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Determination of Ileal Amino Acid Digestibilities of Some By-products for Chickens

Ho Trung Thong[1], Ho Le Quynh Chau[1] and Vu Chi Cuong[2]

1. Faculty of Animal Husbandry and Veterinary Medicine, College of Agriculture and Forestry, Hue University, Thua Thien Hue 530000, Vietnam

2. National Institute of Animal Husbandry, Thuy Phuong, Tu Liem District, Hanoi, Vietnam

Abstract: The aim of this study was to determine the standardized ileal digestibility of amino acids in six by-product ingredients for broiler, i.e., copra meal, rapeseed meal, feather meal, hydrolyzed poultry meal, meat and bone meal, and shrimp head meal. Luong Phuong chickens at 35 d of age were used in the trials. Dietary protein in all assay diets was supplied solely by the test ingredient. In the case of protein-rich ingredients, dextrose was added to assay diets to obtain 20% of crude protein. Standardized ileal amino acid digestibilities were calculated by correcting the apparent ileal digestibility coefficients by basal endogenous amino acid losses. Results of study showed that the variation in ileal digestibility coefficients of amino acids was low in rapeseed meal and high in copra meal. Among animal protein meals, the lowest variation of digestibility among amino acids was observed in shrimp head meal. The high standardized ileal digestibilities of Arg, His, Leu + Ile, Thr, Trp, Val, and Phe were observed in hydrolyzed poultry meal and shrimp head meal. Meanwhile, the standardized ileal digestibility values of Lys, Thr and Trp in feather meal were very low. Meat and bone meal and feather meal were the two least digestible amino acid ingredients.

Key words: Amino acid, by-product, chicken, standardized ileal digestibility.

1. Introduction

It is recognized that not all the nutrients in feed ingredients are available for production purposes, and a portion of nutrients is excreted undigested or not utilized [1]. Therefore, maximizing the efficiency of nutrient utilization, especially protein and amino acid, is very important. Knowledge of amino acid digestibility coefficients in feed ingredients and the requirement of digestible amino acids for a defined production target enables the formulation of diets more close to chicken's requirements [2]. Formulating diets based on digestible amino acids allows increasing the diversity and inclusion levels of non-traditional ingredients, despite the fact that they may contain less than optimal natural amino acid profiles and are poorly digested [1]. Such formulations have significant role in developing countries, where highly digestible conventional ingredients are not available [1]. Many study results indicated the beneficial effects of using ileal digestible amino acids in broiler diet formulations to increase the inclusion levels of poorly digestible ingredients, such as cotton meal, canola meal, meat and bone meal [3-7]. Furthermore, diet formulations based on digestible amino acid improve the precision of formulation, offer economic benefits, ensure more predictable bird performance and reduce nitrogen output from poultry operations [1, 2, 8].

However, a question often posed by commercial nutritionists is which digestible amino acid system is the most appropriate for use in poultry diet formulation [9]. Apparent digestibility measures the digestibility of amino acids of both dietary and endogenous origins [10]. While, standardized digestibility includes a correction for endogenous amino acid secretions [11]. The choice of the

Corresponding author: Ho Trung Thong, associate professor, research field: animal science.

appropriate system of digestible amino acids may depend on the diet formulation method [9]. If diets are being formulated to the least-cost using linear programming, then apparent ileal digestibility values are the most appropriate, as they take into account the endogenous cost of digestion. On the other hand, in case of formulating diets with computer simulation models, then standardized digestibility values will be relevant if the model corrects for the endogenous cost of digestion [9]. Notwithstanding, it should be appreciated that both digestible amino systems are better than the total amino acid system, and all systems have specific applications and shortcomings [9]. This study was carried out with the purpose of determining standardized ileal digestibility of amino acids in some by-product ingredients (copra meal, rapeseed meal, feather meal, hydrolyzed poultry meal, meat and bone meal and shrimp head meal) for broiler.

2. Materials and Methods

2.1 Animals and Diets

The study was performed with Luong Phuong chickens at the Poultry Research Room and Central Lab, Faculty of Animal Husbandry and Veterinary Medicine, Hue University of Agriculture and Forestry from October 2013 to January 2014. A completely randomized experimental design in a single factor experiment was applied. A total of 180 35-day-old Luong Phuong chickens (completely matured digestive system) with uniform body weight 515 g/chick were assigned to six treatments for evaluation of apparent ileal amino acid digestibility in six test ingredients—copra meal, rapeseed meal, feather meal, hydrolyzed poultry meal, meat and bone meal, and shrimp head meal. Each treatment was replicated five times with 30 chicks per treatment. Every two chicks (one male and one female) were housed in a cage.

