Digestibility to swine of energy and nutrients in field peas.

Hans H. Stein, PhD.

Department of Animal Sciences

University of Illinois, Urbana IL 61801

Summary

Field peas (*Pisum sativum L.*) have a nutrient profile that is intermediate between corn and soybean meal. The digestibility of most amino acids in field peas is similar to that in soybean meal, and the concentration of digestible energy (3,864 kcal DE per kg DM) in field peas is similar to that in corn. The apparent total tract digestibility of P in field peas is 55 and 65%, respectively, in diets without or with microbial phytase. Starch is digested by approximately 90% in the small intestine and 100% over the entire digestive tract. The alpha galactosides in field peas are well digested in the small intestine of pigs, and other fibers are mainly digested in the large intestine. The digestibility of energy may be improved by 3 – 4 percentage units upon extrusion at 115^{o}C. Likewise, the digestibility of most nutrients will also be improved if the peas are extruder prior to feeding.

Amino Acid Digestibility

Field peas have a moderate concentration of crude protein (Approximately 22%). The pea protein has a relatively high concentration of lysine but low concentration of methionine, cysteine, and tryptophan compared with soybean protein (Table 1). The ileal digestibility of most amino acids in US-grown field peas is comparable to the digestibility of amino acids in soybean meal (Stein et al., 2004). However, the digestibility of methionine, cysteine, and tryptophan in field peas is lower than in soybean meal (Table 1) and the digestibility of threonine tends to be lower in field peas than in soybean meal. The digestibility values for amino acids in US-grown field peas concur with published reports on the digestibility of amino acids in field peas grown in

Europe (Grala et al., 1999), Australia (van Barneveld and Batterham, 1994), and in Canada (Fan and Sauer, 1995; 1999). The reason why certain amino acids have a lower digestibility than others may be related to their location within the pea seed. Albumin, which has a relatively high concentration of methionine, threonine, and tryptophan, is less digestible than other proteins in the seed (le Guen et al., 1995). This may explain why lower digestibilities for these amino acids have been reported.

The effect of thermal treatment on the ileal digestibility of amino acids has been investigated in a few experiments. For field peas grown in Canada and in the US, improvements of 4 to 6 percentage units in the apparent and standardized ileal digestibilities for most amino acids have been reported as a result of extrusion or micronization (Owusu-Asiedu et al., 2002; Stein et al., unpublished). The amino acids that have the lowest digestibility in raw field peas (i.e., methionine, threonine, and tryptophan) have the largest improvement in digestibility upon thermal treatment.

Carbohydrate Digestibility

The carbohydrate fraction in field peas grown in Europe mainly consists of sucrose (3 – 4%), alpha-galactosides (3 – 4%), starch (40 – 45%), and non-starch polysaccharides (15 – 20%), whereas the concentration of lignin is less than 1% (Bengala Freire et al. 1991; Canibe and Bach Knudsen, 1997). Unpublished data from South Dakota State University indicate that the concentration of starch and non-starch polysaccharides in field peas grown in the US is similar to the values reported for European-grown field peas. The apparent ileal digestibility of sucrose is close to 100%, and the apparent ileal digestibility of starch in European-grown field peas is between 85

and 97% (Bengala Freire et al. 1991; Canibe and Bach Knudsen, 1997). In raw US-grown field peas, the apparent ileal digestibility of starch is approximately 90%, but this value is increased to approximately 95% if the field peas are extruded at 115 to 155°C (Table 2). The alpha-galactosides (i.e., raffiose, stachyose, and verbascose) require the enzyme alpha-galactosidase for digestion. This enzyme is not synthesized by mammals, but there is some intrinsic alpha-galactosidase present in field peas. Intestinal microbes may also produce this enzyme; alpha-galactosides are, therefore, relatively well digested by swine and have an apparent ileal digestibility of 78% (Bengala Freire et al., 1991). The non-starch polysaccharides (i.e., ADF and NDF) have a low digestibility in the small intestine but, due to the microbial fermentation in the hindgut, the total tract digestibility of the non-starch polysaccharides is between 80 and 87% in both raw and extruded field peas (Canibe and Bach Knudsen, 1997; Stein et al., unpublished; Table 2).

