portion of the turkey genome. This study establishes that RAPD markers may be a reliable and efficient resource for constructing a genomic linkage map of the turkey genome.

Key Words: Turkey genome linkage map, RAPD markers, polymorphic loci

185 Use of AFLP DNA markers to evaluate genomic diversity and genetic distances in Japanese quail lines divergently selected for stress responsiveness. F. M. Odeh*[1] and G. G. Cadd[1], [1]*Department of Poultry Science, Louisiana State University Agricultural Center, Baton Rouge, LA 70803.*

The secretion of corticosterone is a classic endocrine response to stress in avians. In this study, the genomic diversity and genetic distances in Japanese quail lines divergently selected for stress responsiveness were evaluated using an amplified fragment length polymorphism (AFLP) technique to generate DNA markers. DNA from individuals of extreme performance within each selected line was extracted and pooled for analysis. DNA from five different individuals was pooled for each replicate. Four replicates from each selected line and two replicates from a randomly bred (RB) line were screened by DNA fingerprinting. The enzyme combination *EcoRI/TaqI* was used for a double digestion of the DNA pools. Fragments with *EcoRI/TaqI*-end were radioactively labeled, separated by molecular weight by gel electrophoresis, and apposed to X-ray film for visualization. Ninety-seven *EcoRI/TaqI* primer combinations generated 20,416 bands with 5,089 of them being polymorphic. The AFLP procedure amplifies a high number of restriction fragments (52 bands, on average, in a single primer combination) and produces markers that are scored as the presence or absence of a band. The average band sharing (BS) values produced from AFLP fingerprinting within lines were 0.590, 0.631, and 0.581 for HS, RB, LS lines, respectively, whereas the average BS values between the lines were 0.573, 0.550, and 0.572 for HS-RB, HS-LS, and LS-RB respectively. The BS values within each given line and between the lines were, however, very sporadic, regardless of primer-combination used and the line analyzed. In this study, 5.5% of the genomic variation was attributed to mutation rate, 0.57% to genetic drift, and 0.057% to bidirectional selection. There were insignificant differences in average genetic distances between the selected lines. Although AFLP failed to resolve genetic diversity between the selected lines, it clearly identified fragments of DNA that may help determine the major genes involved in the stress responsiveness phenotype.

Key Words: Stress responsiveness, AFLP, Genetic distance, Japanese quail

PSA Nutrition: Amino Acids

186 Impact of phase-feeding on growth performance of broilers fed diets adjusted every other day for decreased amino acid content. H.R. Pope*, J.A. Townsend, and J.L. Emmert, *University of Arkansas.*

An experiment was conducted during the finisher period (42 to 56 d) to determine the effects of decreasing dietary amino acid levels as often as every other day using the phase-feeding (PF) approach. Experimental diets were formulated using either NRC recommendations for lysine (Lys), sulfur amino acid (SAA) and threonine (Thr) or recommendations from linear regression equations generated from estimates of Lys, SAA and Thr requirements. To facilitate implementation of PF, two diets were prepared that contained Lys, SAA and Thr levels matching the predicted requirements for birds at 42 d (high nutrient density) and 56 d (low nutrient density). After being properly mixed and pelleted, the high and low nutrient density diets were blended in variable quantities to produce rations containing amino acid levels that matched the predicted PF requirements over two day intervals (42-44 d, 44-46 d, 46-48 d, 48-50 d, 50-52 d, 52-54 d, 54-56 d). Birds were fed either a single NRC diet from 42 to 56 d or a series of PF diets that were switched every other day to supply a gradual decrease in Lys, SAA and Thr. Weight gain, feed intake, and feed efficiency of birds fed the PF regimen were unaffected ($P > 0.05$) relative to birds fed the NRC diet. An evaluation of digestible Lys, SAA, and Thr intake revealed a significant decrease ($P > 0.05$) in Thr intake for those birds given the PF diets, however no differences ($P > 0.05$) in digestible Lys or SAA intake were observed between the NRC and PF diets. These data indicate that dietary Lys, SAA, and Thr content maybe reduced as often as every other day under a PF program in which high and low nutrient density diets are blended without adversely affecting growth performance. Moreover, because dietary Lys, SAA, and Thr levels are decreased under the PF system substantial dietary cost savings may be available with such a program.

