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Ileal and Faecal Amino Acids Digestibility of Some Tropical Feedstuffs in Growing Pigs

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ABSTRACT

To investigate apparent ileal and faecal digestibility of protein and amino acids in some tropical feedstuffs, six barrows, average initial body weight (BW) 25 kg, were fitted with a simple T-cannula at the distal ileum and fed six diets according to a 6 × 6 Latin square design. Three monodiets which three types of cereal, broken rice, rice bran and corn, as the protein source and three cornstarch- based diets using soybean meal, peanut meal and fishmeal as the protein sources and containing 12 % crude protein were used. Chromic oxide was included as a digestibility marker. After a 5 days adaptation period, faeces were collected for 3 days and followed with 12 hours digesta collection for 2 days in each experimental period. Apparent digestibility values over the total tract were found to be greater than values determined at the ileum, indicating a net disappearance of both nitrogen and amino acids in the hind gut. It was also observed that the apparent faecal and ileal digestibilities of nitrogen and amino acids in growing pigs was highest in soybean meal and ricebran showed the lowest values.

Key words: protein, amino acids, digestibility, pigs, tropical feedstuffs

INTRODUCTION

Formulation of diets based on digestible instead of total protein and amino acids content could decrease the nitrogen excretion from pigs. Because of the intense activity of microorganisms in large intestine, the digestibility overall of intestinal tract does not provide a good estimation of the individual amino acids digestibility (Lenis, 1992). It has been shown that the bacterial nitrogen in faeces is about 62-76 % of the total nitrogen. This part of protein nitrogen is not avaiable to animals, because the digestion and absorption of external protein are completely at the end of small intestine in pigs (Mason, 1984). Therefore, ileal digestibility is more suitable for pig to predict the quality of dietary protein. Recent studies have clearly shown that the ileal digestible values are highly correlated to growth as well as the protein deposition (Rademacher *et al*., 1996) In consideration of the variation of quality and nutrient composition among the feedstuffs, the determination of digestibility of protein and amino acids in the tropical feedstuffs was studied for feed formulation in Thailand.

MATERIALS AND METHODS

Six barrows (Landrace × Large white × Pietrain), averaging about 25 kg, were surgically fitted with a simple T-cannula at the distal ileum according to procedures adapted from Karsten (1995). After surgery, the animals were individually housed in 2 m × 2 m concrete floored pens. After a 14-day recovery period, six diets consisted of three

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monodiets (Table 1) containing cereal or a cereal by product (corn, broken rice and ricebran) as the protein source and three semi-purified diets based on cornstarch and sucrose containing three sources of protein (soybean meal, peanut meal and fishmeal) to provide 12 % crude protein were tested according to a 6 × 6 latin square design.Chromic oxide 0.25 % was included as a marker for the determination of digestibility. Animals were fed twice daily at a level of 100 g/kgBW$^{0.75}$ /day. Diets were mixed with an equal portion of water and feed. Water was provided *ad libitum*. The average of initial and final body weights for the collection period were 42.9 ± 4.5 and 78.7 ± 9.3 kg, respectively.

Each experimental period was consisted of 10 days. After a 5 days adaption period, the faeces were collected for 3 d, followed by a 2 days ileal digesta collection between feeding period (12 hours). Ileal digesta were collected in soft plastic bags attached to the barrel of the cannula. The samples were immediately frozen at –20°C. Faeces samples were collected twice daily and stored at –20°C until analysis.

Faeces and digesta samples were dried and ground through a 1-mm mesh screen. Analyses of the nutrient component of the diets were carried out according to AOAC (1984) methods. Chromic oxide concentration was determined as described by Bolin *et al*. (1952). Amino acids were analyzed using HPLC and the samples were hydrolyzed and derivatived with phenylisothiocyanate (PITC) to form phenylthiocarbamyl amino acids as described by Waters (1989) and detected by UV detector with 254 nm. Tryptophan content was not determined in this study. All of data were shown in mean values ± standard deviation.

RESULTS

Apparent faecal digestibility

The protein and amino acid composition of the experimental feedstuffs is presented in Table 2

Table 1 Composition of the experimental diets (% in the diet).