Phosphorus Digestibility

Field peas contain approximately 0.40% phosphorus (NRC, 1998; Stein et al., 2006). Of the total concentration of phosphorus, 45 to 52% is bound in the phytate complex, and therefore, has a low digestibility by swine and poultry. However, the unbound phosphorus is highly digestible and the overall digestibility of phosphorus in US grown field peas fed to growing pigs is 55% (Table 3). For European-grown field peas, apparent total tract digestibility values of 42 to 51% have been reported (Jongbloed and Kemme, 1990; Helander et al., 1996). However, the digestibility of phosphorus can be improved by 10 to 15 percentage units if microbial phytase is added to diets containing field peas (Helander et al., 1996; Stein et al., 2006; Table 3). Thus, the digestibility of

phosphorus in field peas is considerably greater than in corn and soybean meal and the addition of field peas to diets will reduce the need for inorganic sources of phosphorus. The excretion of phosphorus in the manure will also be reduced if field peas are included in the formulas.

Energy Digestibility

The concentration of gross energy in field peas grown in the US is comparable to that in corn (Stein et al., 2004). Likewise, the digestibility of energy and the concentration of digestible energy (**DE**) in field peas are not different from corn (Table 4). The value for DE in field peas grown in the US (3,864 kcal DE per kg DM) is also comparable to values reported for field peas grown in Canada (3,862 kcal DE per kg DM; Zijlstra et al., 1998) and in Europe (3,904 kcal DE per kg DM; Grosjean et al., 1998). However, the concentration of metabolizable energy in field peas is slightly lower than in corn. As shown in Table 2, the digestibility of energy can be improved by 2 – 3 percentage units if field peas are extruded prior to feeding.

References

Bengala Freire, J., A. Aumaitre, and J. Peiniau. 1991. Effects of feeding raw and extruded peas on ileal digetibility, pancreatic enzymes and plasma glucose and insulin in early weaned pigs. J. Anim. Phys. Anim. Nutr. 65:154-164.

Canibe, N., and K. E. Bach Knudsen. 1997. Digestibility of dried and toasted peas in pigs. 1. Ileal and total tract digestibilities of carbohydrates. Anim. Feed Sci. Technol. 64:293-310.

Fan, M. Z., and W. C. Sauer. 1995. Determination of apparent ileal amino acid digestibility in peas for pigs with the direct, difference and regression methods. Livest. Prod. Sci. 44:61-72.

Fan, M. Z., and W. C. Sauer. 1999. Variability of apparent ileal amino acid digestibility in different pea samples for growing-finishing pigs. Can. J. Anim. Sci. 79:467-475.

Grala, W., M. W. A. Verstegen, A. J. M. Jansman, J. Huisman, and P. van Leeuwen. 1999. Apparent protein digestibility and recovery of endogenous nitrogen at the terminal ileum of pigs fed diets containing various soyabean products, peas or rapeseed hulls. Anim. Feed Sci. Technol. 80:231-245.

Grosjean, F., D. Bastianelli, A. Bourdillon, P. Cerneau, C. Jondreville, and C. Peyronnet. 1998. Feeding value of pea (Pisum Sativum, L.) 2. Nutritional value in the pig. Anim. Sci. 7:621-625.

Helander, E., Nasi, M., and Partanen, K. 1996. Effects of supplementary *Aspergillus niger* phytase on the availability of plant phosphorus, other minerals, and

nutrients in growing pigs fed on high pea-diets. J. Anim. Phys. Anim. Nutr. 76:66-79.

Jongbloed, A. W., and Kemme, P. A. 1990. Apparent digestible phosphorus in the feeding of pigs in relation to availability, requirement and environment. 1. Digestible phosphorus in feedstuffs from plant and animal origin. Netherlands J. Agric. Sci. 38:567-575.

le Guen, M. P. J. Huisman, and M. W. A. Verstegen. 1995. Partition of the amino acids in ileal digesta from piglets fed pea protein diets. Livest. Prod. Sci. 44:169-178.

Owusu-Asiedu, A., S. K. Baidoo, and C. M. Nyachoti. 2002. Effect of heat processing on nutrient digestibility in pea and supplementing amylase and xylanase to raw, extruded, or micronized pea-based diets on performance of early weaned pigs. Can. J. Anim. Sci. 82:367-374.

