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The Effect of Source of Dietary Fiber and Starch on Ileal and Fecal Amino Acid Digestibility in Growing Pigs

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ABSTRACT : Studies were carried out with a repeated 4×4 Latin square design with eight cannulated pigs fed four experimental diets to investigate the effect of dietary fiber and starch sources on apparent ileal and fecal amino acid digestibility. Each period lasted 15 d, with diet acclimation from d 1 to 7, feces collection for 48 h on d 8 to 9 and ileal sample collection for 12 h on d 13 to 15. The four experimental diets consisted mainly of cooked rice with the addition of protein sources (CON), partial replacement of cooked rice with either potato starch (PS), sugar beet pulp (SBP) or wheat bran (WB). Chromic oxide was used as an indigestible marker. With the exception of histidine, lysine and tryptophan, no differences were observed in the apparent ileal digestibility of amino acids between diets. The inclusion of potato starch did not affect the ileal and fecal amino acid digestibility. In comparison with diet CON, a decreased ($p<0.05$) ileal digestibility of histidine was found in pigs fed diet SBP, while the ileal digestibilities of histidine, lysine and tryptophan were decreased ($p<0.05$) by the inclusion of wheat bran. Inclusion of fiber sources (sugar beet pulp and wheat bran) caused a reduction ($p<0.05$) in the fecal amino acid digestibility and the net disappearance of amino acids in the large intestine. Of the indispensable amino acids, there was a 'net synthesis' for methionine in the large intestine of pigs when diets were supplemented with dietary fiber. The decrease in fecal amino acid digestibility with the addition of dietary fiber indicates an increase in the synthesis of bacterial protein in the large intestine. (**Key Words :** Amino Acid, Digestibility, Cooked Rice, Fiber, Pigs, Potato Starch)

INTRODUCTION

It is well established that non-starch polysaccharides (NSP) play an important role on the digestion and absorption of nutrients in many non-ruminant species (Graham et al., 1986; Pluske et al., 2001). Carbohydrates consist of mono-, di- and oligo-saccharides and two broad classes of polysaccharides: NSP and starch (Cummings et al., 1997). From a nutritional point of view, starch may be classified into rapidly digestible starch, slowly digestible starch and resistant starch (Englyst et al., 1992).

Carbohydrates comprise 60-80% of the digestible dry matter in the majority of pig diets (Pluske et al., 2001). Numerous studies with pigs fed conventional diets show that the inclusion of dietary fiber caused a decreased ileal apparent crude protein (CP) digestibility (Graham et al., 1986; Phuc and Lindberg, 2000; Wang et al., 2002) and fecal apparent CP digestibility (Ravindran et al., 1987; Wang et al., 2002). The inclusion of fermentable carbohydrate sources resulted in a reduced urinary nitrogen excretion by pigs and ammonia emissions from slurry (Kornegay and Verstegen, 2001; Ko et al., 2004). The addition of β-glucan caused increased endogenous amino acid and nitrogen losses in the pig small intestine (Morel et al., 2005). The influence of fiber on digestion of protein and amino acids is partly dependent on its solubility in water (Li et al., 1994). Fermentable carbohydrates could be utilized as energy sources for microflora in the large intestine (Fuller and Reeds, 1998). The purpose of the present study was to investigate the influence of source of fiber and starch on the apparent ileal and fecal amino acid digestibility in growing pigs. Sugar beet pulp (a water-soluble dietary fiber source) and wheat bran (a water-insoluble dietary fiber source) were selected as sources of dietary fiber, while potato starch (unprocessed) and cooked rice were used as sources of starch in the present study.

MATERIALS AND METHODS

The experiment was carried out at the Danish Institute of Agricultural Sciences, Foulum, Denmark. The experimental protocol for the care and use of animals was in

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Table 1. Nutrient composition of the experimental diets[a]