Key Words: Broiler, Phase-feeding, Amino Acids

187 Evaluation of lysine and arginine needs in broiler finisher diets. E. A. Oviedo-Rondon*, C. A. Fritts, and P. W. Waldroup, *University of Arkansas.*

Two studies were conducted in floor pens to examine response of male broilers to combinations of Lys and Arg in broiler finisher diets. In the first study, a diet was formulated with 0.75% Lys and 1.0% Arg. Aliquots of the diet were supplemented with Lysine HCl and arginine free base to provide a 3 x 4 factorial arrangement with three Arg levels (1.0, 1.2, and 1.4%) in combination with four Lys levels (0.75, 0.85, 0.95, 1.05%). Each treatment was fed to four pens of 50 male Ross 308 broilers from 42 to 63 d. In the second study, three Arg levels (1.0, 1.1, and 1.2%) were fed in combination with four Lys levels (0.75, 0.85, 0.95, and 1.05%) with each treatment fed to four pens of 50 male Cobb 500 broilers from 42 to 56 d. Body weight gain and feed conversion (FC) were determined and birds were processed for dressing percentage (DP), breast yield (BY) and abdominal fat (AF) content. The level of Arg had no significant effect on BW gain, FC, DP, BY, or AF in either study, indicating that the NRC (1994) recommended level of 1.0% is adequate for this age period. No significant interactions occurred between levels of Lys and Arg for any criteria in either study. In the first study, conducted in moderate temperature, Lys had no significant effect on BW, FC, or DP; BY was increased by 0.85% Lys but higher levels gave no further advantage. In the second study, conducted in high temperatures, BW gain, FCR, and BY were significantly improved by increasing Lys from 0.75 to 0.85% but higher levels gave no further advantage. These data suggest that current NRC (1994) levels of Arg and Lys are satisfactory for broilers during the finisher period of 6 to 8 or 9 wks of age under periods of moderate or high temperatures.

Key Words: Arginine, Lysine, Broilers

188 The influence of dietary labile methyl donors on arginine requirement of young broiler chicks using growth and muscle creatine as parameters. M. Chamruspollert*, G.M. Pesti, and R.I. Bakalli, *Department of Poultry Science, The University of Georgia, Athens, GA 30602-2772.*

Two experiments were conducted to investigate the effect of methyl donors on the arginine requirement of young broiler chicks. One-day-old Ross x Ross chicks were fed corn-whey based diets for 14 days. Four replicate pens of ten chicks each were randomly assigned to each treatment. At 14 d, two birds from each pen were killed and breast muscles were collected for creatine analysis. In Experiment 1, six levels of arginine (ARG) (0.95, 1.05, 1.15, 1.25, 1.35, or 1.45%) were fed with two levels of methionine (MET) (0.45 or 0.65%). Based on body gain data, the ARG requirement was 1.19±0.07% or 1.16±0.06% when chicks were fed the 0.45 or 0.65% MET diet, respectively. The requirement was 1.16±0.04% or 1.19±0.06%, respectively, based on muscle creatine. However, based on FCR, the ARG requirement of chicks fed 0.45% MET was higher (1.25±0.04%), compared with those fed with 0.65% MET (1.16±0.04%;$P<0.05$). In Experiment 2, two sources of methyl donors, MET or betaine (BET) were compared on an equal percentage basis. Eighteen treatments with 6 levels of ARG (as above) were factorially arranged with no methyl donor supplementation, or 0.2% MET supplementation (0.65% total) or 0.2% BET supplementation (0.2% total). There was no significant interaction ($P>0.05$) between ARG and methyl donor source on body weight gain and feed intake. The body gain data were pooled to calculate the ARG requirement. Therefore, based on body gain, the ARG requirement was 1.20±0.05%. Based on FCR, we found the interaction between ARG and methyl donor source ($P<0.05$). Based on FCR, the ARG requirement of chicks fed the unsupplemented diets was 1.29±0.06%, fed diets supplemented MET was 1.24±0.04%,

