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Nutritional Value of Ten Peanut Meals for Finishing Pigs: Chemical Composition and Amino Acid Digestibility

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Abstract: The objectives of this study were to determine the chemical composition, amino acid digestibility for peanut meal and to develop prediction equations for estimating amino acid digestibility of peanut meal based on the chemical characteristics. Twelve finishing barrows (initial B.W.: 63.1±3.19 kg) were surgically equipped with a T-cannula in the distal ileum and arranged to two 6×6 Latin square design with eleven diets and six periods. Ten of the diets were formulated using peanut meal as sole source of amino acid and chromic oxide as an inert marker. An N-free diet was used to measure the basal ileal Endogenous Amino acid Losses (EAL). The results showed that the digestibility coefficients of lysine, threonine and tryptophan was dependent on crude fiber content and coefficients of methionine decreased with the increase of ether extract content in peanut meal. And the digestibility coefficients of tryptophan was negatively correlated to crude fiber and positively correlated to ash. Using two chemical characteristics, ether extract and crude fiber together resulted in the best prediction of standardized ileal digestibility of methionine (R^2 = 0.55, $p<0.01$) and crude fiber and ash for standardized ileal digestibility of tryptophan (R^2 = 0.59, $p<0.01$).

Key words: Peanut meal, pigs, amino acid, digestibility, equations

INTRODUCTION

Peanut meal was used for pig starter, grower and finisher rations as the source of supplementary protein (Brooks and Thomas, 1959; Orok and Bowland, 1975; Ranjhan *et al*., 1964; Thomas and Kornegay, 1972; Ilori *et al*., 1984). However, peanut meal is not a satisfactory protein supplement to diets for pigs due to lysine and methionine deficiency and its protein quality is considered to be inferior to soybean meal (Batal *et al*., 2005). By adding synthetic lysine and methionine or other protein such as fish meal, growth rate and muscle development (Brooks and Thomas, 1959; Ranjhan *et al*., 1964) average daily gain, feed intake and feed to gain ratio (Thomas and Kornegay, 1972; Ilori *et al*., 1984) of pigs could be significantly improved. Studies showed that digestibility of peanut meal was significantly less than that of soybean meal, dried skim milk and fish meal (Combs *et al*., 1963; Combs and Wallace, 1962). Susceptible to mycotoxin contamination is another limiting factor for peanut meal usage in swine feed, however, there are many processing technologies the aflatoxins in peanut meal.

The ileal digesta other than feces should be used to determine the amino acid digestibility in feed stuff for pigs because it avoids action of microflora degradation on amino aicd in large intestine (Zebrowska, 1973). So, the Apparent Ileal Digestibility (AID) of amino acid is widely determined for most feedstuff. However, the apparent ileal digestibility underestimates amino acid digestibility due to the endogenous amino acid losses in ileal digesta (Rademacher *et al*., 1999). By correcting the AID for basal endogenous amino acid losses, Standardized Ileal Digestibility (SID) of amino acid can be calculated and has been suggested as a good method to determine the ileal digestibility in feedstuff because it is additive in mixed diets (Stein *et al*., 2005).

There are 3.5 million tones peanut meal being producing every year in China (Revoredo and Fletcher, 2002) and because peanut meal is lower in price than soybean meal by adding some synthetic amino acid economically available, peanut meal can replace soybean meal partially in diet. DeFa *et al*. (2000) has determined the apparent ileal digestibility of the amino acids in one kind of peanut meal using the regression technique and put it into use for growing and finishing pigs. However, few information are available about the AID and SID of amino acid in peanut meal from different regions for finishing pigs and no regression equations of amino acid digestibility are obtained on the basis of chemical

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composition. Therefore, the objective of this experiment is to determine the Apparent Ileal Digestibility (AID) and Standardized Ileal Digestibility (SID) of amino acid in ten different kinds of peanut meal and to develop the prediction equations of amino acid digestibility on the basis of chemical composition of peanut meal.

MATERIALS AND METHODS

Animals and experimental design: Twelve Yorkshire x Landrace x Duroc finishing pigs (initial BW: 63.1±3.19 kg) were used in this experiment. Each pig was surgically equipped with a T-cannula in the distal ileum (Stein *et al*., 1998). Two 6×6 Latin square design was used with eleven diets during six periods. Each experimental period lasted 7 days with 5 days adaption and 2 days digesta collection.

The experimental protocols and procedures used in this experiment were approved by the Institutional Animal Care and Use Committee of China Agricultural University (Beijing, China). The experimental were carried out at the Metabolizable Researching Center in China Agricultural University (Beijing, China).