Composition (% DM)	Diet			
	CON	PS	SBP	WB
Chemical composition				
CP (N×6.25)	19.88	19.19	19.13	19.00
HCl-fat	4.72	4.58	4.78	5.38
S-NSP[b]	0.87	0.92	4.72	1.35
I-NSP[b]	3.40	3.10	6.83	9.30
NSP[b]	4.27	4.02	11.55	10.65
Klason lignin	1.17	0.83	1.55	1.77
Dietary fiber	5.44	4.85	13.10	12.42
Starch	60.63	62.61	52.22	52.15
Ash	3.75	3.44	4.06	4.48
Gross energy (MJ/kg)	19.00	19.00	19.00	19.10
Indispensable amino acid content				
Argnine	1.17	1.08	1.12	1.23
Histidine	0.52	0.50	0.46	0.47
Isoleucine	0.74	0.73	0.81	0.72
Leucine	1.49	1.37	1.38	1.28
Lysine	1.08	1.04	1.22	0.94
Methionine	0.57	0.49	0.55	0.46
Phenylalanine	0.72	0.71	0.80	0.76
Threonine	0.73	0.70	0.79	0.71
Tryptophan	0.18	0.27	0.17	0.16
Valine	0.91	0.87	1.08	0.89
Dispensable amino acid content				
Alanine	0.96	0.92	1.04	0.94
Aspartic acid	1.55	1.49	1.68	1.55
Cystine	0.24	0.27	0.27	0.26
Glutamic acid	2.83	2.62	2.87	2.73
Glycine	0.74	0.73	0.83	0.83
Proline	1.40	0.79	1.60	1.18
Serine	0.86	0.78	0.87	0.77
Tyrosine	0.74	0.63	0.64	0.61

[a] CON = Control diet; PS = Potato starch-supplemented diet; SBP = Sugar beet pulp-supplemented diet; WB = Wheat bran-supplemented diet. The DM contents of diets CON, PS, SBP and WB were 33.6%, 36.6%, 37.7% and 38.9%, respectively.

[b] S-NSP = soluble non-starch polysaccharides; I-NSP = insoluble non-starch polysaccharides; NSP = non-starch polysaccharides.

accordance with the guidelines established by the Danish Ethical Commission.

Experimental diets, animals and feeding

The preparation of cooked rice and the composition of experimental diets have been reported in our earlier papers (Wang et al., 2002; Wang et al., 2004a). The nutrient composition of experimental diets is shown in Table 1.

A total of eight 10-week-old pigs (Danish Landrace× Large White) weighing 30-33 kg, obtained from the Danish Institute of Agricultural Sciences swine herd (Foulum, Denmark), were used in the present study. The pigs were fasted for 24 h prior to surgery, but water was available at all times through low-pressure nipples. The surgical procedure and daily feed allowance was reported in our earlier paper (Wang et al., 2002). The pigs received their daily feed allowance in three equal meals at 0700, 1500 and 2300, and ate their meals quickly and completely. Water was freely available at all times.

The study was carried out with a repeated 4×4 Latin square design with eight cannulated pigs fed with one of the four experimental diets. The experimental periods were 15 d, comprising 7 d of adaptation to each diet, followed by 2 d of collection of feces, 2 d of recording gas exchange (data not shown) and 3 d of collection of ileal digesta. The pigs were moved to individual stainless steel metabolic cages after each period of adaptation. Feces were collected every 6 h daily on d 8 to 9, frozen and stored at -20°C and mixed thoroughly before sampling for analysis. Total ileal digesta samples were collected for 12 h, comprising 0900-1100 and 1300-1500 on d 13, 0800-1000 and 1200-1400 on d 14, and 0700-0900 and 1100-1300 on d 15 (Bach Knudsen et al., 1993). The ileal digesta were collected on ice, frozen immediately after collection, stored at -20°C and mixed thoroughly for further analysis.

Analytical methods

The gross energy content was measured with an adiabatic bomb calorimeter (IKA Calorimeter C 400; Janke and Kunkel, Germany). Hydrochloric acid-hydrolysed fat (HCl-fat) was extracted with diethyl ether after acid hydrolysis (Stoldt, 1952). Ash was analyzed by the method of the Association of Official Analytical Chemists (AOAC, 1990; method 942.05). Dry matter contents of ileal digesta and fecal samples were analyzed after freeze-drying followed by drying at 105°C for 20 h. Starch was measured enzymatically as described by Bach Knudsen (1997). Chromic oxide was determined according to the procedure of Fenton and Fenton (1979). Total NSP and constituent sugars were determined as alditol acetates by GLC, uronic acids by colorimetry and Klason lignin by gravimetry as described by Bach Knudsen (1997). Dietary fiber is calculated as the sum of total NSP and Klason lignin.