and fed supplemental BET was 1.15±0.04%. Based on muscle creatine, the requirement was 1.29±0.06%, 1.27±0.03% or 1.18±0.04% when chicks fed unsupplemented diets or diets supplemented with MET and BET, respectively.

Key Words: Arginine requirement, Methionine, Betaine

189 Influence of maillard reaction products on *Escherichia coli* amino acid lysine auxotroph growth-based assay response. X. Li* and S. C. Ricke, *Texas A&M University, College Station, Texas/USA*.

Lysine availability in poultry feeds can be rapidly assessed by measuring the growth response of an *Escherichia coli* lysine auxotroph. Maillard reaction formation commonly occurs during food or feed processing that involve heating and can reduce the availability of lysine. It is not clear whether formation of Maillard reactions products (MRP) would inhibit *E. coli* growth and influence the accuracy of the assay. The objective of these studies was to examine the effect of MRP formation on *E. coli* mutants lys^- and met^-, and wild type K12 growth in model systems. Three different types of MRP were generated by autoclaving glucose with either lysine, arginine, or histidine for more than 3 hours. In model systems, combinations among types of MRP and different concentrations of MRP were added to an M9 minimal medium. The growth response of different *E. coli* strains were examined in the model systems supplemented with 4 μg/ml of required amino acid. Different types of MRP were added to determine the effect of MRP on the lysine assay. There were significantly ($p<0.01$) different growth rates due to bacterial strain difference, however, addition of different types of MRP or different concentrations of MRP did not cause significant ($p>0.01$) differences in growth rate. Linearity of the standard curve without adding MRP (control) was not significantly ($p>0.01$) different from those of the standard curves adding MRP for the lysine assay. The result indicated that the presence of the MRP should not lead to errors in the *E. coli* lysine availability assay of foods or feeds containing Maillard reaction products.

Key Words: Maillard reaction products, Growth rates, Lysine assay

190 Development of a rapid whole cell biosensor for assessing methionine availability by insertion of genes encoding for green fluorescent protein into an *Escherichia coli* methionine auxotroph. C. A. Froelich*, I. B. Zabala Díaz, and S. C. Ricke, *Texas A&M University, College Station, TX/USA*.

The need to accurately measure the levels of bioavailable methionine in poultry and animal feeds remains an important issue in animal nutrition. Techniques ranging from animal, chemical, and microbial assays exist to measure this nutrient's utility. The objective of this study is to develop a rapid microtiter methionine assay for feeds and feed components using a fluorescent *Escherichia coli* methionine auxotroph strain (ATCC# 23798). Initially an *E. coli* methionine auxotroph strain was transformed with plasmid *p519ngfp*, containing a green fluorescent protein gene (*gfp*) coupled to a constitutive promoter that confers a fluorescent phenotype. Transformation was achieved by conventional $CaCl_2$ method. Plasmid presence was confirmed by antibiotic markers and by gel electrophoresis. Microbial assay was started by placing fully grown and depleted *E. coli* cells in minimal mineral media containing increasing concentrations of methionine and cells were then incubated at 27°C with constant agitation. Fluorescence was monitored using a multilabel counting fluorometer (Victor2V, PerkinElmer, Massachusetts) every 15 minutes for 2 hours set at an excitation/emission wavelength of 485nm/535nm for 1 second. Measuring absorbency at 585nm assessed bacterial growth. Since the bacterial assay was performed at 27°C, cells never left lag phase and A585nm correlated poorly with varying methionine concentrations (0.5-2.0 μg/ml, $R^2 \geq 0.1$). However, bacterial fluorescence during this time assayed correlated with methionine concentrations at lower levels ($\leq 0.25\mu$g/ml, $R^2 \leq 0.98$). The proposed method allows more sensitive measurements than conventional microbial assays for methionine bioavailability.

