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Sulfur amino acid requirements of broilers from two to five weeks of age

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ABSTRACT

Phase-feeding (PF) in broiler chickens has been researched as a way to reduce feed costs without reducing growth performance and yield. Predicted amino acid requirements for PF are generated using linear regression equations derived from best estimates of lysine (Lys), sulfur amino acid (SAA), and threonine (Thr) requirements. During the late starter and early grower periods, predicted requirements for the SAA methionine (Met) and cysteine (Cys) are higher than levels recommended by the National Research Council (NRC), and previous research suggests that SAA may be lowered during the grower period without sacrificing growth performance or yield. The objective of this study was to estimate Met and Cys requirements for broilers from 2 to 5 weeks of age. In Experiment 1, a Met-deficient corn-peanut meal diet was formulated to contain excess Cys, so that supplemental Met was not utilized for Cys synthesis. The basal diet for Experiment 2 met the Met requirement but was deficient in Cys. Graded levels of Met (0, 0.045, 0.09, 0.135, and 0.225%) and Cys (0, 0.035, 0.070, 0.105, 0.140, 0.175%) were added in Experiments 1 and 2, respectively, and diets were fed to five replicates of five broilers per pen. Broken-line analysis was used to estimate SAA requirements. The digestible Met and Cys requirements from 2 to 5 weeks of age were 0.33% and 0.31%, respectively. Requirement estimates were lower than those predicted by PF or recommended by NRC, indicating that lower SAA levels may be utilized in a PF program.

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Meet the Student-Author

Jill A. Townsend

I graduated from Malvern High School as a cum laude graduate, and I am now a senior majoring in Poultry Science. I have received a number of scholarships including the Freshman Academic Scholarship, Randal Tyson Memorial Scholarship, Joseph E. Fleming Scholarship, Governor Homer M. Adkins Scholarship, Woodmen of the World Scholarship, James T. Whitmore Scholarship, John Rust Foundation Scholarship, Cecil Hearn Memorial Scholarship, and the Stephen F. Peters Scholarship. I have also been inducted into the Golden Key National Honor Society, Gamma Beta Phi, and Mortar Board, and I was awarded the Peggy Walker Scholarship from the Arkansas Alumni Association for my dedication to academics, community service and leadership with the Student Alumni Board.

Along with academics, I enjoy working with others in many campus activities, as the Senior Ambassador to the Bumpers College Student Ambassador program, the vice president to the Student Alumni Board, an active member of the Poultry Science Club, a member of an intramural volleyball team, and a member of the championship women's intramural softball team for the spring semester.

During the summer I am working as a Human Resources intern with Wayne Farms in Danville, Arkansas. Upon graduation, I hope to attend graduate school at the University of Arkansas and eventually obtain a position within the poultry industry with a career in research or possibly human resources.

I became interested in research during my summer internship while working with Dr. Emmert and his nutrition trials. Throughout the summer I learned about many aspects of performing a research trial, including the process of developing feed formulations, proper feed mixing procedures, and how to analyze results to an experiment. I chose to participate in this research project because of the invaluable experience I could use towards my studies in graduate school. I have learned a lot about poultry nutrition and the skills needed for performing experiments.

INTRODUCTION

In commercial broiler chicken diets, sulfur amino acids (SAA; methionine and cysteine) are the most deficient of all essential amino acids. Nearly all broiler diets require supplemental methionine (Met) to supply the necessary sources of SAA. As a result of the supplementation, the SAA market continues to be a multi-million dollar industry each year and a serious cost concern for the poultry industry. Information regarding SAA requirements for broilers less than three weeks of age is plentiful, but reliable requirement data beyond three weeks is scarce for the modern commercial broiler. This lack of knowledge about SAA requirements for older birds has led to research with the goal of decreasing feed costs for broiler diets. A better understanding of SAA requirements would provide poultry nutritionists with an opportunity to potentially save money by decreasing the need for over-use of supplemental Met in the broiler diets.

Accurate estimates of SAA requirements for broilers are also needed to fine-tune the phase-feeding (PF) system that is currently under investigation (Loupe and Emmert, 2000; Pope and Emmert, 2001; Warren and Emmert, 2000). Phase-feeding is a concept in which dietary amino acid levels are decreased throughout the starter (0-3 weeks), grower (3-6 weeks) and finisher (6-8 weeks) periods to more closely match a bird's daily requirement. The steady decrease in dietary amino acid levels potentially provides the poultry industry with a more cost-effective way of growing birds. The PF regimen also addresses environmental concerns by possibly leading to a decrease in nitrogen excretion through elimination of excess amino acids (Loupe and Emmert, 2000). However, predicted SAA requirements for days within the 3 to 6 week age range are higher than those recommended by the National Research Council (NRC, 1994), a broiler diet guideline used by most poultry nutritionists. Previous research (Emmert, unpublished data) has indicated that SAA may be lowered during the grower phase without negatively impacting growth performance or carcass yield. Our objectives were to determine the Met and Cys requirements of commercial broilers from 2 to 5 weeks of age, and to compare these requirements to those predicted by PF linear regression equations.