Crude protein (N×6.25) was determined in a Kjell-Foss 1620 autoanalyser (Foss Electric A/S, Denmark) by the Kjeldahl method. For amino acid analysis, with the exception of methionine, cystine, and tryptophan, approximately 0.1 g of freeze-dried sample was weighed into a screw-capped tube and mixed with 3 ml 6 M HCl. The tubes were purged with nitrogen and then hydrolyzed in an oven at 110°C for 24 h. The hydrolyzed samples were mixed with the internal standard, DL-amino-n-butyric acid, and centrifuged (1,110 g, 15 min) at room temperature. The supernatant of the sample was analyzed according to the method of Spackman et al. (1958) using an amino acid autoanalyser (Hitachi L-8800, Tokyo, Japan). Methionine and cystine were measured as methionine sulfone and cysteic acid with separate samples after oxidation with 98%

Table 2. Apparent ileal dry matter, CP, and amino acid digestibilities (%) in pigs fed the test diets[a]

Item	Diet[b]				SEM	p-value[c]
	CON	PS	SBP	WB		
Dry matter	87.7^{x}	84.8^{x}	77.2^{y}	76.9^{y}	1.24	0.001
CP	81.3^{x}	$77.7^{x, y}$	$76.1^{y, z}$	75.2^{z}	1.05	0.012
Indispensable amino acids						
Arginine	90.8	89.9	89.2	89.4	0.78	0.546
Histidine	87.9^{x}	86.3^{x}	82.6^{y}	83.2^{y}	1.17	0.023
Isoleucine	84.3	84.0	83.4	82.6	0.91	0.560
Leucine	86.1	84.7	82.9	82.0	1.24	0.116
Lysine	90.7^{x}	89.8^{x}	$88.6^{x, y}$	86.4^{y}	0.73	0.002
Methionine	86.8	84.8	86.2	85.8	1.11	0.630
Phenylalanine	82.9	83.1	81.6	82.1	1.06	0.796
Threonine	79.3	78.1	77.2	76.8	1.32	0.583
Tryptophan	$81.9^{x, y}$	84.6^{y}	$78.6^{y, z}$	76.4^{z}	1.64	0.008
Valine	82.9	82.8	82.0	81.0	1.02	0.540
Dispensable amino acids						
Alanine	82.9	81.9	81.5	83.1	1.81	0.921
Aspartic acid	80.8	79.8	79.5	79.8	1.29	0.910
Cystine	77.4	76.9	75.2	74.9	0.76	0.695
Glutamic acid	85.6	84.6	83.3	84.1	1.08	0.625
Glycine	74.1	72.6	70.1	73.0	1.91	0.630
Proline	91.6	90.2	90.1	90.1	1.02	0.656
Serine	83.4	81.5	79.9	79.5	1.33	0.185
Tyrosine	86.5	83.9	81.6	83.8	1.18	0.101

[a] Values represent means of eight observations.

[b] CON = Control diet; PS = Potato starch-supplemented diet; SBP = Sugar beet pulp-supplemented diet; WB = Wheat bran-supplemented diet.

[c] The P-value represents the total diet effect; when $p<0.05$ was observed, the means were further separated by a Fisher LSD separation test at $p = 0.05$.

[x, y, z] Means within a row lacking a common superscript differ ($p<0.05$).

performic acid at 0°C for 24 h (Moore, 1963). The oxidized samples were hydrolyzed in the same manner as the samples that were not oxidized. For tryptophan analysis, approximately 50 mg of sample was weighed into a screw-capped polytetrafluoroethylene (PTFE) tube and mixed with 5 ml 5 M NaOH containing 5% $SnCl_2$. Thereafter, the samples were treated in the same manner as the hydrolyzed samples and analyzed according to the method of Bech-Andersen (1991).

Calculations and statistical analysis

Total ileal effluent was calculated relative to the content of Cr_2O_3 as described by Bach Knudsen et al. (1993). Digestibility of dietary component and amino acids were calculated relative to the content of Cr_2O_3 as described by Bach Knudsen et al. (1993).

Data were analyzed by ANOVA using the GLM procedure (SAS Inst. Inc., Cary, NC) based on a repeated 4 ×4 Latin square design according to the model $Y_{ijkl} = \mu+\alpha_i+\beta_j+\gamma_k+\delta_l(\beta_{jl})+\varepsilon_{ijkl}$, where Y is the observed response, μ is the overall mean, α_i is the effect of diet ($i = 1, \ldots, 4$), β_j is the effect of block ($j = 1$ or 2), γ_k is the effect of period ($k = 1, \ldots, 4$), $\delta_l(\beta_{jl})$ is the effect of animal within block ($l = 1, \ldots, 4$), ε_{ijkl} is the residual error. When there was an overall effect of diet ($p<0.05$), differences between means were compared by the Fisher's least significant difference. Results are presented as mean values and standard error of means (SEM).