Key Words: *Escherichia coli*, Green Fluorescent Protein, Methionine

191 Sulfur amino acids requirement of slow- and fast-feathering male broilers from 0-21 days of age. A. Kalinowski* and E.T. Moran, *Auburn University, Auburn, AL*.

Corn-soybean meal based diets (C-SBM) are limiting in total sulfur amino acids (TSSA) for broiler development. Differences in feather development are thought to influence the demand for cystine (Cys) thus, TSAA requirement. Two experiments were conducted with fast (Ross x 3F8) and slow (Ross x 308) feathering males from 0 to 3 wk of age. For each experiment, chicks were randomly assigned to 72 battery cages (6 birds/cage) and fed a C-SBM diet (21.5% CP; 3050 kcal ME/kg). A 2 x 4 FAT was used, consisting of feathering rate (fast and slow) in combination with four levels of methionine (Met) (Exp. 1) and Cys (Exp. 2). In Exp. 1 diets contained 0.50% Cys with 0.35%, 0.40%, 0.45%, and 0.50% total Met. Feed conversion (FC) responded linearly ($P \leq .01$) to progressive Met level but not weight gain (WG). No significant interaction occurred between feathering and Met level for either WG or FC suggesting a similar need by both sources of males. The second experiment examined the response to Cys level with feeds having marginal total Met (0.45%) to minimize sparing of Cys. Total dietary Cys progressed from 0.35% to 0.50%. Increasing Cys led to improved FC with fast (cubic response; $P \leq .02$) but not slow feathering birds, whereas WG was unaffected. Nitrogen balance studies conducted concurrently (from day 20 to 21) also failed to establish an interaction between Met level and extent of feathering (Exp.1), but an optimization at 0.45% with both broiler sources was apparent (quadratic response; $P \leq .0001$). Differences in the need for Cys attributable to feathering was detected in nitrogen retention ($P \leq .0001$), and slow feathering males attained an optimum at 0.45% (quadratic response; $P \leq .08$), whereas fast feathering males exhibited continuous improvement to the highest level of Cys (linear response; $P \leq .05$). Although present results indicate a Met requirement approximating 0.50% is appropriate, regardless of feather rate, and agrees with NRC (1994); the advocated Cys requirement is more a reflection of need for slow than fast feathering males.

Key Words: Broilers, Sulfur amino acids, requirement

192 Influence of dietary sodium level on response to source and level of methionine in broiler diets. M. A. Motl*, C. A. Fritts, and P. W. Waldroup, *University of Arkansas*.

Numerous studies have compared DL-methionine (DL-Met) and the hydroxy-methyl analogue 2-hydroxy-4-methylthiobutanoic acid (HMB) as sources of methionine for young chicks with variable results. One possible explanation for differences in results is the sodium content of the test diet, as absorption of DL-Met appears to be Na-dependent while absorption of HMB does not. A study was conducted in which a Met-deficient (0.28% Met) diet based on grain sorghum and soybean meal with 0.15% Na and 0.20% Cl was divided into three aliquots and fortified with additional Na from sodium bicarbonate to provide dietary Na levels of 0.15, 0.20, and 0.25%. Within each Na level, either DL-Met (99%) or HMB (88%) were added in amounts sufficient to provide either 0 or 0.30% Met activity. These diets were then blended in amounts calculated to provide 0, 0.04, 0.08, 0.12, 0.16, 0.20, 0.24, and 0.28% supplemental Met from each source at each level of sodium. Each of the 48 test diets was fed to six replicate pens of six male chicks in electrically heated battery brooders from 1 to 21 d posthatch. Source of Met had no significant ($P < 0.05$) effect on either BW or feed utilization (FU). Sodium level significantly influenced both BW and FU, with an interaction of Met level but not with Met source. At the lower levels of Met, the highest level of Na significantly reduced both BW and FU. As Met level increased no significant differences among Na levels were observed. These data suggest that Na level does not appear to influence the response to DL-Met or HMB as sources of Met under thermoneutral conditions.

