FINAL REPORT
Midwest Poultry Research Program

Ileal Digestibility of Amino Acids in Feeds for White Pekin Ducks

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Summary

The experiment was conducted to determine ileal amino acid digestibility of various ingredients in ducks. A total of 288 White Pekin ducks were used in a 5-d trial to determine apparent ileal amino acid digestibility of various feed ingredients. Six feed ingredients including soybean meal (SBM), meat and bone meal (MBM), canola meal (CM), corn distillers' dried grains with solubles (DDGS), corn, and wheat were used for study. The feed ingredients served as the sole source of amino acid in semipurified diets composed of dextrose, soy oil, solka floc, minerals and vitamins. The ducks received standard duck starter diet for 13 d post-hatch and at day 14, were sorted by weight and allocated to 6 dietary treatments in a randomized complete block design. There were 8 replicate cages per treatment and 6 ducks per replicate cage. Beginning from day 14, ducks received the assay diet for 5 d and ileal digesta was collected on day 19. Ileal N digestibility was greatest ($P < 0.01$) in diet with SBM and the range was 72.4 (MBM) to 88.3% (SBM). Ileal digestibility of amino acids was highest for SBM among the feed ingredients. Soybean meal had the greatest digestibility for lysine followed by CM, corn, wheat and MBM with DDGS being least digestible ($P < 0.01$). Methionine digestibility in SBM was greater ($P < 0.01$) than in corn, wheat, DDGS or CM, whereas MBM was the least digestible. For threonine, SBM had the highest digestibility and corn was the least digestible ($P < 0.01$), but there were no differences among other feed ingredients. The ranges in ileal amino acid digestibility were 69.2 (DDGS) to 90.3% (SBM) for lysine, 78.4 (MBM) to 91.8% (SBM) for methionine, 61.6 (corn) to 84.0% (SBM) for threonine, and 78.9 (MBM) to 93.0% (SBM) for tryptophan. In conclusion, there are considerable differences among protein sources in their ability to supply amino acid in a form utilizable by the duck. Therefore, more accurate diet formulation may be attained if digestible amino acids in a feed ingredient are taken into account.

Introduction

Digestibility and balance experiments represent the cornerstone of feedstuff evaluation for nutrients utilization. Whereas performance experiments can give some insight into the potential value of a feed ingredient, nutrient utilization is most important for the purposes of diet formulation. Additivity of nutrient utilization values is also a crucial consideration in diet formulation. It is assumed that the supply of utilizable nutrients in a complete diet is equal to the sum of the supply based on the nutrient utilization values determined for single ingredients. Nitrogen utilization is an important component of animal nutrition and hence several studies have addressed the issue of protein and amino acid digestibility and utilization in chickens especially.

Recent studies in chickens have provided data on ileal amino acid digestibility in chickens using different feedstuffs, classes and age of chickens (Ravindran et al., 1999; Kadim et al., 2002; Huang et al., 2005). Few studies have been done to determine total tract amino acid retention in ducks in various cultivars of corn and soybean meal (Adeola, 2005) and in spray-dried egg, plasma protein and soybean meal (Norberg et al., 2004). But amino acids are absorbed only from the small intestine and there is the effect of hindgut fermentation on amino acid metabolism. Because of these reasons, it is now accepted that ileal digestibility is more accurate method of amino acid digestibility than the total tract digestibility. Hong et al.(2002) showed that amino acid digestibility estimated at the ileal level in ducks was lower than estimated at the total tract, the same conclusions was drawn in Ravindran et al. (1999) and Kadim et al., (2002) studies with chickens.

Studies that consider the ileal amino acid digestibility of different feedstuffs in ducks are very scarce. Martin et al. (1998) provided data on ileal amino acid digestibility of ducks receiving vegetable protein and rice bran supplemented with fishmeal and phytase. In order to study possible effects of the microfloral of distal gastro intestinal tract on amino acid digestibility, Ragland et al. (1999) performed cecectomy on ducks and compared the amino acid digestibility in these duck to that of intact duck. The authors reported variable results in amino digestibility of specific amino acids in these two groups and concluded that result obtained in cecectomized birds may be feed ingredient-specific.

Objective

The objective of this study was to determine ileal amino acid digestibility of various ingredients in order to provide data that could be used for practical feed formulation in the duck.

Materials and Methods

Feed ingredients and diets

Six feedstuffs including soybean meal, meat and bone meal, canola meal, distillers dried grains with solubles (DDGS), corn, and wheat were used for determination of

apparent ileal digestibility of amino acids. The feedstuffs were used as the sole source of amino acid in semi-purified diets composed of dextrose, soy oil, solka floc, minerals and vitamins. Dextrose served as carrier of chromic oxide that was used as an indigestible marker in diets.