Dietary protein in all assay diets was supplied solely by the test ingredient [12, 13]. In the case of protein-rich ingredients, dextrose was added to assay diets to obtain 20% of crude protein [12]. Paper powder (3.0%) was added as a source of fiber in diets containing animal protein meals [12]. Celite (Celite® 545RVS, Nacalai Tesque, Japan) was added at 1.5% to all diets as a source of acid insoluble ash (AIA), which was used as an indigestible marker in the calculation of digestibility coefficients [14]. The nutritional value of test ingredients and the composition of experimental diets are presented in Tables 1 and 2.

2.2 Experimental Procedure

The experiment was implemented for 7 d following the method of Bryden and Li [12]. Diets were provided *ad libitum* and water was available at all times [12]. At the 8th day of experiment, all chickens were euthanized. Ileal digesta was collected as described by Bryden and Li [12]. The ileum was defined as the portion of the small intestine extending from Meckel diverticulum to a point of 4 cm proximal to the ileo-caecal junction. The contents of the lower half of the ileum were collected by gently flushing with distilled water into plastic containers. Ileal digesta of six chickens within a replication were pooled and frozen at -20 °C immediately after collection.

2.3 Chemical Analysis and Calculations

Digesta samples were dried at 60 °C in forced-ventilation oven for 8 h. Feed and dried digesta samples were ground to pass through a 0.5 mm sieve and stored in airtight container at 4 °C for chemical analyses. All proximate composition of samples was analyzed following AOAC procedures [15] at Central Lab, Faculty of Animal Husbandry and Veterinary Medicine, Hue College of Agriculture and Forestry, Hue University. Dry matter (DM) content of samples was determined by oven drying at 130 °C for 3 h as AOAC official method 930.15 [15]. Nitrogen (N) content was determined by using Kjeltec 8200 system (Foss, Sweden) following AOAC official method

Table 1 Nutritive value of test ingredients (as fed basis).

Nutritive		Copra meal	Rapeseed meal	Feather meal	Hydrolyzed poultry meal	Meat and bone meal	Shrimp head meal
Total amino acid (%)	Arg	2.27	2.07	5.15	4.21	3.39	2.43
	His	0.34	1.06	0.75	1.14	0.89	5.88
	Ile + Leu	1.92	3.48	10.01	6.73	4.53	4.41
	Lys	0.50	1.97	2.02	0.58	2.31	1.88
	Met	0.30	0.65	0.49	1.18	0.68	0.53
	Phe	0.80	1.77	3.63	2.52	1.55	1.71
	Thr	0.61	1.44	3.50	2.46	1.57	1.26
	Trp	0.16	0.41	0.58	0.41	0.31	0.20
	Val	1.09	1.65	5.34	2.98	2.30	1.91
	Ala	0.73	1.56	3.85	4.00	3.03	2.00
	Asp	1.49	2.39	4.57	5.79	3.39	2.45
	Cys	0.20	0.81	4.09	0.58	0.48	1.63
	Glu	3.56	6.12	8.20	6.11	6.27	4.27
	Gly	0.78	1.83	7.08	5.62	6.83	1.66
	Pro	0.60	2.05	9.51	4.14	4.19	1.10
	Ser	0.80	1.37	7.94	3.40	1.57	0.90
	Tyr	0.56	0.94	1.96	1.83	1.05	1.36
Proximate composition (%)	DM	93.16	88.34	94.15	90.93	96.00	87.67
	CP	19.59	36.08	85.74	67.41	51.47	46.18
	EE	13.70	2.51	4.48	13.56	2.33	8.25
	CF	13.25	12.09	0.28	0.45	2.33	10.12
	Ash	7.02	6.97	3.64	6.88	3.91	14.56

Table 2 Composition and nutrient content of experimental diets.