Key Words: Methionine, Hydroxy Analogue, Sodium

193 Lysine need of broiler males from 42 to 56 days of age under terms of an ideal amino acid pattern. A. Corzo*[1], E. T. Moran, Jr.[1], and M. E. Jackson[2], [1]*Auburn University, Auburn, AL*, [2]*Degussa-Huls, Kennesaw, GA*.

An "ideal" relationship of amino acids one to the other optimizes utilization of dietary protein. Dietary lysine has been used as the standard in this relationship, and its level prior to slaughter is known to influence final live performance as well as breast meat yield. An experiment

was conducted to measure lysine response by broilers to a finishing feed with the protein formulated to approximate an ideal amino acid pattern (Mack et al., 1999). A total of 1050 Ross x Ross 308 male broilers were randomly distributed into 30 floor pens of an open-sided house and provided common diets from placement until 6 weeks of age. From 6 to 8 weeks birds were fed a corn-soybean meal diet (18% CP and 3250 Kcal/kg ME) having essential amino acids "ideally" related to one another within the limits of practicality based on lysine at 0.85%. Five lysine levels from 0.75 to 1.15% were provided. Birds had continuous access to feed, water and light. Body weight gain was similar among treatments; however, feed conversion improved between the 0.75 and 1.15% lysine levels with an optimum approximating 0.85%. All birds were processed, and no significant differences were observed for abdominal fat, carcass yield without fat, and skinless boneless breast meats. The lysine requirement of 0.85% as advocated by NRC (1994) is in agreement with present results.

Key Words: Broiler, Lysine, Protein

194 Lysine, threonine, and arginine supplementation and effects on performance of young tom turkeys raised in a summer environment. J. Kalbfleisch*[1], V. Stangeland[2], J. Brannon[1], and S. Noll[1], [1]*University of Minnesota, St. Paul, MN, USA,* [2]*Stangeland Feed Consulting, Willmar, MN, USA.*

The purpose of this study was to determine the response to lysine and threonine in diets of young tom turkeys, and any interaction among levels of lysine, threonine, and arginine to 11 wks of age. At 5 wks of age, 980 male Nicholas turkey poults were randomly sorted into 98 pens so that average starting weights were equal. Performance data was collected at 3-wk intervals. The basal diet was formulated to 92% NRC (1994) threonine, 95% NRC lysine, and 110% NRC TSAA at 3-wk intervals and all diets were supplemented with isoleucine, valine, and tryptophan. The basal diet was primarily composed of corn, soybean meal 47%, meat and bone meal, and canola meal. Diet protein in the basal diet was set by desired threonine level, and sources of L-lysine HCl, DL-methionine, L-arginine, and L-threonine were used to obtain desired supplemental levels of each amino acid. A factorial arrangement was used with three levels of lysine (0, .12%, .24%), two levels of threonine (0, .075%), and two levels of arginine (0, .12%). Average daily temperature ranged from 21°C to 26°C from 5-8 wks and 23°C to 29°C from 8-11 wks of age. At 11 wks of age, body weights were significantly affected ($P<0.05$) by dietary lysine supplementation, where the .12% supplemented lysine diet performed better than the non-supplemented lysine diet. Threonine supplementation improved body weight by 1.05% ($P<0.03$). During 8-11 wks of age, feed efficiency was improved by 1.83% with supplemental threonine ($P<0.002$). The .12% supplemented lysine level, representing 105% NRC lysine, provided a better BW response over the basal lysine level (95% NRC) and high lysine level (113% NRC). Diets supplemented with threonine to 100% NRC provided a better BW response and feed efficiency compared to the non-supplemented threonine level, representing 92% NRC threonine. Interactions among amino acids were not detected except for feed efficiency during 8-11 wks for lysine and arginine.