Composition	Diet I	Diet II	Diet III	Diet IV	Diet V	Diet VI
Corn	95.54	-	-	-	-	-
Broken rice	-	95.45	-	-	-	-
Ricebran	-	-	96.35	-	-	-
Cornstarch	-	-	-	57.6	56.6	66.55
Soybean meal	-	-	-	26.0	-	-
Peanut meal	-	-	-	-	27.0	-
Fishmeal	-	-	-	-	-	20.7
Sucrose	-	-	-	10.0	10.0	10.0
Ricebran oil	-	-	-	2.0	2.0	2.0
Dicalcium phosphate	3.11	3.45	1.20	3.30	3.30	-
$CaCO_3$	0.25	-	1.35	-	-	-
NaCl	0.35	0.35	0.35	0.35	0.35	0.35
Vitamin /mineral premix[1]	0.50	0.50	0.50	0.50	0.50	0.50
Chromic oxide	0.25	0.25	0.25	0.25	0.25	0.25

1: vitamin/mineral premix per kg diet : 16,000 IU Vit. A; 1,340 IU Vit. D_3; 20 mg Vit. E; 1.4 mg menadione; 2 mg Thiamin; 4 mg Riboflavin; 2.6 mg Pyridoxine; 0.024 mg Cobalamin; 10 mg d-Ca-pantothenate; 20 mg Niacin; 0.5 mg Folic acid; 0.2 mg D-Biotin; 300 mg Choline-chloride ; 0.2 mg Se; 80 mg Fe; 50 mg Mn; 100 mg Zn; 150 mg Cu; 0.2 mg Co; 0.5 mg I

and the apparent faecal digestibilities of nitrogen and amino acids are shown in Table 3. Ricebran had the lowest digestibility of protein and amino acids compared to other protein sources, whereas the values between other feedstuffs showed only little difference. Of the indispensable amino acids, arginine and leucine in all protein sources showed the highest digestibility and the digestibility of threonine normally was lowest.

Apparent ileal digestibility

The digestibilities of protein and amino acids at the end of small intestine showed greater difference between feedstuffs (Table 4). For the values measured over the digestive tract, the digestible protein and amino acids from pigs fed with ricebran as the protein source were lower than the other feedstuffs in this study. The digestibility of arginine and leucine was high in all of six feedstuffs, whereas threonine and lysine showed low digestibility at the end of small intestine. Of the nonessential amino acids, glutamic acid had the highest value and glycine, proline and cystine showed the low digestibilities.

DISCUSSION

The faecal and ileal digestibility of protein and amino acids in cereal and cereal-by products agreed well with those from literatures, such as in corn, broken rice and ricebran (Yin *et al*., 1993). Some variation of the digestibility from the same feedstuff may be caused by the altering of the relative amount of each of four major proteins in

Table 2 Protein and amino acid composition of feedstuffs (in %).

Items	Corn	Broken rice	Ricebran	Soymeal	Peanut meal	Fishmeal meal
Crude protein	8.30	6.87	13.1	46.1	44.4	56.7
Essential amino acids						
Arginine	0.44	0.56	1.00	3.28	4.81	3.39
Histidine	0.26	0.18	0.32	1.26	1.20	1.38
Isoleucine	0.27	0.23	0.46	1.94	1.28	2.09
Leucine	1.06	0.53	0.87	3.07	2.84	4.08
Lysine	0.28	0.25	0.58	2.75	1.47	3.83
Methionine	0.19	0.17	0.26	0.61	0.49	1.44
Phenylalanine	0.42	0.37	0.61	2.24	2.17	2.28
Threonine	0.33	0.27	0.50	1.77	1.17	2.35
Valine	0.47	0.39	0.64	1.95	1.99	2.43
Nonessential amino acids						
Alanine	0.65	0.36	0.76	2.03	1.81	3.43
Aspartic acid	0.58	0.62	1.16	4.65	4.92	4.60
Cystine	0.19	0.17	0.24	0.64	0.58	0.53
Glutamic acid	1.55	1.15	1.63	8.08	8.15	7.28
Glycine	0.32	0.31	0.57	2.19	2.31	4.02
Proline	0.79	0.34	0.66	2.23	1.87	2.47
Serine	0.38	0.33	0.59	2.21	2.17	2.20
Tyrosine	0.32	0.28	0.38	1.67	1.79	1.67

cereal (albumin, globulins, prolamines and glutelines) which could be depended on the variety of grain, fertilizer application and environmental conditions (Mosenthin *et al*., 1997). The nutrient composition in cereal by product especially showed the great variable according to the processing techniques. Warren and Farrell (1989) reported that the crude protein content in ricebran from the different part of Australia varied from 134 to 173 g/kg DM depend on the content of broken rice and husk and could be affected on the variation of digestibility. Comparing between cereal and cereal by-product, the faecal and ileal digestibilities of protein and amino acids were as follows : broken rice > corn > ricebran. The higher content of crude fiber in ricebran could be due to the increasing digesta movement and the reducing digestion time (Schutte *et al*., 1992).

