube digestif des porcs en croissance. Pour cela, ils ont préparé deux rations à base de pois, avec ou sans phytase bactérienne. Ils ont aussi préparé une ration sans P afin de mesurer les pertes endogènes de cet élément. Les résultats indiquent que la digestibilité apparente et la digestibilité réelle du P présent dans le pois sont plus élevées ($P < 0,01$) avec la phytase bactérienne (65,9 et 72,3 %, respectivement) qu'en l'absence de celle-ci (55,0 et 60,8 %, respectivement). L'addition de phytase bactérienne au pois diminue aussi ($P < 0,01$) l'excrétion de P dans les fèces (de 5,77 à 4,09 g pour cinq jours).

Mots clés: Digestibilité, pertes endogènes, pois de grande culture, phosphore, porc

There is no information available on the digestibility of phosphorus (P) in US grown field peas [National Research Council (NRC) 1998] or on the effects of adding microbial phytase to diets containing field peas. Therefore, it was the objective of the current experiment to measure the digestibility of P in field peas by growing pigs in diets without or with microbial phytase.

A smooth white flowered spring variety of field peas (Carneval) was used in the experiment. The peas were grown and harvested in South Dakota in 2003. Peas were ground through a 4.7-mm screen prior to feed mixing. Pigs used in the experiment originated from the matings of SP-1 boars to Line 13 sows (Ausgene Intl. Inc., Gridley, IL). The protocol for the experiment was reviewed and approved by the Institutional Animal Care and Use Committee at South Dakota State University (# 04-E017).

Two diets containing field peas (75%), cornstarch, and sugar were formulated. One of these diets contained no microbial phytase while 695 units per kg of microbial phytase (Rhonozyme, DSM, Pasippany, NJ) were added to the other diet. Field peas were the only P-contributing ingredient in these diets. Limestone was included in the diets to satisfy a calcium (Ca) to P ratio of 1.2:1. A P-free diet based on cornstarch, sugar, gelatin, and crystalline amino acids was also formulated according to the principles outlined by Petersen and Stein (2006).

Six barrows (initial body weight: 19.65 ± 0.9 kg) were placed in metabolism cages and allotted to a repeated 3 × 3 Latin square design. The squares were balanced for carryover effects and each of the three diets was fed to each of the

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Abbreviations: **ATTD**, apparent total tract digestibility; **DMI**, dry matter intake; **TTTD**, true total tract digestibility six pigs during one period. The daily quantity of feed provided per pig was calculated as 2.5 times the maintenance energy requirement of the pigs (i.e., 106 kcal ME $kg^{-0.75}$; NRC 1998) and divided into two equal meals. Water was available at all times from a nipple drinker. Each experimental period lasted 14 d. Procedures for feeding, sample collections, and analysis for dry matter, P, and Ca in diets, fecal samples, and urine were similar to those described previously (Stein et al. 2004; Petersen and Stein 2006). Phytase was analyzed in field peas and diets using spectrophotometry.

The apparent total tract digestibility (ATTD) for Ca and P were calculated for the two diets containing field peas, and the endogenous losses of P were calculated from the pigs fed the P-free diet. These values were then used to calculate the true total tract digestibility (TTTD) for P in field peas. The retention of Ca and P was also calculated. The ATTD, absorption, and retention of Ca in the P-free diet were calculated as well. In all calculations, previously published equations were used (Petersen and Stein 2006).

Results were analyzed by ANOVA using PROC MIXED in SAS (SAS Institute, Inc., Cary NC). Diet was the fixed effect and pig and period were the random effects. In the first model, all means except data for P digestibility, P absorption, and P retention were compared among all three diets. In the second model, means for P digestibility, P absorption, and P retention were compared between the two pea-containing diets. The diet fed in the previous period was included in both models to analyze for carry-over effects. However, there were no effects of the previous diet on any of the variables measured. Therefore, the models were run again without including the previous diet. Possible effects of period and pig were tested using the COVTEST option in PROG MIXED; however, neither period nor pig was found to be significant. The LSMeans procedure and the PDIFF option in PROC MIXED were used to separate the means. The pig was the experimental unit and an alpha level of 0.05 was used to assess significance among means.

