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Digestible Sulfur Amino Acid Requirements for Maintenance in the Starting Turkey

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Abstract: Amino acid requirement data can be determined in multiple fashions. One method for determining amino acid requirement is through modeling. A portion of the data required for a comprehensive model is the maintenance requirement. Two studies were conducted to determine the maintenance requirement for the sulfur amino acids during the starter period for turkeys. A low protein diet was formulated so that different levels of total sulfur amino acids could be fed to young turkeys. A maintenance requirement of approximately 26 mg/bird/day was found in both experiments. This information, coupled with the amino acid requirements for growth, will allow for the construction of an effective model to predict amino acid requirements over a wide range of environment and physiological conditions.

Key words: Turkey, amino acid, low protein diet

Introduction

Meeting the nutritional requirements for growing turkeys constitutes the majority of costs associated with turkey production. By reducing the level of protein in the diets of these birds, significant cost savings can be realized. Firman (1994) reported that a one percent decrease in protein level could yield savings of five dollars per ton of feed. Although the use of ideal amino acid ratios and digestible formulation have the potential to reduce feed costs significantly, the combination of these concepts with other factors in a model offers the potential for the most efficient feeding program.

In order for a model of amino acid requirements to be most effective, amino acid requirements must be determined as precisely as possible. Since amino acid requirements can be partitioned into a requirement for maintenance and a requirement for growth, a comprehensive model must take each of these requirements into account to achieve maximum efficiency. While amino acid requirements for growth are rather easily defined as the amino acid level that produces maximal growth, defining a maintenance requirement is less straightforward.

Maintenance can be defined as the point of static lean tissue content or static amino acid content. It has been demonstrated in broiler chicks that these two requirements are not the same (Baker *et al.*, 1996; Edwards *et al.*, 1997,1999; Edwards and Baker, 1999). Regardless of which definition of maintenance is used, there has been little research into the maintenance requirements of poultry. Leveille and Fisher (1959; 1960) and Leveille *et al.* (1960) performed balance studies to determine maintenance amino acid requirements in adult roosters, and maintenance requirements for some amino acids have been determined in broiler chicks (Baker *et al.*, 1996; Edwards *et al.*, 1997; 1999; Edwards and Baker, 1999). Currently, no experimentally obtained data on the maintenance amino acid requirements of turkeys in the starter period are available.

The following experiments were designed to determine the digestible total sulfur amino acids (TSAA) requirement for maintenance in turkeys during the starter period.

Materials and Methods

Day-old poults were obtained from a commercial hatchery and fed an NRC (NRC, 1994) corn and soybean meal diet until seven days of age. On day 7, after 10 hours of feed deprivation, birds were weighed, wing-banded, and randomly assigned to pens to ensure that each pen was of similar weight. Each trial contained 192 birds to provide for six replications of eight treatments. Ten birds with an average weight equal to that of the experimental pens were killed (CO_2 asphyxiation) and frozen to provide for initial body composition data.

Diets for the trials were formulated on a digestible basis utilizing least-cost formulation software. Birds were fed specialized diets in order to achieve the low amino acid levels required to determine maintenance requirements (Table 1). Corn and sucrose comprised the majority of the diets, with amino acids, vitamins, and other nutrients provided in purified form. Sand was included as filler on all diets. Other than synthetic amino acids, corn was the only amino acid-containing ingredient used in the experimental diets. Amino acid digestibility values for the corn were obtained through previous testing with cecectomized turkeys.

The treatment levels of TSAA in the diets were as follows: 0.11, 0.16, 0.21, 0.26, 0.31, 0.36, 0.41, 0.46. All other amino acids were maintained at 15% excess relative to TSAA level based on the Missouri Ideal Turkey Ratio. Glutamic acid was added to the diets to prevent confounding of results due to a generalized nitrogen deficit.

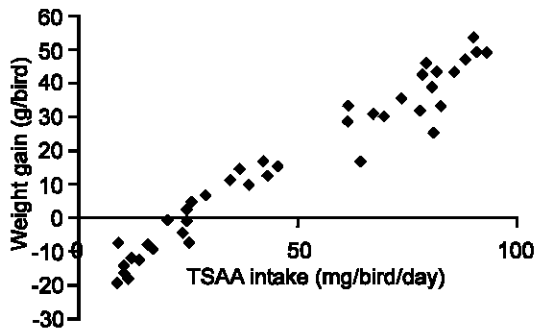

Fig. 1: Plot Weight Gain (Y) as a Function of TSAA Intake (X)

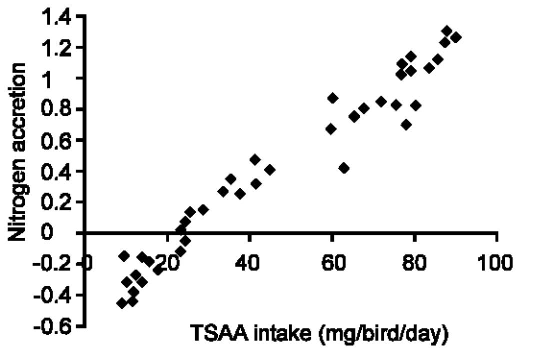

Fig. 2: Plot of Whole-body Nitrogen Accretion (Y) as a Function of TSAA Intake (X)