Experimental diets, feeding and sample collection: Ten of peanut meals were collected from the provinces of Henan, Guangdong, Hebei and Northeast of China in China. And the chemical compositions of ten peanut meals were analyzed (Table 1 and 2).

Ten of the diets were formulated (Table 3) using corn starch, peanut meal, sucrose and cellulose acetate. Peanut meal served as the sole source of amino acid. A N-free diet was also prepared in this experiment to determine the endogenous amino acid losses. Chromic oxide (0.30%) was added in all diets as an inert marker. Vitamins, salt and minerals were included at levels that met or exceeded the estimated requirements for finishing pigs (NRC, 1998).

All the pigs were housed in single metabolism cages and the room temperature was maintained at between 20~28°C throughout the experimental period. The pigs had free access to water by drinking nipples and were fed to 4% of their Body Weight (BW) twice every day at 8:00 and 17:00. The initial 5 days of each period were considered an adaptation period to the diet. Ileal digesta were collected on days 6 and 7 from 8:00-17:00 in plastic bags (Stein *et al*., 1999). Bags were removed whenever

Table 1: Analyzed chemical composition of peanut meals

	Peanut meal number														
Items	1	2	3	4	5	6	7	8	9	10	Max.[1]	Means	Min.[2]	SD[3]	CV[4]
Composition (%)															
Crude protein	48.65	47.00	46.86	46.98	46.35	47.35	49.95	46.38	47.31	48.28	49.95	47.51	46.35	1.13	2.37
Ether extract	0.65	0.94	2.45	0.55	0.78	1.65	0.35	1.78	2.78	1.68	2.78	1.36	0.35	0.83	61.28
Crude fiber	4.98	8.77	6.73	4.12	5.62	7.66	4.59	8.12	5.84	6.54	8.77	6.29	4.12	1.54	24.60
Neutral detergent fiber	10.96	19.29	14.81	14.06	13.36	16.85	10.10	19.86	12.85	12.39	19.86	14.45	10.10	3.29	22.81
Acid detergent fiber	9.06	14.19	12.89	10.34	11.83	12.39	6.43	14.61	9.45	9.11	14.61	11.03	6.43	2.59	23.49
Ash	5.67	3.12	4.37	6.95	4.48	5.56	6.16	3.53	4.83	3.86	6.95	4.85	3.12	1.21	25.12

Table 2: Analyzed amino acid composition of peanut meals

	Peanut meal number														
Items	1	2	3	4	5	6	7	8	9	10	Max.[1]	Means	Min.[2]	SD[3]	CV[4]
Indispensable amino acid (%)															
Arginine	4.91	4.70	5.36	4.82	4.97	4.58	5.30	4.55	5.76	5.39	5.76	5.03	4.55	0.40	7.96
Histidine	0.88	0.76	0.85	0.73	1.21	0.76	0.88	0.76	1.39	1.00	1.39	0.92	0.73	0.21	23.77
Isoleucine	1.61	1.48	1.61	1.48	1.39	1.36	1.52	1.24	1.48	1.45	1.61	1.46	1.24	0.11	7.66
Leucine	2.91	2.76	2.88	2.64	2.70	2.55	2.88	2.39	3.00	2.85	3.00	2.75	2.39	0.18	6.79
Lysine	1.45	1.39	1.58	1.30	1.39	1.39	1.55	1.45	1.73	1.48	1.73	1.47	1.30	0.12	8.32
Methionine	0.48	0.45	0.42	0.42	0.39	0.42	0.45	0.42	0.48	0.45	0.48	0.43	0.39	0.02	6.61
Phenylalanine	2.24	2.21	2.42	2.27	2.12	2.12	2.42	2.03	2.42	2.30	2.42	2.25	2.03	0.13	6.15
Threonine	1.21	1.18	1.24	1.24	1.42	1.15	1.30	1.12	1.48	1.33	1.48	1.26	1.12	0.11	9.16
Tryptophan	0.36	0.27	0.39	0.39	0.36	0.39	0.42	0.36	0.48	0.33	0.48	0.37	0.27	0.05	14.72
Valine	2.09	2.03	2.24	2.15	1.82	1.88	2.03	1.67	2.00	1.91	2.24	1.98	1.67	0.16	8.41
Dispensabl amino acid (%)															
Alanine	2.18	2.06	2.18	1.97	2.03	2.00	2.21	1.85	2.30	2.27	2.30	2.10	1.85	0.14	6.89
Aspartate	5.55	5.39	6.00	5.58	5.18	5.15	6.03	5.03	5.82	5.85	6.03	5.55	5.03	0.36	6.53
Cystine	0.61	0.64	0.67	0.58	0.73	0.70	0.76	0.76	0.91	0.64	0.91	0.70	0.58	0.09	13.70
Glutamic acid	7.91	7.64	8.39	7.73	7.70	7.36	8.61	7.12	8.79	8.33	9.79	7.95	7.12	0.55	6.91
Glycine	2.52	2.48	2.88	2.85	2.52	2.52	2.88	2.30	2.76	2.64	2.88	2.63	2.30	0.20	7.56
Proline	2.36	2.33	2.48	2.42	2.45	2.15	2.45	2.18	2.58	2.39	2.58	2.37	2.15	0.13	5.55
Serine	1.94	1.85	2.06	2.00	1.94	1.91	2.21	1.88	2.33	2.18	2.33	2.03	1.85	0.16	7.91
Tyrosine	0.91	0.91	0.91	0.85	0.94	0.88	0.85	0.82	0.94	0.94	0.94	0.89	0.82	0.04	4.80