MATERIALS AND METHODS

All experimental procedures have been reviewed and accepted by the University of Arkansas Institutional Animal Care and Use Committee. Prior to experiment initiation broiler chicks of a commercial strain were obtained from a local hatchery, placed in floor pens with pine wood shavings, and provided with a 23% crude protein commercial starter diet from 1 day to 2 weeks of age. Following a 12-hour period of feed withdrawal, at 2 weeks of age birds were weighed, wing-banded and randomly assigned to experimental diets. During both experimental periods birds from 2 to 5 weeks of age were housed in battery cages with raised wire floors. A 24-hour constant light schedule was maintained and feed and water were freely available. Experimental diets were formulated to meet or exceed NRC (1994) recommendations for all essential nutrients with the exception of Met and Cys. Experimental diets were fed to five replicate pens of five birds each, and at experiment termination birds and feed were weighed to allow calculation of weight gain, feed intake, and feed efficiency.

Because of the metabolic relationship between Met and Cys, two experiments were necessary to allow clear determination of individual amino acid requirements. Methionine is a precursor for Cys, so when Cys is deficient excess Met is converted to Cys. However, Cys cannot be converted to Met, so a Met deficiency cannot be alleviated by excess Cys. In Experiment 1, the Met requirement was evaluated in the presence of excess Cys, so the determined requirement was not confounded by Met conversion to Cys. Graded levels of Met (0, 0.045, 0.09, 0.135, and 0.225%) were added to a Met-deficient corn-peanut meal basal diet (Table 1, 0.22% digestible Met) that contained excess Cys. In Experiment 2, the Cys requirement was evaluated by adding graded levels of Cys (0, 0.035, 0.070, 0.105, 0.140, 0.175%) to a Cys-deficient corn-peanut meal basal diet (Table 1) containing the level of Met determined to be the requirement in Experiment 1.

TABLE 1. Composition of experimental diets.[z]

Ingredient	Percent (%)
Cornstarch	to 100
Corn	58.1
Peanut meal	32.1
Soybean oil	6.00
Dicalcium phosphate	2.00
Limestone	1.00
Vitamins mix[y]	0.20
Mineral mix[y]	0.15
Amino acid[x]	1.47
DL-methionine[w]	0.11
L-cystine[v]	0.25

[z] The basal diet (without supplemental methionine or cysteine) contained 0.22% digestible methionine and 0.25% digestible cysteine.

[y] Han and Baker (1993).

[x] Included a mixture of (g/100 g): L-lysine monohydrochloride, 0.86; L-threonine, 0.30; L-valine, 0.14; L-tryptophan, 0.01; L-isoleucine, 0.17.

[w] DL-methionine was added to the basal diet only in Experiment 2.

[v] L-cystine was added to the basal diet only in Experiment 1.

Data were analyzed as a completely randomized design and all requirements were estimated by the broken line method (Robbins et al., 1979). The number of replications and birds per pen was chosen to support statistical validity. The General Linear Models procedure of SAS was used to conduct analysis of variance (SAS Institute, 1996).

RESULTS AND DISCUSSION

As expected, feed intake and feed efficiency was increased ($P < 0.05$) by the addition of Met or Cys to the basal diet in Experiments 1 and 2, respectively (data not shown). Weight gain was plotted against digestible Met (Fig. 1) and digestible Cys (Fig. 2) con-

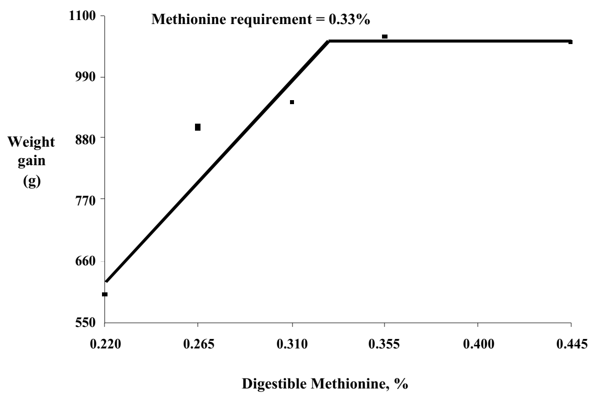

Fig. 1. Digestible methionine requirement of commercial broilers from 2 to 5 weeks of age. Graded levels of methionine were added to a methionine-deficient basal diet and weight gain was plotted versus dietary digestible methionine content (%). Broken-line analysis was used to generate an estimate of the methionine requirement.