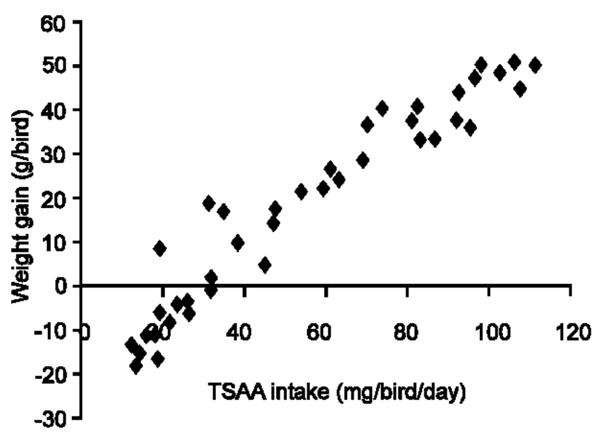

Fig. 3: Plot Weight Gain (Y) as a Function of TSAA Intake (X)

Poults were housed in stainless steel batteries in a thermostatically controlled room with constant fluorescent lighting. Access to experimental diets and water was provided *ad libitum* for 7 days. Poults were deprived of feed for 10 hours to remove gut fill prior to being killed (CO_2 asphyxiation), weighed, and frozen for later analysis.

Frozen birds were ground, mixed thoroughly, and a sub-

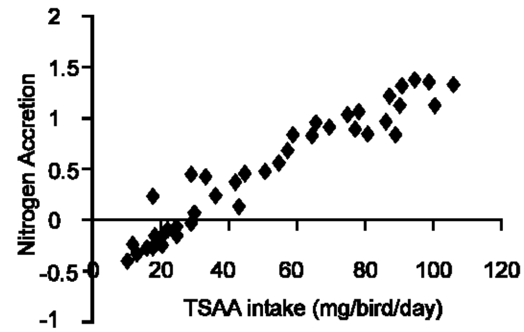

Fig. 4: Plot of Whole-body Nitrogen Accretion (Y) as a Function of TSAA Intake (X)

sample was retained for analysis. Samples were weighed and dried in a laboratory oven at 60°C until dry. Dried samples were weighed to determine dry matter content prior to being ground. Ground samples were analyzed by LECO® to determine nitrogen content.

Analysis of data was performed using pen means as the experimental unit. The JMP (SAS®) statistical software package was used to provide linear regression equations.

Results and Discussion

Two trials were conducted to determine the digestible TSAA requirement for maintenance in the starting turkey. In each trial, weight gain and nitrogen accretion responded linearly to TSAA intake ($p<0.0001$).

In the first experiment, weight gain as a function of TSAA intake (Fig. 1) was described by a straight line: Y=0.7345X-19.393 (R^2=0.95). Solving this equation yields a requirement for maintenance of body weight of 26.40 mg/bird/day of TSAA. When body weight was applied to the equation, the requirement was 222.71 mg/kg body weight/day. The relationship of nitrogen accretion as a function of TSAA intake (Fig. 2) was also described by a straight line: Y=0.0186X-0.491 (R^2=0.95). Once solved, the equation predicts a requirement of 26.40 mg/bird/day of TSAA for maintenance of nitrogen content. Applying body weight data to the linear equation yields a requirement of 222.71 mg/kg body weight/day.

Data from the second experiment supported the linear relationships between TSAA intake and measured parameters that were found in the first experiment. Weight gain as it related to TSAA intake (Fig. 3) was represented by the following linear regression equation: Y=0.6831X-17.925 (R^2=0.93). The straight-line relationship of nitrogen accretion with TSAA intake (Fig. 4) was represented by the equation, Y=0.0179X-0.4625 (R^2=0.92). Solving for these equations yields requirements of 26.24 and 25.84 mg/bird/day TSAA, respectively; 215.28 and 211.99 mg/kg body weight/day.

In each of the experiments conducted, weight gain and nitrogen accretion responded linearly to TSAA intake