[1]Max.: Maximum; [2]Min.: Minimum; SD: [3]Standard Deviation; [4]CV: Coefficient of Variation

Table 3: Composition of experimental diets (as fed-basis)

Items	N-free diet	Peanut meal diet
Ingredient (%)		
Peanut meal	-	33.00
Corn starch	68.50	40.90
Sucrose	20.00	20.00
Cellulose acetate[1]	4.00	-
Soybean oil	3.00	3.00
Limestone	1.00	0.50
Dicalcium phosphate	2.00	1.00
Salt	0.30	0.30
Chromic oxide	0.30	0.30
Potassium carbonate	0.30	-
Magnesia	0.10	-
Vitamin and mineral premix[2]	0.50	0.50
Total	100.00	100.00

[1]Made by Chemical Reagents Company, Beijing, China; [2]Provided per kg of complete diet: Mn, 50 mg (MnO); Fe, 125 mg ($FeSO_4 \cdot H_2O$); Zn, 125 mg (ZnO); Cu, 150 mg ($CuSO_4 \cdot 5H_2O$); I, 50 mg (CaI_2); Se, 0.48 mg (Na_2SeO_3); retinyl acetate, 4500 IU; cholecalciferol, 1350 IU; DL-a-tocopheryl acetate, 13.5 mg; menadione sodium bisulfite complex, 2.7 mg; niacin, 18 mg; vitamin B 12, 27.6 mg; thiamine, 0.6 mg; pyridoxine, 0.9 mg; riboflavin, 1.8 mg; D-calcium-pantothenate, 10.8 mg; nicotinic acid, 30.3 mg; choline chloride, 210 mg

they were filled with digesta and the digesta was immediately stored at -20°C to prevent microbial degradation of the amino acid in the digesta.

Chemical analysis: All chemical analyses were conducted in duplicate and were repeated if the results differed by >5%. Crude protein, ether extract, crude fiber, NDF and ADF of all peanut meals were analyzed (AOAC, 2000).

At the conclusion of the experiment, all the ileal digesta samples were thawed and pooled within animals and diets. A subsample was lyophilized and used for chemical analyses and all samples were ground to pass through 1.0 mm screen (40 mesh) before analysis. Diets and digesta were analyzed for their contents of DM (AOAC, 2000). Chromium was analyzed by atomic absorption spectrophotometer (Williams *et al*., 1962). Amino acid concentrations in peanut meals, diets and digesta samples were hydrolyzed for 24 h at 110°C with 6 N HCl before analysis. Methionine and cysteine were determined after performic acid oxidation (AOAC, 2000). Tryptophan content was determined colorimetrically after hydrolysis with NaOH for 24 h at 110°C (Miller, 1967).

Calculation and statistical analysis: Apparent ileal digestibility was calculated according to the following equation (Stein *et al*., 2001):

$$\text{AID (\%)} = 100-\left(\frac{Cr_f \times AA_d}{Cr_d \times AA_f}\right)\times 100$$

Where:

AID = Apparent ileal digestibility of amino acid (%)
AA_f = Amino acid content in feed (%)
AA_d = Amino acid content in ileal digesta (%)
Cr_f = The Cr content in feed (%)
Cr_d = The Cr content in ileal digesta (%)

The basal ileal endogenous losses of amino acid were calculated based on the flow of amino acid to the distal ileum in pigs fed the N-free diet according to the following equation (Stein *et al*., 2001):

$$\text{EAL (DM g/kg)} = AA_d \times \frac{Cr_f}{Cr_d}$$

Where:

EAL = Endogenous losses of amino acid (DM g/kg)
Cr_f = The Cr content in N-free diet (DM g/kg)
Cr_d = The Cr content in ileal digesta (DM g/kg)

The standardized ileal digestibility of amino acid was calculated by correcting the apparent ileal digestibility of amino acid for the basal endogenous amino acid losses (Stein *et al*., 2001):

$$\text{SID (\%)} = \text{AID (\%)} + \left(\frac{EAL}{AA_f}\right)\times 100$$

Where:

SID = The standardized ileal digestibility of amino acid (%)
AID = Apparent ileal digestibility of amino acid (%)
EAL = Endogenous losses of amino acid (DM g/kg)
AA_f = Amino acid content in feed (DM g/kg)

The data were analyzed by ANOVA using the Mixed procedure by SAS (1996) (SAS Inst., Inc., Cary, NC). The pig was the experimental unit for all analyses. Diet was the main effect and pig and period were random effects. The LS means was used to calculate mean values and PDIFF was used to separate means. Simple and multiple regression analyses (stepwise regression analysis) were conducted to study the relationship among chemical composition and amino acid digestibility. For selecting the amino acid digestibility prediction equations, the Residual Standard Deviation (RSD) was used as the selection criterion. A smaller residual standard deviation was proposed to indicate a better fit. In all analyses, the differences were considered significant if $p<0.05$.

RESULTS

Nutrient composition of peanut meals: The chemical composition (Table 1) and amino acid content (Table 2) were quite variable, especially the ether extract. With regards to chemical composition, the coefficient of variation of all criteria except crude protein was >20%. The concentrations of crude protein, crude fiber, ether extract, Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF) and ash averaged 47.51% (46.35~49.95%), 1.36%

(0.35~2.78%), 6.29% (4.12~8.77%), 14.45% (10.10~19.86%), 11.03% (6.43~14.61%), 4.85% (3.12~6.95%), respectively. The coefficient of variation of Histidine, Tryptophan, Crystine content was >10%. And the concentration of most amino acid was lower than listed by NRC (1998) (Table 4).

Digestibility of amino acid: The AID and SID of amino acid in ten peanut meals for finishing pigs are presented in Table 5 and 6. The result of the experiment indicated that the AID for lysine, histidine, serine and proline (from 61.95-86.81%) in all the source of peanut meal is relatively lower than that of the other amino acid (from 81.31-97.95%). The AID for isoleucine, leucine, lysine, methionine, phenylalanine, tryptophan and cystine in sample 7 is higher ($p<0.05$) than that of other samples and the same results were observed in arginine, valine, aspartate and phenylalanine ($p<0.01$). The AID for serine in sample 2 (85.70%), 5 (84.89%) and 6 (85.10%) is relatively lower ($p<0.05$) than the other samples (ranging from 86.67-93.58%). The AID for Gly in sample 7 (88.21%) is relatively higher ($p<0.01$) than the other samples (ranging from 69.07-83.35%). Among the AID of all the ten kinds of peanut meals, the coefficient variance of the AID of histine, proline, tryptophan and glycine are higher than that of the other amino acid (18.06, 17.40, 11.64

Table 4: Analyzed nutrients of experimental diets

		Peanut meal test diets									
Items	N-free	1	2	3	4	5	6	7	8	9	10
DM (%)	90.59	90.60	93.12	91.03	89.50	95.18	88.82	90.34	93.69	91.72	91.37
Indispensable amino acid (%)											
Arginine	-	1.62	1.55	1.77	1.59	1.64	1.51	1.75	1.50	1.90	1.78
Histidine	-	0.29	0.25	0.28	0.24	0.40	0.25	0.29	0.25	0.46	0.33
Isoleucine	-	0.53	0.49	0.53	0.49	0.46	0.45	0.50	0.41	0.49	0.48
Leucine	-	0.96	0.91	0.95	0.87	0.89	0.84	0.95	0.79	0.99	0.94
Lysine	-	0.48	0.46	0.52	0.43	0.46	0.46	0.51	0.48	0.57	0.49
Methionine	-	0.16	0.15	0.14	0.14	0.13	0.14	0.15	0.14	0.16	0.15
Phenylalanine	-	0.74	0.73	0.80	0.75	0.70	0.70	0.80	0.67	0.80	0.76
Threonine	-	0.40	0.39	0.41	0.41	0.47	0.38	0.43	0.37	0.49	0.44
Tryptophan	-	0.12	0.09	0.13	0.13	0.12	0.13	0.14	0.12	0.16	0.11
Valine	-	0.69	0.67	0.74	0.71	0.60	0.62	0.67	0.55	0.66	0.63
Dispensable amino acid (%)											
Alanine	-	0.72	0.68	0.72	0.65	0.67	0.66	0.73	0.61	0.76	0.75
Aspartate	-	1.83	1.78	1.98	1.84	1.71	1.70	1.99	1.66	1.92	1.93
Cystine	-	0.20	0.21	0.22	0.19	0.24	0.23	0.25	0.25	0.30	0.21
Glutamic acid	-	2.61	2.52	2.77	2.55	2.54	2.43	2.84	2.35	2.90	2.75
Glycine	-	0.83	0.82	0.95	0.94	0.83	0.83	0.95	0.76	0.91	0.87
Proline	-	0.78	0.77	0.82	0.80	0.81	0.71	0.81	0.72	0.85	0.79
Serine	-	0.64	0.61	0.68	0.66	0.64	0.63	0.73	0.62	0.77	0.72
Tyrosine	-	0.30	0.30	0.30	0.28	0.31	0.29	0.28	0.27	0.31	0.31