RESULTS

The ileal cannulated pigs remained healthy post-surgery and throughout the experimental period with no signs of infection or diseases. In general, feces had higher ($p<0.05$) moisture content in pigs fed diets SBP and WB (on average 69.1%) than in pigs fed diets CON and PS (on average 58.4%).

Ileal amino acid digestibility

With the exception of histidine, leucine, lysine and tryptophan, there were no differences in the apparent ileal digestibility of amino acids among the experimental diets. In comparison with diet CON, feeding potato starch did not affect the ileal amino acid digestibility. Feeding soluble dietary fiber (sugar beet pulp) caused a reduced ($p<0.05$) ileal digestibility of histidine, while the ileal digestibilities of three essential amino acids (histidine, lysine and tryptophan) were decreased ($p<0.05$) by the inclusion of insoluble dietary fiber (wheat bran).

Fecal amino acid digestibility

There were no differences in the fecal digestibility of

Table 3. Apparent fecal dry matter, CP, and amino acid digestibilities (%) in pigs fed the test diets[a]

Item	Diet [b]				SEM	p-value[c]
	CON	PS	SBP	WB		
Dry matter	94.7^{x}	95.1^{x}	92.0^{y}	87.3^{z}	0.88	0.001
CP	91.2^{x}	88.7^{y}	86.4^{z}	85.2^{z}	0.34	0.001
Indispensable amino acids						
Arginine	94.5^{x}	94.4^{x}	91.3^{y}	90.8^{y}	0.51	0.001
Histidine	93.8^{x}	93.2^{x}	88.5^{y}	86.9^{y}	0.62	0.001
Isoleucine	90.7^{x}	91.1^{x}	85.9^{y}	82.3^{x}	1.03	0.001
Leucine	91.9^{x}	91.7^{x}	86.5^{y}	83.7^{y}	0.88	0.001
Lysine	94.6^{x}	94.4^{x}	90.4^{y}	85.2^{z}	0.67	0.001
Methionine	90.9^{x}	90.3^{x}	85.6^{y}	82.6^{y}	1.08	0.001
Phenylalanine	89.6^{x}	90.2^{x}	85.5^{y}	83.2^{y}	1.02	0.001
Threonine	90.7^{x}	90.8^{x}	85.6^{y}	82.0^{z}	0.88	0.001
Tryptophan	91.8^{x}	93.2^{x}	87.0^{y}	84.1^{z}	0.87	0.001
Valine	91.8^{x}	92.0^{x}	88.2^{y}	83.2^{z}	0.91	0.001
Dispensable amino acids						
Alanine	91.2^{x}	91.1^{x}	86.2^{y}	82.5^{z}	0.94	0.001
Aspartic acid	91.8^{x}	91.9^{x}	87.3^{y}	84.5^{z}	0.78	0.001
Cystine	90.7^{x}	89.5^{x}	85.2^{y}	84.8^{y}	1.02	0.001
Glutamic acid	93.1^{x}	93.0^{x}	89.6^{y}	87.9^{y}	0.73	0.001
Glycine	91.2^{x}	91.3^{x}	86.3^{y}	84.3^{y}	0.77	0.001
Proline	97.7^{x}	97.1^{x}	$96.4^{x, y}$	94.6^{y}	0.59	0.004
Serine	92.3^{x}	91.9^{x}	88.0^{y}	85.0^{z}	0.68	0.001
Tyrosine	90.9^{x}	89.8^{x}	83.6^{y}	82.6^{y}	1.08	0.001

[a] Values represent means of eight observations.

[b] CON = Control diet; PS = Potato starch-supplemented diet; SBP = Sugar beet pulp-supplemented diet; WB = Wheat bran-supplemented diet.

[c] The P-value represents the total diet effect; when p<0.05 was observed, the means were further separated by a Fisher LSD separation test at p = 0.05.

[x, y, z] Means within a row lacking a common superscript differ (p<0.05).

amino acids between diets CON and PS (Table 3). In comparison with diet CON, the inclusion of dietary fiber (especially insoluble dietary fiber) decreased (p<0.001) the fecal amino acid digestibility. The fecal digestibility of amino acids tended (p<0.10) to be lower for diet WB than for diet SBP.