The phytase in field peas analyzed three phytase units, which confirms that the intrinsic phytase activity in field peas is low as has been previously reported (Eekhout and de Paepe 1994; Helander et al. 1996). The concentration of phytase in the diet containing field peas without phytase was 7 units and the diet containing field peas and added phytase analyzed 695 units of phytase. The concentrations of Ca and P in field peas were 0.06 and 0.41%, respectively. These values also concur with previous estimates (Eeckhout and de Paepe 1994; NRC 1998; INRA-AFZ-INAPG 2004).

Results from the experiment (Table 1) showed that the fecal excretion of P was lower ($P < 0.01$) from pigs fed the field peas with phytase compared with pigs fed the field peas without phytase (4.09 vs. 5.77 g per 5 d), but pigs fed the P-free diet had the lowest ($P < 0.01$) excretion of P (0.74 g per 5 d). There were no differences among treatments in the fecal excretion of Ca. However, pigs on all treatment groups had different ($P < 0.001$) excretions of Ca in the urine (1.45, 0.51, and 6.29 g per 5 d for pigs fed field peas without phytase, field peas with phytase, and the P-free diet, respectively). Supplementation of the field pea diet with phytase also increased ($P < 0.01$) the urinary excretion of P (0.017 g per 5 d) compared with the urinary excretion from pigs fed field peas without phytase (0.007 g per 5 d) or the P-free diet (0.002 g per 5 d).

The ATTD for Ca did not differ among diets, but the ATTD for P was greater ($P < 0.01$) in the field peas containing phytase (65.9%) than in the field peas without phytase (55.0%). Values for ATTD of P ranging from 42 to 51% have been reported for European grown field peas without supplementation of microbial phytase (Jongbloed and Kemme 1990; INRA-AFZ-INAPG 2004; Skiba et al. 2004). Values for ATTD of P in field peas without and with microbial phytase of 47 and 69%, respectively, were also reported (Helander et al. 1996). Thus, the values for ATTD of P obtained in the present experiment concur with the values obtained for European grown field peas.

The addition of microbial phytase improved the ATTD of P by 10.9 percentage units. This improvement is less than what is sometimes observed for diets based on corn and soybean meal. The reason for this difference may be that more phytate is present in corn and soybean meal than in field peas (Eeckhout and de Paepe 1994), thus increasing substrate availability for the enzyme.

The endogenous loss of P was estimated from the pigs fed the P-free diet at 207 ± 15 mg kg^{-1} DMI. This value concurs with Ajakaiye et al. (2003) who reported an endogenous loss of P in growing pigs of 210 mg per kg DMI using a regression technique. A P-free diet that was adequate in amino acids was used in the present experiment to measure the endogenous loss of P. We did not observe any problems with feed intake or the wellbeing of pigs as a result of feeding this diet. This observation is in agreement with observations from our previous experiment using a similar diet (Petersen and Stein 2006).

The TTTD for P was calculated at 60.8 and 72.3% for field peas without and with phytase, respectively. These values were different ($P < 0.01$). The absorption of Ca was greater ($P < 0.01$) for the pigs fed the phytase supplemented field peas (11.52 g per 5 d) than for the pigs fed field peas without phytase (10.26 g per 5 d) or the P-free diet (9.38 g per 5 d). Likewise, the addition of phytase to the field pea-containing diet increased ($P < 0.05$) the absorption of P (7.10 vs. 8.13 g per 5 d for pigs fed the field pea diets without or with phytase, respectively). The retention of P also was greater ($P < 0.05$) if the field pea-diet supplemented with phytase was fed compared with the field pea-diet without phytase (7.78 vs. 6.97 g per 5 d). Calculated as a percentage of P-intake, the retention of P increased ($P < 0.05$) from 54.0 to 63.1% as phytase was added to field peas.

The retention of Ca varied ($P < 0.05$) among all three diets. Pigs fed the phytase supplemented diet had a retention of 11.01 g per 5 d whereas the retention of Ca was only 8.81 and 3.09 g per 5 d, respectively, for pigs fed the field pea-diet without phytase or the P-free diet. These numbers were equivalent to a Ca retention of 75.0, 62.5, and 23.6% for the diet with phytase, the diet without phytase, and the P-free diet, respectively.