As the higher fiber content might stimulated the secretion of endogenous protein, Boisen and Moughan (1996) reported that the endogenous protein of pigs averaged 10-15 g/kg DM-intake by feeding free protein diet and increased to 20-40 g/kg DM-intake by feeding diet being consisted of fiber and antinutritive substances. The fraction of fiber also affected the digestibility. Mariscal (1992) reported that NDF (neutral detergent fiber) had more negative effect on the ileal digestibility than ADF (acid detergent fiber). Ricebran contained high content of NDF (256 g/kg DM ; Warren and Farrell, 1989). Therefore, the digestibility of amino acids in ricebran was low.

Table 3 Apparent faecal digestibilities of nitrogen and amino acids of feedstuffs.

Item	Apparent faecal digestibility (in %)					
	Corn	Broken rice	Ricebran	Soybean meal	Peanut meal	Fishmeal
Nitrogen	83.9 ±1.9	88.5 ±3.5	67.8±7.3	86.6±3.4	86.2±2.0	81.4±2.7
Essential amino acids						
Arginine	88.8±1.3	91.8±1.2	85.4±2.8	90.9±2.5	91.5±1.2	86.5±0.6
Histidine	84.7±3.4	86.1±1.1	70.6±4.1	88.6±1.4	86.0±2.0	84.1±1.5
Isoleucine	83.8±1.8	88.0±1.1	69.8±6.1	86.0±2.4	85.0±0.9	86.6±2.3
Leucine	91.1±1.6	90.8±0.8	69.0±7.0	86.5±1.6	86.9±2.6	86.8±2.1
Lysine	84.8±3.3	87.6±2.1	74.5±5.8	90.1±1.7	82.8±1.0	87.5±1.2
Methionine	84.5±1.3	87.9±0.9	79.8±3.8	83.6±3.2	82.9±3.5	85.7±3.5
Phenylalanine	88.4±1.4	89.9±1.1	72.4±5.0	88.1±2.9	88.2±2.1	83.8±2.5
Threonine	79.2±2.3	87.5±2.4	65.5±7.4	85.8±2.8	81.3±2.3	82.9±4.3
Valine	83.0±3.1	87.4±1.1	72.3±6.3	84.8±3.4	85.0±1.1	82.4±1.8
Nonessential amino acids						
Alanine	88.0±2.1	87.2±1.5	74.4±5.3	83.3±3.6	85.0±1.2	84.5±3.1
Aspartic acid	85.5±2.9	89.3±1.8	69.2±6.3	88.5±2.0	92.5±0.8	88.7±1.8
Cystine	84.8±1.8	85.1±1.9	64.9±7.4	84.6±2.6	84.6±1.1	83.5±1.7
Glutamic acid	90.7±0.9	91.5±1.0	81.6±3.9	91.4±1.6	91.7±0.3	89.3±1.7
Glycine	80.8±3.0	87.8±0.8	76.9±5.0	84.5±2.9	85.3±1.6	82.1±1.2
Proline	86.3±1.9	86.6±3.0	72.6±6.1	87.3±1.6	85.1±3.2	82.8±1.6
Serine	87.0±1.8	86.8±1.6	72.9±4.2	88.2±2.5	88.5±2.7	82.7±2.4
Tyrosine	83.7±1.6	87.1±1.4	72.8±5.7	87.3±2.7	86.9±2.5	83.2±3.1

The apparent ileal nitrogen and amino acids digestibilities in high-protein feedstuffs (soybean meal, peanut meal and fishmeal) reported in this study agreed with the values, summerized by Mosenthin *et al*. (1997). There was considerable variation in the apparent ileal amino acid digestibilities, especially in fishmeal. A review of those studied revealed that the digestibilities were determined in diets with varying amino acids content. Other factors included inherent factors in different samples, processing techniques, and cannulation methods (Sauer and Ozimek, 1986).