Table 5: Apparent ileal digestibility of amino acid in ten peanut meals for finishing pigs

	Peanut meal number												
Items	1	2	3	4	5	6	7	8	9	10	SEM[1]	p-values[3]	CV[2]
DM (%)	74.14	71.81	76.13	70.29	69.61	72.12	71.41	73.15	80.2	71.73	-	-	-
Indispensable amino acid (%)													
Arginine	95.67^{ab}	94.78^{b}	95.18^{b}	95.83^{ab}	94.77^{b}	95.10^{b}	97.95^{a}	95.76^{ab}	96.93^{ab}	95.50^{ab}	0.46	<0.01	1.50
Histidine	79.75	74.61	80.74	77.43	86.81	75.56	85.63	73.48	85.24	83.91	4.59	0.71	18.06
Isoleucine	89.57^{ab}	86.70^{b}	87.12^{b}	90.01^{ab}	85.74^{b}	87.90^{b}	93.86^{a}	86.13^{b}	88.55^{ab}	87.52^{b}	1.12	0.01	4.02
Leucine	90.27^{ab}	88.42^{ab}	87.54^{b}	90.13^{ab}	86.76^{b}	88.19^{ab}	94.03^{a}	86.68^{b}	89.52^{ab}	89.27^{ab}	1.10	0.02	3.90
Lysine	85.26^{ab}	81.55^{b}	83.18^{ab}	83.89^{ab}	80.17^{b}	81.88^{b}	91.73^{a}	82.53^{b}	87.30^{ab}	83.38^{ab}	1.58	0.01	5.94
Methionine	87.91^{ab}	83.20^{b}	82.93^{b}	88.43^{ab}	81.31^{b}	85.09^{ab}	92.26^{a}	82.20^{b}	85.40^{ab}	86.86^{ab}	1.58	0.01	5.84
Phenylalanine	92.34^{ab}	90.76^{b}	91.22^{b}	93.52^{ab}	89.46^{b}	91.60^{b}	96.04^{a}	90.95^{b}	92.53^{b}	91.26^{b}	0.80	<0.01	2.75
Threonine	82.59	78.65	80.05	84.14	82.38	79.21	89.75	79.82	84.38	81.53	2.17	0.22	8.35
Tryptophan	80.15^{ab}	69.09^{b}	79.27^{ab}	84.77^{ab}	69.84^{b}	75.69^{ab}	88.72^{a}	78.56^{ab}	82.29^{ab}	77.54^{ab}	2.89	0.01	11.64
Valine	88.71^{ab}	86.22^{b}	86.78^{b}	90.63^{ab}	84.44^{b}	87.07^{b}	93.62^{a}	86.87^{b}	88.51^{ab}	86.76^{b}	1.18	<0.01	4.24
Dispensable amino acid (%)													
Alanine	84.27	79.35	77.74	80.96	78.59	78.26	89.65	78.48	83.21	79.32	2.27	0.12	8.79
Aspartate	92.14^{ab}	90.73^{b}	91.22^{ab}	92.77^{ab}	89.16^{b}	89.84^{b}	95.58^{a}	91.71^{ab}	92.85^{ab}	91.30^{ab}	0.79	<0.01	2.72
Cystine	83.13^{b}	81.38^{b}	81.54^{b}	83.53^{b}	84.42^{b}	82.93^{b}	92.46^{a}	84.07^{b}	86.03^{b}	83.74^{b}	1.60	0.02	6.00
Glutamic acid	92.70^{ab}	91.63^{ab}	90.78^{b}	92.41^{ab}	90.67^{b}	90.77^{b}	95.99^{a}	91.97^{ab}	94.04^{ab}	91.60^{ab}	0.80	0.01	2.74
Glycine	83.35^{ab}	74.40^{ab}	76.80^{ab}	79.67^{ab}	70.87^{b}	69.07^{b}	88.21^{a}	81.32^{ab}	80.37^{ab}	69.85^{b}	2.61	<0.01	10.07
Proline	88.44^{a}	78.21^{ab}	76.92^{ab}	80.77^{ab}	76.77^{ab}	61.95^{b}	88.43^{a}	78.14^{ab}	79.49^{ab}	78.27^{ab}	4.33	0.11	17.40
Serine	88.88^{ab}	85.70^{b}	86.67^{ab}	89.22^{ab}	84.89^{b}	85.10^{b}	93.58^{a}	87.32^{ab}	89.19^{ab}	87.61^{ab}	1.25	0.01	4.50
Tyrosine	85.68	85.56	84.01	86.78	83.30	84.38	90.93	77.68	82.84	86.33	2.28	0.25	8.52