The low excretion of P in the urine for all diets is in agreement with previous published data for pigs (Petersen and

Table 1. Balance and apparent total tract digestibility (ATTD) of Ca and P and true total tract digestibility (TTTD) of P in field peas without and with added microbial phytase[z, y]

Item	Peas without phytase	Peas with phytase	P-free	SEM	*P* value
Feed intake (kg DM)	3.64*a*	3.75*b*	3.54*c*	0.270	0.004
Ca intake (g)	14.02*b*	14.54*c*	13.11*a*	0.95	0.001
P intake (g)	12.87*b*	12.21*a*	–	0.666	0.001
Ca in feces (g)	3.76	3.02	3.73	0.380	0.15
P in feces (g)	5.77*a*	4.09*b*	0.74*c*	0.340	0.001
Ca in urine (g)	1.45*a*	0.51*b*	6.29*c*	0.245	0.001
P in urine (g)	0.007*a*	0.017*b*	0.002*a*	0.0031	0.008
ATTD, Ca (%)	72.8	78.1	71.5	3.39	0.07
ATTD, P (%)	55.0*a*	65.9*b*	–	4.64	0.004
TTTD, P (%)	60.8*a*	72.3*b*	–	4.64	0.004
Ca absorption (g)	10.26*a*	11.52*b*	9.38*a*	1.13	0.002
P absorption (g)	7.10*a*	8.13*b*	–	0.990	0.02
Ca retention (g)	8.81*b*	11.01*c*	3.09*c*	1.034	0.001
P retention (g)	6.97*a*	7.78*b*	–	0.952	0.02
Ca, retention (%)	62.5*b*	75.0*c*	23.6*a*	3.40	0.001
P, retention (%)	54.0*a*	63.1*b*	–	4.48	0.003

[z]Data represent intake and output over a 5-d collection period.
[y]Data represent means of six observations per treatment.
a–c Data within a row without a common letter are different ($P < 0.05$).

Stein 2006) and indicates that the concentration of P in the diets used in the current experiment did not exceed the pig's requirement for maximum P retention. When pigs were fed the diet containing phytase, they absorbed more P, and therefore, increased retention. This also explains why the retention of Ca increased as phytase was added to the diet because bone tissue synthesis requires both Ca and P to be present in sufficient quantities. The increased absorption of Ca in the diet containing phytase is likely a result of some Ca being released from the phytate molecule by the microbial phytase. Recently, an increase in the digestibility of Ca in a barley-canola meal based diet upon the addition of microbial phytase was reported (Sauer et al. 2003).

The values for ATTD of Ca in the P-free diet and the fecal excretion of Ca from pigs fed this diet were close to the values for the pigs fed the field pea diet without phytase. However, because no P was present for bone tissue synthesis in pigs fed the P-free diet, most of the absorbed Ca was excreted in the urine. The urinary output of Ca, therefore, was much greater in pigs fed the P-free diet than in pigs fed the two field pea diets. These observations indicate that Ca digestibility is not influenced by the presence or absence of P in the diet. This finding is in agreement with Helander et al. (1996) who reported that the fecal excretion of Ca was not influenced by the P concentration in the diet, but the urinary excretion of Ca was reduced and Ca retention was improved as the concentration of P in the diet increased. Based on these observations, it can be concluded that pigs are able to efficiently absorb Ca from the intestinal tract regardless of the dietary P concentration, but if the absorbed Ca cannot be used for bone tissue synthesis because of insufficient quantities of available P, then it will be excreted in the urine. The urinary excretion of Ca, therefore, is important for the overall Ca homeostatus of the pig.

In conclusion, results from the current experiment indicate that P in field peas grown in the United States has a relatively high digestibility that is comparable to values reported for field peas grown in Europe. Because of the presence of phytate-bound P in field peas, the digestibility of P may be further improved by supplementing field pea-containing diets with microbial phytase. As a consequence, by using both field peas and microbial phytase in diets fed to growing pigs, the excretion of P in the manure can be reduced.

Financial support from the USDA/CSREES Consortium for Alternative Crops is greatly appreciated.

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