Ingredient	Ratio (%)					
Copra meal	94.00	-	-	-	-	-
Rapeseed meal	-	55.50	-	-	-	-
Feather meal	-	-	23.30	-	-	-
Hydrolyzed poultry meal	-	-	-	30.00	-	-
Meat and bone meal	-	-	-	-	38.86	-
Shrimp head meal	-	-	-	-	-	45.53
Dextrose	-	38.05	65.55	58.85	49.99	43.32
Soybean oil	2.00	2.00	6.00	6.00	6.00	6.00
Paper powder	-	-	3.00	3.00	3.00	3.00
Vitamin premix*	0.20	0.20	0.20	0.20	0.20	0.20
Mineral premix**	0.25	0.25	0.25	0.25	0.25	0.25
$CaCO_3$	1.45	-	-	-	-	-
DCP	0.40	2.30	-	-	-	-
NaCl	0.20	0.20	0.20	0.20	0.20	0.20
Celite	1.50	1.50	1.50	1.50	1.50	1.50
Total	100	100	100	100	100	100
Nutrient content, as-fed basis						
Protein (%)	18.41	20.02	19.98	20.22	20.00	21.02
Metabolizable energy (kcal/kg)	2,223	995	1,127	1,383	1,135	1,259

* Bio-pharmachemie (Bio-ADE + B-complex premix), 1 kg contains: vitamin A, 3,100,000 UI; vitamin D3, 1,100,000 UI; vitamin E, 300 UI; vitamin B1, 320 mg; vitamin B2, 140 mg; niacinamide, 1,000 mg; vitamin B6, 600 mg; vitamin B12, 1,200 μg; vitamin C, 1,000 mg; acid folic,130 mg.

** Bio-pharmachemie (Bio-chicken minerals), 1 kg contains: Mn, 10,800 mg, Fe, 2,160 mg; Zn, 7,200 mg; Cu, 1,260 mg; iodine, 144 mg; Co, 21.6 mg; Se, 14.4 mg; acid folic, 40 mg; biotin, 4,800 μg; choline chloride, 20,000 mg.

984.13 [15]. Crude protein contents of the samples were calculated as N × 6.25. Ether extract, crude fiber and total ash contents of the samples were determined following AOAC official methods 920.39, 978.10, and 942.05 [15], respectively. Amino acids in digesta and feed were analyzed using LC/MS/MS system with EZ:faast^{TM} amino acids analysis kit (Phenomenex) at Hai Dang Chromatography Scientific Services Joint Stock Company (Ho Chi Minh city, Vietnam). AIA content was assayed following the method of Vogtmann et al. [16].

Standardized ileal amino acid digestibilities were calculated by correcting the apparent ileal digestibility coefficients by basal endogenous amino acid losses [17], as shown in Eq. (1) [14]:

SID (%) = AID (%) + [basal endogenous amino acid losses (g/kg DM intake)/amino acid content of the raw material (g/kg DM) × 100] (1)

where, AID (%): apparent ileal digestibility coefficient; SID (%): standardized ileal digestibility coefficient; DM: dry matter.

In the authors' previous study, basal endogenous amino acid losses had been determined based on the concentration of amino acids in ileal digesta collected from chickens fed protein free diet, AIA contents in diet and the ileal digesta [17].

2.4 Data Analysis

The mean value was calculated from five replicate values. The data were analyzed using Microsoft excel 2007.

3. Results and Discussion

The crude protein content and amino acid composition of test ingredients (Table 1) are within the ranges reported in Ref. [18]. The apparent and standardized ileal digestibilities of amino acids of six test ingredients are presented in Tables 3 and 4. The apparent ileal digetibilities of protein or amino acids were lower than the standardized ileal digetibilities. The variations between apparent and standardized ileal digetibilitie values were low in protein-rich ingredients, and vice versa.

There are no remarkable differences in the ileal digestibility coefficients of amino acids of rapeseed meal. This finding was similar to the previous study conducted by Ravindran et al. [13]. Regarding to copra meal, high variation of the standardized ileal

Table 3 Apparent ileal amino acid digestibility of test ingredients.