The net disappearance of amino acids in the large intestine

The net disappearance of amino acids in the large intestine tended (p<0.10) to increase in pigs fed diet PS than in pigs fed diet CON. The inclusion of sugar beet pulp and wheat bran decreased (p<0.05) the net disappearance of many amino acids in the large intestine.

DISCUSSION

In the current study, of the indispensable amino acids, the ileal digestibility of threonine was lowest and that of arginine and lysine highest with diets CON, PS and SBP. Of the dispensable amino acids, the ileal digestibility coefficients of cystine and glycine were lowest. The values for the average of the ileal digestibility of the dispensable amino acids were 85%, 85%, 83% and 83% for diets CON, PS, SBP and WB, respectively. The present results clearly show that the inclusion of insoluble dietary fiber (e.g. wheat bran) decreased the ileal digestibility of histidine, lysine and tryptophan, while feeding soluble dietary fiber (sugar beet pulp) resulted in a lowered ileal digestibility of histidine. This could be explained by the fact that probably more than half digestive losses are endogenous losses specifically induced by feed components (e.g. fiber sources) and the relatively low ileal digestibility of these amino acids may, in part, result from their relatively high concentrations in endogenous secretions (Li et al., 1994). Li et al. (1994) reported that the small intestine secretions including mucins supply the largest proportion of nitrogen to the endogenous nitrogen secretions in the small intestine. In contrast, Dierick et al. (1983) reported that the inclusion of dietary fiber (e.g. 5% pectin and 5-15% dried sugar beet pulp) resulted in a considerable reduction amounting to 10-15% in digestion of amino acids at the terminal ileum and the influence in the feces was greatly reduced. Also, Mosenthin et al. (1994) reported a reducing effect by the addition of 7.5% pectin (a water-soluble fiber source) on ileal digestibilities of the essential amino acids. de Lange et al. (1989) again reported an increased ileal recovery of glycine and proline in a protein-free diet in which 10% Alphafloc (purified cellulose) was included. However, Li et al. (1994) reported that the ileal digestibilities of amino acids were uninfluenced by the dietary inclusion of Solkafloc (a purified source of dietary fiber containing 93% cellulose).

Table 4. The net disappearance (%) of dry matter, CP, and amino acids in the large intestine in pigs fed the test diets[a, b]

Item	Diet[c]				SEM	p-value[d]
	CON	PS	SBP	WB		
Dry matter	7.0^{x}	10.2^{y}	14.3^{y}	9.8^{y}	0.85	0.016
CP	10.1	11.3	10.0	10.2	0.74	0.180
Indispensable amino acids						
Arginine	3.7	4.5	2.1	1.4	0.96	0.232
Histidine	5.9^{x}	6.9^{x}	5.9^{x}	3.7^{y}	0.47	0.007
Isoleucine	6.4^{x}	7.1^{x}	2.5^{y}	-0.3^{z}	1.22	0.026
Leucine	5.8^{x}	7.0^{x}	3.6^{y}	1.7^{y}	0.55	0.031
Lysine	3.9^{x}	4.6^{x}	1.8^{y}	-1.2^{z}	0.49	0.015
Methionine	4.1^{x}	5.5^{x}	-0.6^{y}	-3.2^{y}	0.51	0.002
Phenylalanine	6.7^{x}	7.1^{x}	3.9^{y}	1.1^{y}	1.08	0.040
Threonine	11.4^{x}	12.7^{x}	8.4^{y}	5.2^{y}	0.85	0.047
Tryptophan	9.9	8.6	8.4	7.7	1.18	0.261
Valine	8.9	9.2	6.2	2.4	2.34	0.138
Dispensable amino acids						
Alanine	8.3^{x}	9.2^{x}	4.7$^{x, y}$	-0.6^{y}	0.88	0.029
Aspartic acid	11.0	12.1	7.8	4.7	0.73	0.055
Cystine	13.3	12.6	10.0	9.9	1.25	0.111
Glutamic acid	7.5	8.4	6.3	3.8	1.03	0.168
Glycine	17.1	18.7	16.2	11.3	2.06	0.224
Proline	6.1	6.9	6.3	4.5	1.29	0.141
Serine	8.9	10.4	8.1	5.5	1.97	0.073
Tyrosine	4.4$^{x, y}$	5.9^{x}	2.0^{y}	-1.2^{y}	1.02	0.016

[a] The net disappearance in the large intestine was estimated as the difference between ileal and fecal digestibility.