The faecal digestibilities of nitrogen and amino acids were consistently higher than when measured at the end of the small intestine, indicating a loss of nitrogenous components in the caecum and colon, affected by the microbial fermentation. Amino acids that were the great component of endogenous protein and had the low ileal digestibility, such as threonine, glycine and proline, the losses of these amino acids in the hindgut were high. This showed that the endogenous protein was intensively digested by microflora in caecum and colon (Sauer *et al*., 1991). The nitrogen from these amino acids was lost mostly as ammonia which can be absorbed and excreted as urea in the urine (Just *et al*., 1981). In the case of methionine, the ileal digestibility was not different from faecal digestibility and in some cases, the post ileal digestibility showed negative value. This might reflect the net synthesis by transformation of cystine to methionine in the large intestine (Weerden *et al*.,

Table 4 Apparent ileal digestibilities of nitrogen and amino acids of feedstuffs.

Item	Apparent ileal digestibility (in %)					
	Corn	Broken rice	Ricebran	Soybean meal	Peanut meal	Fishmeal
Nitrogen	73.8 ±2.5	78.4 ±1.5	61.1±6.2	82.2±1.5	78.0±1.3	72.4±4.4
Essential amino acids						
Arginine	84.4±1.0	84.9±2.0	82.1±2.3	86.8±1.1	88.0±1.0	84.2±0.5
Histidine	74.2±2.8	77.8±3.4	63.5±2.9	80.3±1.8	79.2±1.4	82.4±1.5
Isoleucine	79.3±2.6	83.0±1.2	67.0±7.4	84.6±3.0	83.1±2.0	83.4±2.1
Leucine	83.4±1.2	84.6±2.8	67.2±7.0	84.2±1.4	82.1±1.9	84.8±1.6
Lysine	76.9±3.2	79.9±1.6	71.8±3.4	86.3±0.9	78.6±1.4	84.3±1.6
Methionine	81.6±1.1	85.7±1.9	78.7±5.8	82.2±2.8	83.9±2.2	83.9±3.2
Phenylalanine	83.7±2.5	82.3±1.9	69.7±5.4	83.9±2.1	83.3±1.4	80.4±1.7
Threonine	63.4±3.5	74.4±3.2	56.6±8.7	75.6±4.6	68.8±3.3	78.9±3.8
Valine	78.2±3.0	81.0±2.5	67.8±5.8	82.0±2.5	81.2±1.4	80.2±1.6
Nonessential amino acids						
Alanine	82.6±1.6	80.4±2.4	69.1±6.0	80.0±2.7	80.3±1.7	82.0±3.7
Aspartic acid	77.9±4.3	82.7±2.0	67.5±6.2	84.8±1.3	87.1±1.2	83.2±3.1
Cystine	75.8±2.1	76.3±1.7	59.8±7.4	73.8±2.4	77.3±2.1	73.0±2.4
Glutamic acid	86.4±1.5	88.3±1.8	79.5±4.0	88.9±1.4	88.7±1.3	87.3±1.4
Glycine	56.4±4.1	72.7±2.9	67.4±5.2	74.6±3.5	76.7±1.9	77.3±1.8
Proline	61.3±3.0	60.4±6.1	54.7±6.5	78.2±3.3	75.6±2.4	78.1±2.4
Serine	80.1±2.6	79.8±2.9	69.8±3.9	84.4±2.4	83.2±2.4	77.6±3.9
Tyrosine	80.8±1.5	82.2±2.6	70.2±6.3	82.2±1.6	83.5±1.8	80.4±2.6

1980).

The ileal analysis method was found to be more sensitive than faecal method for determining amino acids digestibility in feedstuffs for pigs. However, the number of the tropical feedstuffs that have been carried in this study were limited. To formulate diet on the basis of digestible, as opposed to total, amino acids supply for the pig production in Thailand, more studies using diets with a wider array of feedstuffs are necessary.

CONCLUSION

Measured by the faecal analysis method, there was only a slight difference in the digestibility of the amino acids in the six feedstuffs tested. Greater differences were found by the ileal analysis method. Of all six tropical feedstuffs investigated, the ileal and the faecal digestibility of crude protein and amino acids were highest in soybean meal and lowest in ricebran.

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