[1]SEM: Standard Error of the Mean; [2]CV: Coefficient of Variation; [3]Means within the same row lacking a common superscript letter differ significantly (p<0.0.5)

Table 6: Standardized ileal digestibility of amino acid in ten peanut meals for finishing pigs

	Peanut meal number												
Items	1	2	3	4	5	6	7	8	9	10	SEM[1]	p-values[3]	CV[2]
DM (%)	71.81	76.13	70.29	69.61	72.12	71.41	73.15	80.2	71.73	75.72	-	-	-
Indispensable amino acid (%)													
Arginine	98.08	96.75	97.39	98.34	97.22	96.69	98.74	97.29	97.55	96.76	0.85	0.39	2.78
Histidine	91.07	82.98	94.12	81.31	94.61	91.90	87.27	85.78	96.17	92.12	2.37	0.50	8.26
Isoleucine	96.00	92.61	94.17	97.90	94.12	93.02	97.08	91.5	94.10	92.39	1.01	0.07	3.39
Leucine	97.33	94.62	94.65	96.92	93.44	93.43	97.82	91.89	94.54	94.02	1.08	0.18	3.58
Lysine	94.33	88.51	91.40	94.07	89.71	87.18	94.71	87.43	92.37	90.94	1.47	0.04	5.11
Methionine	96.34	95.44	92.25	99.21	96.6	93.63	99.24	91.66	93.21	94.52	1.49	0.63	5.00
Phenylalanine	97.33	95.15	96.27	98.71	95.41	95.18	98.2	94.53	94.87	94.47	0.78	0.26	2.57
Threonine	95.43	92.27	91.53	95.37	92.99	90.21	97.04	93.11	92.79	93.58	1.55	0.55	5.25
Tryptophan	92.94	85.24	90.84	94.29	91.59	89.84	92.93	86.14	90.37	89.06	8.00	0.36	30.95
Valine	96.1	91.77	93.65	97.37	93.17	92.47	96.81	93.16	92.34	92.10	1.07	0.11	3.60
Dispensable amino acid (%)													
Alanine	94.24	91.59	92.35	94.13	91.37	89.41	94.42	87.48	93.51	86.11	1.85	0.27	6.42
Aspartate	97.03^{a}	94.78^{ab}	95.71^{ab}	97.73^{a}	94.52^{ab}	92.60^{ab}	96.81^{a}	94.84^{ab}	94.95^{ab}	93.89^{ab}	0.71	<0.01	2.36
Cystine	95.12^{ab}	87.41^{ab}	92.41^{ab}	94.83^{ab}	94.54^{ab}	87.99^{b}	97.21^{a}	88.76^{b}	90.53^{ab}	87.56^{b}	1.32	<0.01	4.54
Glutamic acid	96.70	95.76	94.54	96.59	94.87	93.23	97.24	94.81	96.05	93.77	0.72	0.11	2.39
Glycine	91.09	88.63	87.61	90.42	84.75	87.16	89.85	88.45	85.70	86.49	1.88	0.68	6.70
Proline	93.57	92.81	88.40	85.75	85.25	87.74	93.98	82.95	92.90	85.04	2.57	0.45	9.18
Serine	96.83	93.94	94.13	96.07	92.99	91.83	97.55	96.64	93.02	93.86	1.20	0.26	3.99
Tyrosine	94.94	92.23	94.17	93.14	92.61	94.56	96.85	88.39	90.17	94.30	2.19	0.90	7.46

[1]SEM: Standard Error of the Mean; [2]CV: Coefficient of Variation; [3]Means within the same row lacking a common superscript letter differ significantly (p<0.0.5)

Table 7: Correlation coefficients between physical, chemical characteristics and digestibility of amino acid of peanut meal