Ducks and ileal digestibility assay

Two-hundred eighty-eight ducks were used for this study. The ducks received standard duck diet and at 14 days old, the ducks were sorted by weight and allocated to 6 dietary treatments in a randomized complete block design. There were eight replicate cages per treatment and 6 ducks per replicate cage. Beginning from day 14, duck received the assay diet for 5 d. On day 19, the ducks were asphyxiated with CO_2, the distal part of ileum was removed and the content gently rinsed with distilled water into plastic containers, and stored frozen.

Chemical analyses

All digesta samples were consequently freeze-dried and ground prior to analyses. The diets and digesta samples were analyzed for individual amino acids. Samples for amino acids analysis were prepared using a 24 h hydrolysis in 6 N hydrochloric acid at 110℃ under an atmosphere of nitrogen. For methionine and cysteine, performic acid oxidation was done before acid hydrolysis. Samples for tryptophan analysis were hydrolyzed using barium hydroxide. Amino acids in hydrolysate were determined by HPLC after post column derivatization. All amino acids analyses were done at the University of Missouri Experiment Station Chemical Laboratory. Dry matter analysis of samples was conducted by drying the samples in a drying oven at 105℃ for 24 h. Gross energy was determined in a bomb calorimeter using benzoic acid as a calibration standard. Chromium content of samples was determined by digesting the samples in concentrated nitric and 70% perchloric acid and determining the absorption in spectrophotometer at 440 nm. Nitrogen was determined by the combustion method using EDTA as a calibration standard.

Calculations

Apparent ileal amino acid digestibility was calculated using the following relation:

$$AAD\ (\%) = \left[1 - \left(\frac{C_i}{C_o} \times \frac{AA_o}{AA_i}\right)\right] \times 100$$

Where:
AAD is apparent ileal amino acid digestibility(%); C_i is the concentration(%) of chromium in the diet; C_o is the concentration(%) of chromium in the digesta; AA_o is the concentration(%) of the amino acid in digesta; and AA_i is the concentration(%) of the amino acid in the diet.

Statistical Analysis

Apparent ileal digestibility of total and individual amino acids was compared among the feedstuffs using the General Linear Model (GLM) procedure of SAS. Means were separated using Tukey's test and level of significance will be set at 5%.

Results and Discussion

Table 1 shows the ingredients and chemical composition of the experimental diets. In all diets, the test feedstuffs served as the sole source of amino acid in the diet. Different diets were used for the determination of amino acid digestibility of test ingredients. Assay diets for corn and wheat contained 925 g of test ingredient/kg of diet. Assay diets for DDGS, Canola meal, Soybean meal, and Meat and bone meal were based on dextrose and contained the test ingredient as the only source of amino acid. The proportion of dextrose in the assay diet varied so that the assay diet contained approximately 200 g of crude protein/kg of diet. Solka Floc was also included in the assay diet for meat and bone meal. Table 2 presents nitrogen and amino acid concentrations of the test feedstuffs. Analyzed level of N in feedstuffs was the highest in MBM, whereas corn had the least level. In general, the concentration of nonessential amino acids is the greatest in MBM except for isoleucine, phenylalanine and tryptophan.

Table 3 are data on apparent ileal digestibility of dry matter, nitrogen, and amino acids in duck. Apparent ileal N digestibility was greatest ($P < 0.01$) in diet with SBM and the range was 72.4 (MBM) to 88.3% (SBM). In general, apparent ileal digestibility of amino acids was highest for SBM among the feed ingredients and the digestibility coefficients for most of the essential amino acids in SBM are higher than 90% except for leucine, threonine and tryptophan. Soybean meal had the greatest digestibility for lysine followed by CM, corn, wheat and MBM with DDGS being least digestible ($P < 0.01$). Methionine digestibility in SBM was greater ($P < 0.01$) than in corn, wheat, DDGS or CM, whereas MBM was the least digestible. For threonine, SBM had the highest digestibility and corn was the least digestible ($P < 0.01$), but there were no differences among other feed ingredients. The ranges in apparent ileal amino acid digestibility were 69.2 (DDGS) to 90.3% (SBM) for lysine, 78.4 (MBM) to 91.8% (SBM) for methionine, 61.6 (corn) to 84.0% (SBM) for threonine, and 78.9 (MBM) to 93.0% (SBM) for tryptophan. A comparison of apparent ileal digestibility coefficients for the indispensable and dispensable amino acids in corn, wheat, DDGS, CM, SBM and MBM revealed a considerable variation. A part of variation might reflect the differences in amino acid composition and structure and distribution of proteins in the feedstuffs. Although both of SBM and MBM have a high amount of protein, apparent ileal digestibility of amino acid in SBM was greater than that of MBM due to amino acid balance.