Amino acid	Apparent ileal digestibility (%)					
	Copra meal	Rapeseed meal	Feather meal	Hydrolyzed poultry meal	Meat and bone meal	Shrimp head meal
Arg	83.54	82.12	66.23	86.45	72.65	80.14
His	66.92	79.72	53.69	79.36	68.75	75.76
Ileu + Leu	68.00	73.79	68.44	79.89	72.14	77.90
Lys	63.44	71.4	51.55	79.09	64.21	74.01
Met	70.97	72.88	54.69	74.19	67.79	78.19
Phe	67.58	73.52	59.17	79.14	64.65	75.85
Thr	61.09	65.53	50.82	79.49	60.81	73.87
Trp	69.23	75.19	46.43	76.01	53.67	74.61
Val	73.31	71.45	64.33	75.66	68.88	76.99
Ala	66.62	73.85	75.96	73.91	68.99	71.99
Asp	59.33	70.08	66.70	67.74	62.89	77.26
Cys	58.85	72.94	45.30	67.88	48.02	75.85
Glu	62.94	82.47	65.77	76.23	72.68	76.48
Gly	60.87	71.2	79.26	73.07	70.80	72.87
Pro	55.84	71.01	71.04	80.74	72.88	72.93
Ser	55.04	69.29	74.77	69.08	64.94	72.15
Tyr	66.27	73.55	57.44	72.64	69.82	74.23

Table 4 Standardized ileal amino acid digestibility of test ingredients.

Amino acid	Standardized ileal digestibility (%)					
	Copra meal	Rapeseed meal	Feather meal	Hydrolyzed poultry meal	Meat and bone meal	Shrimp head meal
Arg	84.80	84.33	68.49	88.52	74.75	82.43
His	71.36	82.00	61.90	83.39	72.99	76.27
Ileu + Leu	71.70	77.06	71.32	83.11	76.04	81.04
Lys	67.49	73.04	55.63	82.84	66.39	76.11
Met	74.58	75.53	63.51	76.97	71.73	82.15
Phe	71.18	76.13	62.40	82.63	69.27	79.14
Thr	69.38	71.18	56.73	85.81	68.84	81.72
Trp	75.74	79.23	53.61	83.72	61.95	84.43
Val	77.23	75.59	67.59	80.03	73.50	81.34
Ala	70.77	76.96	79.16	76.22	71.48	74.92
Asp	63.00	73.76	71.58	70.63	66.92	81.62
Cys	70.42	77.44	47.57	79.93	59.91	78.58
Glu	64.99	84.39	69.40	79.88	75.58	79.82
Gly	67.05	75.44	82.04	75.69	72.56	78.56
Pro	62.36	74.09	72.72	84.59	75.22	79.92
Ser	60.37	74.32	76.97	72.93	71.71	81.45
Tyr	71.43	78.44	64.38	77.43	76.64	78.33

amino acid digestibilities was observed, ranging from 60.37% to 84.80%. The difference in quality of rapeseed meal and copra meal may be explained due to the difference in concentrations of limiting amino acids and bulking properties.

The variation of digestibility between amino acids in shrimp head meal was lower than that in other animal protein ingredients. Standardized ileal digestibility of amino acids ranged from 74.92% to 84.43% in shrimp head meal. Meanwhile, the standardized ileal digestibility values of amino acid in feather meal, meat and bone meal ranged from 47.57% to 82.04% and from 59.91% to 76.64%, respectively. Among the essential amino acids, the standardized ileal digestibility values of Lys, Thr and Trp in feather meal were very low. On the other hand, the standardized ileal digestibilities of Arg, His, Leu + Ile, Thr, Trp, Val and Phe were very high in hydrolyzed poultry meal and shrimp head meal (Table 4). The low standardized ileal digestibility of amino acids was observed in feather meal, meat and bone meal. The variation in quality of meat and bone meal is likely to be caused by the correlation variability between muscle protein and collagen content in raw materials, or by processing conditions of the meals [7, 19, 20]. In poor-quality meat and bone meal, 50%-65% of total protein may be collagen [1]. Collagen is the major protein in bone, connective tissue, cartilage and tendon. Eastoe and Long [21] found that collagen is severely deficient in most indispensable amino acids and poorly digested because of the low level of collagenase in digestive tract.

4. Conclusions

The variation in ileal digestibility coefficients of amino acids was low in rapeseed meal and high in copra meal. Among animal protein meals, the lowest variation of digestibility between amino acids in shrimp head meal was observed. The high standardized ileal digestibilities of Arg, His, Leu + Ile, Thr, Trp, Val and Phe was observed in hydrolyzed poultry meal and shrimp head meal. Meanwhile, the standardized ileal digestibility values of Lys, Thr and Trp in feather meal were very low. Meat and bone meal and feather meal were the two least digestible amino acid ingredients.

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