Table 1: Composition of Experimental Diets for TSAA Trials

TSAA Treatment	0.11%	0.16%	0.21%	0.26%	0.31%	0.36%	0.41%	0.46%
Corn	32.934	47.904	62.874	73.325	70.881	68.699	66.519	64.337
Sucrose	42.613	27.047	11.419	0	0	0	0	0
Corn Oil	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
Sand	3	3	3	3	3	3	3	3
Dicalcium Phosphate	3.035	2.972	2.908	2.864	2.875	2.884	2.893	2.902
Sodium Bicarbonate	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Lime	1.147	1.181	1.216	1.24	1.234	1.229	1.224	1.219
Potassium Chloride	1.142	1.057	0.971	0.912	0.926	0.938	0.95	0.963
Selenium Premix	0.032	0.031	0.03	0.03	0.03	0.03	0.03	0.03
Cobalt Sulfate	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.001	0.0001
Trace Mineral[4]	0.072	0.066	0.061	0.057	0.058	0.059	0.06	0.061
Iodized Salt	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Arginine	0.234	0.259	0.282	0.323	0.406	0.489	0.572	0.655
Glutamic acid	1.36	1.932	2.505	3.131	4.66	5.936	7.212	8.488
Glycine	0.137	0.141	0.145	0.164	0.225	0.286	0.347	0.408
Histidine Hcl	0.142	0.156	0.168	0.191	0.244	0.297	0.349	0.401
Isoleucine	0.22	0.251	0.282	0.323	0.391	0.46	0.529	0.597
Leucine	0.356	0.375	0.393	0.445	0.596	0.744	0.893	1.04
Lysine HCl	0.533	0.630	0.727	0.837	0.975	1.112	1.25	1.389
DL Methionine	0	0	0	0.015	0.075	0.133	0.192	0.25
Phenylalanine	0.347	0.383	0.418	0.478	0.601	0.724	0.847	0.969
Threonine	0.197	0.223	0.249	0.284	0.348	0.411	0.474	0.538
Tryptophan	0.069	0.083	0.096	0.11	0.128	0.145	0.163	0.180
Valine	0.194	0.212	0.23	0.262	0.334	0.406	0.478	0.55
Vitamin A[1]	1.007	1.007	1.007	1.007	1.007	1.007	1.007	1.007
Vitamin D[2]	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Vitamin K[3]	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208
Vitamin B_{12}[6]	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027
Vitamin E[7]	0.173	0.053	0	0	0	0	0	0
Choline Chloride	0.269	0.251	0.233	0.22	0.223	0.226	0.229	0.231
Vitamin Premix[5]	0.052	0.05	0.048	0.047	0.047	0.047	0.048	0.048

[1]A vitamin A source was created by diluting vitamin A with cornstarch to provide 563.41 IU/kg of vitamin A. [2]A vitamin D source was created by diluting vitamin D with cornstarch to provide 220,000 ICU/kg of vitamin D. [3]A vitamin K source was created by diluting vitamin K with cornstarch to provide 840 mg/kg of vitamin K. [4]Trace Mineral supplied the following per kg of diet: zinc 140,000 mg; copper 8,000 mg; manganese 140,000 mg; iron 130,000 mg. [5]Vitamin premix supplied the following per kg of diet: thiamin 2,200 mg; niacin 110,000 mg; folacin 2,750 mg; vitamin B_{12} 22mg; riboflavin 13,200 mg; pantothenic acid 33,000 mg; pyridoxine 4,400 mg; biotin 440 mg. [6]A vitamin B_{12} source was created by diluting vitamin B_{12} with cornstarch to provide 10,900 mg/kg of vitamin B_{12}. [7]A vitamin E source was created by diluting vitamin E with cornstarch to provide 2,750 IU/kg of vitamin E.

Table 2: Nutrient Composition[1,2,3] of experiment diets for TSAA Trials

TSAA Treatment, %	0.11	0.16	0.21	0.26	0.31	0.36	0.41	0.46
Crude Protein, %	6.48	8.59	10.69	12.63	14.81	16.76	18.70	20.65
ME, kcal/kg	3709	3665	3620	3588	3593	3597	3601	3605
Calcium, %	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Available Phosphorous,%	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6

[1]Other nutrients, with the exception of essential amino acids, were provided according to NRC (1994) recommendations.
[2]As the subject amino acid treatment level increased, essential amino acids were added according to the Missouri Ideal Turkey Ratio, with a 15% safety margin. At the time of diet formulation the ration was as follows: Lys 100%, TSAA 59%, Thr 55%, Val 61%, Arg 71%, His 36%, Ile 69%, Leu 124%, Phe+Tyr 105%, and Thr 16%.
[3]Values were calculated based on the amino acid analysis of corn and multiplied by the digestibility coefficients determined in turkeys.

($p<0.0001$), and it is reasonable to believe that TSAA accretion would also indicate a linear response. The titrations performed in the initial trial produced an adequate number of points above and below the maintenance requirements, which allowed the same titrations to be used for the second trial. Between the two experiments, the fits of the lines were surprisingly close, considering the variability that exists in turkeys at this age.

Although the above levels of dietary TSAA allow for maintenance of body weight and nitrogen content, it is probable that TSAA requirement for maintenance of the level of sulfur amino acid content in the bird is greater. Similar work in broilers by Edwards and Baker (1999) demonstrated that when birds are in static condition in regard to nitrogen, they are actually in a TSAA deficit, Further research will be required to determine if, and by how much, the requirement for maintenance of TSAA level differs from the requirement for the maintenance of nitrogen level in the turkey.

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