In conclusion, there are considerable differences among protein sources in their ability to supply amino acid in a form utilizable by the duck. Therefore, more accurate diet formulation to meet the amino acid requirement for ducks while minimizing the excretion

of excess nutrients may be attained if digestible amino acids in a feed ingredient are taken into account.

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Table 1. Ingredients and chemical composition of the experimental diets

Ingredients, g/kg	Corn	Wheat	DDGS	Canola meal	Soybean meal	Meat and bone meal
Test feedstuff	925	925	730	527	413	397
Dextrose	0	0	167	370	484	479
Soy oil	20	20	50	50	50	50
Dicalcium phosphate[1]	19	19	19	19	19	0
Limestone (38% Ca)	12	12	10	10	10	0
Solka Floc	0	0	0	0	0	50
Salt	3	3	3	3	3	3
Chromic oxide marker[2]	15	15	15	15	15	15
Choline Chloride	3	3	3	3	3	3
Vitamin-mineral premix[3]	3	3	3	3	3	3
Total	1000	1000	1000	1000	1000	1000
Calculated Nutrients & Energy						
Protein, g/kg	78.6	130.4	200.0	200.3	200.3	200.1
ME, kcal/kg	3313.6	2897.3	2928.5	2963.8	3362.1	3188.5
Ca, g/kg	8.5	8.8	8.8	11.2	8.7	25.5
P, g/kg	6.1	6.9	8.8	9.7	6.1	14.0
Non-phytate P, g/kg	4.3	4.7	6.4	5.1	4.4	14.0
Total amino acids, g/kg						
Arg	3.5	5.6	7.2	11.0	14.4	13.0
His	2.1	2.9	4.8	4.9	5.3	3.8
Ile	2.7	4.1	7.3	7.2	8.8	6.1
Leu	9.3	8.2	16.1	13.0	15.4	13.0
Lys	2.4	3.4	5.5	10.2	12.2	10.4
Met	1.7	1.9	4.4	3.7	2.8	2.7
Phe	3.5	5.6	8.8	7.6	9.7	7.2
Thr	2.7	3.6	6.7	8.1	7.7	6.9
Trp	0.6	1.5	1.4	2.3	3.1	1.1
Val	3.7	5.3	9.5	9.3	9.2	9.4

[1]20% Ca, 18.5% P.

[2]Prepared as 1 g chromic oxide added to 4 g dextrose. Dextrose will serve as carrier in the diets.

[3]Supplies the following per kg DIET: Vit. A, 5484 IU; Vit. D3, 2643 ICU; Vit E,11 IU; Menadione sodium bisulfite,4.38 mg; Riboflavin, 5.49 mg; d-pantothenic acid, 11 mg; Niacin, 44.1 mg; Choline chloride, 771 mg; Vit B12, 13.2 ug; Biotin, 55.2 ug; Thiamine mononitrate, 2.2 mg; Folic acid, 990 ug; Pyridoxine hydrochloride, 3.3 mg; I, 1.11 mg; Mn, 66.06 mg; Cu, 4.44 mg; Fe, 44.1 mg; Zn, 44.1 mg; Se, 300 ug. Also contains per g of premix: Vit. A, 1828 IU; Vit. D3, 881 ICU; Vit E,3.67 IU; Menadione sodium bisulfite,1.46 mg; Riboflavin, 1.83 mg; d-pantothenic acid, 3.67 mg; Niacin, 14.69 mg; Choline chloride, 257 mg; Vit B12, 4.4 ug; Biotin, 18.4 ug; Thiamine mononitrate, 735 ug; Folic acid, 330 ug; Pyridoxine hydrochloride, 1.1 mg; I, 370 ug; Mn, 22.02 mg; Cu, 1.48 mg; Fe, 14.69 mg; Zn, 14.69 mg; Se, 100 ug.