[b] Values represent means of eight observations.

[c] CON = Control diet; PS = Potato starch-supplemented diet; SBP = Sugar beet pulp-supplemented diet; WB = Wheat bran-supplemented diet.

[d] The p-value represents the total diet effect; when $p<0.05$ was observed, the means were further separated by a Fisher LSD separation test at $p = 0.05$.

[x, y, z] Means within a row lacking a common superscript differ ($p<0.05$).

Similarly, Sauer et al. (1991) demonstrated that, with the exception of two amino acids (leucine and glycine), the ileal digestibilities of the other amino acids were unaffected by the inclusion of 10% either Alphafloc (purified cellulose) or ground barley straw (a natural fiber source). This can be explained by the fact that the pig diets in the current study were based on freshly cooked rice containing a higher concentration of starch as compared with the pig diets used in other studies.

The present results clearly showed decreased fecal digestibilities of amino acids when pigs were fed diets in which dietary fiber was included. The decrease might result from the adsorption of amino acids and peptides by dietary fiber, withholding these from absorption (Mitaru et al., 1984) or from an increase in the synthesis of bacterial protein in the large intestine (Sauer et al., 1991) and subsequently an increase in the quantity of microbial protein voided in feces. In addition, the inclusion of dietary fiber increases the sloughing of intestinal mucosal cells (Bergner et al., 1975) and mucus production (Schneeman et al., 1982). In contrast, several studies reported that the fecal CP and amino acid digestibilities were unaffected by the inclusion of either Solkafloc in diets for growing pigs up to a level of 13.3% (Li et al., 1994) or sugar beet pulp in diet for finishing pigs up to a level of 10% (Ko et al., 2004). The absence of a decrease in the fecal amino acid digestibilities with an increase in the dietary fiber level might be ascribed to the low fermentability of Solkafloc used by Li et al. (1994). In addition, with the young pigs, the microbial production in the large intestine might be not fully established yet. In our previous study (Wang et al., 2004b), we found that the inclusion of dietary fiber sources resulted in increased amounts of all the short-chain fatty acids and various bacterial counts in the large intestine. This suggests that the fermentative action could be enhanced by the inclusion of dietary fiber. Choct and Annison (1990) suggest that the decrease in the digestibility of nutrients might be caused by increasing viscosity and by disturbing commensal microflora. Wang et al. (2004b) reported that the inclusion of potato starch stimulates the growth of the lactic acid bacteria and lactobacilli that are beneficial to health at different sampling occasions after feeding, especially at 2 and 4 h after feeding. One possible explanation could be that potato starch is acting as a prebiotic, promoting specifically the growth of beneficial microorganisms, resulting in an increased fecal DM output, including bacterial mass, which may be a prerequisite for the enhancement of the mucosal immune system. Morein and Hu (2001) reported that cellular components of lactic acid bacteria strains could exert an adjuvant influence by stimulating cell-mediated immune responses and promoting productions of cytokines (e.g. tumor necrosis factor-α and interleukin-8). Besides, in our earlier study, we found that the inclusion of dietary fiber caused a lowered rate of lipogenesis and a reduced activity of malic enzyme (Zhu et al., 2003). The inclusion of fermentable carbohydrate sources reduced urinary nitrogen excretion by pigs and ammonia emissions from slurry (Kornegay and Verstegen, 2001). The present study shows a ‘net synthesis’ of methionine in the large intestine in pigs fed diets with the inclusion of sugar beet pulp. This is in good agreement with numerous reports (Sauer et al., 1982; Knabe et al., 1989).

To conclude, the decrease in the ileal digestibility of histidine was observed from adding fiber sources (sugar beet pulp and wheat bran) to diets based on cooked rice, indicating that a lowered rate of absorption in the small intestine occurred when diet was supplemented with fiber sources. The ileal digestibilities of histidine, lysine and tryptophan were reduced by the inclusion of dietary fiber. The inclusion of potato starch in diets for growing pigs up to a level of 9.4% did not affect the digestibilities of amino acids at either the ileal or the fecal levels. The fecal amino acid digestibilities decreased in pigs fed diets with the addition of dietary fiber, indicating that an increase in the synthesis of microbial protein in the large intestine occurred.

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