Stein, H. H., G. Benzoni, R. A. Bohlke, and D. N. Peters. 2004. Assessment of the feeding value of South Dakota grown field peas (*Pisum sativum L.*) for growing pigs. J. Anim. Sci. 82:2568-2578.

Stein, H. H., M. G. Boersma, and C. Pedersen. 2006. Apparent and true total tract digestibility of phosphorus in field peas (*Pisum sativum L.*) by growing pigs. Can. J. Anim. Sci. (*Submitted*).

van Barneveld, R. J., and E. S. Batterham. 1994. The effect of heat on amino acids for growing pigs. 2. Utilization of ileal digestible lysine from heat treated field peas (Pisum Sativum cultivar Dundale). Br. J. Nutr. 772:243-256.

Zijlstra, R. T., J. F. Patience, S. L. Fairbairn, D. A. Gillis, and D. L. Whittington. 1998.

Variation in the digestible energy content of field peas for grower pigs. J. Anim. Sci. 76 (Suppl. 1): 63 (Abstr.)

Table 1. Amino acid composition of the protein and amino acid and protein digestibility in field peas and soybean meal (as fed basis) [a]

Ingredient:	Field peas			Soybean meal		
Item:	% of ingredient	% of crude protein	SID [b]	% of ingredient	% of crude protein	SID [b]
Nutrient						
Crude protein	22.8	100	79.9	47.5	100	84.5
Arginine	1.87	8.20	92.8	3.48	7.32	93.0
Histidine	0.54	2.37	88.3	1.28	2.70	89.7
Isoleucine	0.86	3.77	83.4	2.16	4.55	86.3
Leucine	1.51	6.62	85.7	3.66	7.71	86.1
Lysine	1.50	6.58	88.1	3.02	6.36	88.4
Methionine	0.21	0.92	77.9	0.67	1.41	89.1
Cysteine	0.31	1.36	67.3	0.74	1.56	83.9
Phenylalanine	0.98	4.30	86.9	2.39	5.05	86.9
Tyrosine	0.71	3.11	84.7	1.82	3.83	87.2
Threonine	0.78	3.42	80.2	1.85	3.90	85.9
Tryptophan	0.19	0.83	54.3	0.65	1.37	78.5
Valine	0.98	4.30	78.2	2.27	4.78	82.7

[a] Data for amino acid concentration and composition are from NRC (1998). Data for SID of protein and amino acids are from Stein et al., 2004.

[b] SID = standardized ileal digestibility (%).

Table 2. Effects of thermal treatment on the digestibility (%) of starch, NDF, ADF, and energy in field peas fed to growing pigs [a]

	Extrusion				SEM [b]	*P*-Value	
Item	None	75 °C	115 °C	155 °C	-	Linear effect	Quadratic effect
Apparent ileal digestibility							
Starch	89.8	92.1	94.7	95.9	0.79	0.001	0.50
Energy	71.5	76.4	79.3	79.0	1.43	0.001	0.09
Apparent total tract digestibility							
Starch	99.2	99.6	99.7	98.6	0.45	0.50	0.20
NDF	81.3	85.2	86.3	73.2	6.83	0.50	0.30
ADF	79.5	83.2	84.8	71.9	7.71	0.60	0.40
Energy	89.0	91.8	93.3	91.7	0.78	0.02	0.01

[a] Unpublished data from South Dakota State University (N = 6).

[b] SEM = standard error of the mean.

Table 3. Apparent total tract digestibility (ATTD) of calcium and phosphorus in field peas without and with added microbial phytase [a]

Item	Diet: Peas without phytase	Peas with phytase [b]	SEM [c]	*P*-value
ATTD, calcium, %	72.8	78.1	3.39	0.07
ATTD, phosphorus, %	55.0	65.9	4.64	0.004

[a] Data (N = 6) from Stein et al. (2006a).

[b] Microbial phytase (Rhonozyme, DSM, Passippani, NJ) added in the amount of 695 units per kilogram (315 units per lb) of diet.

[c] SEM = standard error of the mean.

Table 4. Energy concentration in field peas and corn [a]

Item	Ingredient: Field Peas	Corn	SEM [b]	*P*-value
Apparent digestible energy in DM, kcal	3,864	3,879	27	0.68
Metabolizable energy in DM, kcal	3,741	3,825	24	0.04

[a] Data (N = 6) from Stein et al. (2004).

[b] SEM = Standard error of the mean.