Table 2. Nitrogen and amino acid concentrations of the test ingredients (g/kg, as-is basis)

Ingredient	Corn	Wheat	DDGS	Canola meal	Soybean meal	Meat and bone meal
Dry matter	918.4	939.7	897.9	958.5	927.1	981.6
Nitrogen	14.6	18.1	41.7	64.8	76.0	95.9
Nonessential amino acids						
Arginine	4.9	5.8	12.4	26.0	35.6	36.7
Histidine	2.5	2.7	7.9	10.4	12.5	14.3
Isoleucine	3.4	4.0	9.8	16.2	22.4	21.0
Leucine	9.8	7.8	30.2	29.1	37.6	39.3
Lysine	3.8	3.7	9.8	23.2	30.4	38.0
Methionine	1.7	1.8	5.6	6.7	6.6	9.3
Phenylalanine	4.4	5.1	11.9	17.2	24.3	21.5
Threonine	3.2	3.3	10.1	16.1	18.2	19.5
Tryptophan	0.7	1.4	1.7	5.2	6.8	4.6
Valine	4.3	5.1	14.0	19.7	23.6	27.4
Essential amino acids						
Alanine	5.9	4.3	18.0	17.3	20.6	40.2
Aspartic Acid	7.0	5.9	17.2	34.2	54.6	46.1
Cysteine	1.6	2.5	4.7	7.6	6.6	4.1
Glutamic Acid	16.0	31.6	35.2	67.7	86.5	73.9
Glycine	3.6	4.9	10.5	18.4	20.1	59.4
Proline	6.3	10.3	19.4	21.2	23.0	35.1
Serine	4.1	5.0	11.4	16.2	21.1	17.9
Tyrosine	2.8	3.0	8.9	12.2	17.6	17.9

Table 3. Apparent ileal digestibility of dry matter, nitrogen, and amino acids

Ingredient	Corn	Wheat	DDGS	Canola meal	Soybean meal	Meat and bone meal	SEM
n[1]	8	8	7	8	8	8	
Digestibility, %							
Dry matter	78.96^{a}	72.25^{b}	62.96^{c}	64.88^{c}	79.64^{a}	76.97^{a}	1.03
Nitrogen	74.85^{bc}	78.83^{b}	77.35^{b}	75.99^{bc}	88.33^{a}	72.42^{c}	0.88
Nonessential amino acids							
Arginine	79.27^{cd}	77.82^{d}	84.15^{bc}	87.11^{b}	93.82^{a}	83.54^{bcd}	1.00
Histidine	83.79^{bc}	82.78^{b}	81.43^{b}	82.73^{bc}	91.59^{a}	73.37^{c}	0.89
Isoleucine	75.18^{b}	80.75^{b}	79.49^{b}	77.69^{b}	90.09^{a}	77.31^{b}	0.97
Leucine	84.81^{ab}	81.54^{bc}	87.90^{a}	79.41^{c}	89.24^{a}	78.18^{c}	0.79
Lysine	77.95^{b}	76.75^{b}	69.19^{c}	79.04^{b}	90.34^{a}	75.60^{b}	1.07
Methionine	85.62^{b}	84.68^{b}	85.05^{b}	84.78^{b}	91.81^{a}	78.40^{c}	0.72
Phenylalanine	81.06^{bc}	83.84^{b}	84.15^{b}	81.53^{bc}	90.41^{a}	78.81^{c}	0.76
Threonine	61.64^{c}	66.39^{bc}	69.79^{b}	69.57^{b}	83.95^{a}	69.95^{b}	1.28
Tryptophan	80.24^{cd}	90.66^{ab}	78.99^{d}	84.95^{bc}	93.00^{a}	78.91^{d}	1.02
Valine	68.07^{c}	73.45^{bc}	78.08^{b}	74.10^{bc}	87.15^{a}	74.62^{bc}	1.16
Essential amino acids							
Alanine	83.43^{bc}	73.61^{e}	84.88^{ab}	79.27^{cd}	88.87^{a}	78.15^{de}	0.89
Aspartic Acid	74.19^{b}	70.28^{b}	70.55^{b}	74.65^{b}	87.86^{a}	53.29^{c}	1.69
Cysteine	53.84^{b}	72.29^{a}	73.21^{a}	70.90^{a}	81.10^{a}	32.71^{c}	2.80
Glutamic Acid	86.56^{b}	92.06^{a}	85.29^{b}	85.96^{b}	92.26^{a}	75.49^{c}	0.92
Glycine	59.35^{c}	71.94^{b}	71.14^{b}	74.49^{b}	85.57^{a}	71.68^{b}	1.48
Proline	76.26^{b}	87.41^{a}	84.02^{a}	75.75^{b}	88.04^{a}	71.39^{b}	1.13
Serine	65.95^{c}	75.88^{b}	76.37^{b}	71.43^{bc}	86.29^{a}	64.44^{c}	1.44
Tyrosine	75.19^{c}	78.80^{bc}	83.72^{ab}	76.42^{c}	89.58^{a}	79.18^{bc}	1.00

$^{a-e}$Means in a row bearing different superscripts are significantly different ($P < 0.01$).
[1]The values are means of 7 replicate pens (6 birds/replicate) for cysteine of corn and tryptophan of wheat.