centration and broken-line methodology was used to arrive at requirement estimates. In Experiment 1, the level of Met needed to maximize weight gain was 0.33% (Fig. 1). In Experiment 2, the level of Cys needed to maximize weight gain was 0.31% (Fig. 2).

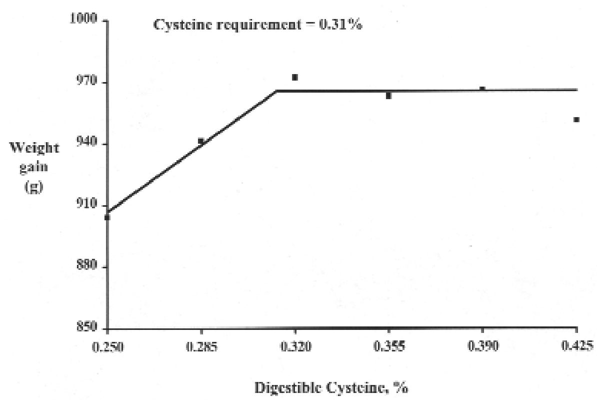

Fig. 2. Digestible cysteine requirement of commercial broilers from 2 to 5 weeks of age. Graded levels of cysteine were added to a cysteine-deficient basal diet and weight gain was plotted versus dietary digestible cysteine content (%). Broken-line analysis was used to generate an estimate of the cysteine requirement.

Determination of SAA requirements can be problematic, due to the complexity of SAA metabolism. Through a series of steps the body can convert Met to Cys; however, the reaction is irreversible, so that no net Met synthesis may occur from Cys. Because Cys can be synthesized from Met it is not considered an essential amino acid, but dietary Cys levels are extremely relevant because if Cys is not present in adequate amounts supplemental Met must be added to allow for synthesis of Cys to cover the dietary shortfall. To further complicate this process, the conversion efficiency of Met to Cys is only 81% efficient (Graber and Baker, 1971). In poultry diets, two conditions usually occur: 1) dietary Cys and Met are both deficient, making Met additions necessary as a source of both Met and Cys (keeping in mind the 81% efficiency), and 2) dietary Cys is adequate or in excess and Met is deficient, making supplemental Met necessary only for the lack of Met. Many previous SAA requirement studies have failed to determine the Cys requirement, which makes interpretation very difficult to determine. Our studies were designed to provide a clear requirement estimate for both Cys and Met.

Our results may be compared with previous SAA requirement estimates, however it must be noted that our trials were conducted from 2 to 5 weeks of age, whereas previous studies have focused on the traditional growth periods of starter (0 to 3 weeks), grower (3 to 6 weeks), and finisher (6 to 8 weeks). Baker and Han (1994) estimated grower period digestible requirements of 0.33% and 0.34% for Met and Cys, respectively. In contrast, NRC (1994) recommendations for the grower period are 0.33 and 0.30%, respectively. Our results clearly showed a lower Cys requirement estimate and a Met requirement similar to that of Baker and Han (1994). Our results showed Met and Cys requirements similar to those listed by the NRC (1994). However, given that amino acid requirements decrease with age (NRC, 1994), one would conclude that our requirement estimates even for Met were slightly lower than Baker and Han (1994) and the NRC (1994), because we had similar requirement estimates at an earlier average age.

In addition to providing accurate requirement estimates for Met and Cys for modern commercial broilers from 2 to 5 weeks of age, our data are pertinent to phase-feeding. Predicted amino acid requirements for PF are generated using linear regression equations derived from best estimates of lysine (Lys), sulfur amino acid (SAA), and threonine (Thr) requirements. However, during the late starter and early grower periods predicted requirements for methionine (Met) and cysteine (Cys) are higher than levels recommended by NRC, largely because predictions are based on the requirements of Baker and Han (1994). Preliminary data (Loupe and Emmert, 2000) indicated that SAA levels may be lowered in the PF regimen without sacrificing growth performance or yield, and data from these experiments verify that SAA requirements for the period 2 to 5 weeks of age are lower than the requirement predicted by PF linear regression equations.

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