Items	CP	EE	CF	NDF	ADF	Ash	Lys	Met	Thr	Trp	SLys	SMet	SThr	STrp
CP	1.00	-	-	-	-	-	-	-	-	-	-	-	-	-
EE	-0.38	1.00	-	-	-	-	-	-	-	-	-	-	-	-
CF	-0.46	0.41	1.00	-	-	-	-	-	-	-	-	-	-	-
NDF	-0.70*	0.25	0.85**	1.00	-	-	-	-	-	-	-	-	-	-
ADF	-0.84**	0.30	0.79**	0.92**	1.00	-	-	-	-	-	-	-	-	-
Ash	0.42	-0.42	-0.81**	-0.57	-0.61	1.00	-	-	-	-	-	-	-	-
Lys	0.25	0.66*	0.05	-0.33	-0.32	-0.14	1.00	-	-	-	-	-	-	-
Met	0.58	0.12	0.13	-0.37	-0.50	0.05	0.52	1.00	-	-	-	-	-	-
Thr	0.09	0.20	0.47	-0.60	-0.47	0.07	0.53	0.16	1.00	-	-	-	-	-
Trp	0.19	0.37	0.51	-0.47	-0.84**	0.54	0.63	0.18	0.49	1.00	-	-	-	-
SID Lys	0.62	-0.36	-0.94**	-0.80*	-0.69*	0.88**	-0.01	0.01	0.34	0.53	1.00	-	-	-
SID Met	0.49	-0.33	-0.89**	-0.84*	-0.82**	0.66*	0.25	0.46	0.38	0.42	0.64*	1.00	-	-
SID Thr	0.65*	-0.86**	-0.71*	-0.54	-0.60	0.66*	-0.39	0.02	0.16	-0.01	0.55	0.75*	1.00	-
SID Trp	0.39	-0.65*	-0.75*	-0.63*	-0.72*	0.52	-0.02	0.33	0.15	0.14	0.79	0.64*	0.55	1.00

*Significant at p<0.05; **Significant at p<0.01

and 10.07, respectively). The SID of amino acid in the mostly samples varied (p<0.01) from 84.75-98.20% which have no difference among all the samples, except that SID for aspartate in sample 1 (97.02%), 2 (94.89%) and 3 (95.71%) is higher (p<0.01) than that in sample 10 (93.89%). For histine, threonine and glycine, the SID varied between 81.31 and 96.17%, 85.67 and 96.17%, 84.75 and 91.09%, respectively. The SID for histidine, threonine and glycine in relatively lower than that of remaining amino acid (ranging from 91.04-98.20%). Among the SID of all the ten kinds of peanut meals, the coefficient variance (30.95%) of the SID of tryptophan is higher than that of the other amino acid (Table 7). It is concluded that the AID for amino acid in sample 7 is relatively higher than the other samples. The SID for any amino acid have no difference and are relatively similar among samples except that SID for aspartate in sample 1-3 is higher than that in sample 10 perhaps due to different source and processing procedures. More research should be done to focus on the reasons for the variation in the digestibility.

Prediction equations for digestibility of amino acid: Equations were developed to predict amino acid digestibility for peanut meals by the regression analysis of their chemical characteristics (Table 8). Some equations were based on a single chemical characteristic. The crude fiber was a suitable predictor for the SID of lysine, thr and tryptophan. However, it was not a suitable predictor for methionine digestibility due to the low R^2 <0.50. However, the ether extract was a suitable predictor for methionine digestibility. Inclusion of a second characteristic into the equations improved the accuracy of the equation for digestibility of amino acid. The R^2 of prediction equation for met was improved from 0.45-0.55 with inclusion of a second characteristic. And with the addition of ash, the R^2 of the prediction equation for tryptophan improved from 0.29-0.59.

Table 8: Prediction equation of digestibility of amino acid from chemical composition of peanut meal (DM %)

Regression equations	R^2	RSD	p-values
SID lysine = 101.23-1.61 CF	0.38	1.89	<0.01
SID methionine = 98.96-2.75 EE	0.45	2.03	<0.01
SID methionine = 102.89-2.18 EE-0.74 CF	0.55	0.91	<0.01
SID threonine = 99.57-0.97 CF	0.41	2.03	<0.05
SID tryptophan = 101.50-1.77 CF	0.49	1.04	<0.01
SID tryptophan = 93.93-1.23 CF+0.85 Ash	0.59	0.71	<0.01

RSD: Residual Standard Deviation

DISCUSSION

Nutrient composition of peanut meals: The peanut meals in this study were collected randomly from different province in China, the lack of representativeness and the small sample size in the collection exaggerated the coefficient of variation. The concentration of crude protein was less different among ten kinds of peanut meal which may be the reason why the amino acid profile was quite stable (Table 1). The difference of the chemical composition may be attributed to different raw peanut and the processing procedure. Same raw peanut in one area with different processing procedure may result in high degree variability.

Digestibility of amino acid of peanut meals: The AID and SID for finishing pigs measured in the current experiment were presented in Table 5 and 6. The AID of methionine and histidine were in agree with published values and the AID of most amino acid were greater than published values except histidine and methionine, however, the SID of all the amino acid in the peanut meal were lower than published values (NRC, 1998). Among the ten kinds of peanut meals, significant differences were obtained. For arginine, aspartate, cyscine, glycine, isoleucine, leucine, lysine, methionine, phenylalanine, tryptophan and valine, the AID from sample 7 is higher than that of other samples. The AID for serine in sample 2 (85.70%), 5 (84.89%) and 6 (85.10%) is relatively lower than the other samples (ranging from 86.67-93.58%). The SID of amino acid in the mostly samples varied from 84.75-98.20% which have no difference among all the samples, except that SID for aspartate in sample 1 (97.02%), 2 (94.89%) and 3 (95.71%) is higher than that in sample 10 (93.89%). For histidine and glycine, the SID varied between 81.31 and 96.17%, 84.75 and 91.09%, respectively. Adeola (2009) reported that the bioavailability of threonine and tryptophan in peanut meal using weight gain or gain to feed ratio as dependent variables are 72-76 and 76-92%, respectively are lower than that of the study (threonine 90.21 and 96.17%; tryptophan (85.24-94.29).

The SID for histidine, threonine and glycine in relatively lower than that of remaining amino acid (ranging from 91.04-98.20%). Among all the ten kinds of peanut meals, the coefficient variance of the AID of histidine, proline, tryptophan and glycine are higher than that of the other amino acid (18.06, 17.40, 11.64 and 10.07, respectively) and the coefficient variance (30.95) of the SID of Trp is higher than that of the other amino acid.

The fundamental factors influencing the variation of amino acid digestibility is the different constitutes in peanut meals which due to peanut cultivars, growing envrionment and its processing technologies. Generally, ether extract and crude fiber have largest variation in peanut meal. Therefore, in the study, differences in crude fiber content were partially responsible for the variability in the digestibility values of amino acid among the peanut meals. Some early studies have reported the negative correlations between the neutral detergent fiber content and amino acid digestibility values in peas (Gdala *et al*., 1992), wheat (Taverner *et al*., 1981) and canola meal (Fan *et al*., 1996). Another factor which affects the amino acid digestibility is the crude protein and amino acid content in diets (Fan and Sauer, 1999). However, the coefficient variation of crude protein was low so that it influenced the amino acid digestibility slightly. And the different experimental animal (growth phase or body weight) and condition may affect the amino acid digestibility as well.

Prediction equations for digestibility of amino acid: Crude protein and amino acid deficiency in diets reduced growth performance of pigs while diets containing high crude protein and amino acid could increase the negative impact on the environment due to excessive nitrogen with swine manure emissions. Therefore, it would be necessary to formulate diets on the basis of amino acid digestibility to make diets precisely. Standardized ileal digestibility of amino acid was considered as a good method to determine the ileal digestibility in feedstuff because it is additive in mixed diets (Stein *et al*., 2005). However, the determination of standardized ileal digestibility of amino acid in feedstuff is difficult, owing to difficulties of feedstuff collection and complications of pig's T-cannula ileal surgery. So, it would be necessary to establish the prediction equations of amino acid digestibility in feedstuff on the basis of feedstuff chemical characteristics.

In the study, the digestibility coefficients of lysine, methionine, threonine and tryptophan were negatively correlated to crude fiber. Some study also showed that high crude fiber could reduce digestibility of crude protein (Donangelo and Eggum, 1986). The possible mechanism by which crude fiber reduced the crude protein and amino acid digestibility was that it could improve digesta passing rate through the digestive tract (Stanogias and Pearce, 1985) increased the loss of endogenous nitrogen. Moreover, crude fiber could wrap up some peptide and amino acid which was prevented from being absorbed (Bergner *et al*., 1975; Sauer *et al*., 1991).

CONCLUSION

Using two chemical characteristics resulted in better prediction equations of amino acid digestibility which indicated that the R^2 of prediction equation for amino digestibility was improved with inclusion of a second characteristic. Further, study should be conducted to develop the best prediction equations of amino acid digestibility by more sample collection usage of more chemical characteristics.

IMPLICATIONS

The nutritive value of protein in peanut meal is determined not only by its total amino acid content but also by their digestibility values. However, the concentration of most amino acid in the study was lower than that listed by NRC (1998). Ten kinds of peanut meals were collected to determine the amino acid digestibility and develop the prediction equation of amino acid digestibility on the basis of chemical characteristics of peanut meal. And there were variability in the chemical composition of peanut which may be due to different peanut cultivars and processing procedures. The crude fiber was a suitable predictor for establishing the prediction equations of amino acid digestibility of peanut meal, however, using two chemical characteristics resulted in better prediction equations of amino acid digestibility. More different peanut meals should be collected and more research should be done to focus on the establishment of better prediction equation of amino acid digestibility.

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