Key Words: Turkey, Lysine, Threonine

195 Lysine needs of starting chicks and subsequent effects during the growing period. M. T. Kidd*[1], J. B. Yeatman[1], and B. I. Fancher[2], [1]*Department of Poultry Science, Mississippi State University, Mississippi State, MS 39762,* [2]*Aviagen North America, Inc., Huntsville, AL 35805.*

The lysine requirement for broiler chicks has been studied extensively. Many factors such as protein quality, experimental conditions, dietary nutrients, and genetic strain affect lysine needs of chicks. Because lysine increases protein synthesis and decreases protein degradation in chicks, its requirement may vary as meat-type broiler genetics are improved. We conducted two experiments to evaluate lysine needs during the starter period in a broiler strain cross selected for enhanced white meat yield (Ross x Ross 508). Male broilers were randomly placed in 30 floor pens in two experiments (14 birds/pen in Experiment 1 and 30 birds/pen in Experiment 2). There were six dietary treatments representing graduations of lysine from 80 to 130% of NRC in 10% increments from Days 1 to 18. The lysine deficient diets (0.88% total lysine or 80% of 1994 NRC specifications) were similar in both experiments and were created by blending corn, soybean meal, corn gluten meal, wheat middlings, poultry fat, and crystalline amino acids. All broilers received a common diet from Days 19 to 41 and Days 19 to 42 in Experiments 1 and 2, respectively. Growth responses were measured for the starter period and birds were processed and deboned at termination to determine effects of starter lysine on breast meat development. Quadratic response curves were fitted to growth performance criteria of chicks. Broilers fed lysine levels below NRC specifications as chicks had reduced growth and carcass attributes at Day 41 and 42. The lysine level required (95% of the upper asymptote) for chick growth responses was between 107 and 111% of NRC (1994).

Key Words: Lysine, Broiler, Amino Acid

196 Broiler growth and carcass responses to diets containing L-threonine versus diets containing threonine from intact protein sources. M. T. Kidd*[1], C. D. Zumwalt[1], D. W. Chamblee[2], M. L. Carden[2], and D. J. Burnham[3], [1]*Department of Poultry Science, Mississippi State University, Mississippi State, MS 39762,* [2]*South Central Poultry Research Unit, USDA-ARS, Mississippi State, MS 39762,* [3]*Ajinomoto Heartland, Inc., Chicago, IL 60631.*

The third limiting amino acid for broilers is typically Thr and meeting its minimum in least cost formulation with L-Thr results in reduced CP. This experiment evaluated if diets formulated utilizing the supplemental amino acids Met, Lys, and Thr could achieve the same performance as commercially fed diets utilizing supplemental Met and Lys. Ross x Ross 308 broilers (1,440 of each sex) were randomized across 72 floor pens (40 birds/pen). The experimental design consisted of a 2 (sex) x 6 (dietary Thr) factorial arrangement (12 treatments and 6 replications/treatment). Two basal diets, with and without L-Thr, were formulated using identical minimum digestible amino acid values. This resulted in one diet with 600g/ton of L-Thr and one with no L-Thr. These two diets were blended together to make the intermediate treatments which consisted of: 1) a control diet with no L-Thr; 2) as 1 plus 150g/ton of L-Thr; 3) as 1 plus 300g/ton of L-Thr; 4) as 1 plus 450g/ton of L-Thr; 5) as 1 plus 600g/ton of L-Thr; and 6) as 5 with a digestible Thr/Lys ratio of 0.65. Dietary treatments were implemented from Days 1 to 20, 21 to 35, and 36 to 48. Growth responses were measured for each period and carcass responses were measured at Day 49. There were no significant Thr x sex interactions. Also, dietary Thr treatment differences did not occur for any parameter measured. BW gain, feed intake, and carcass parts weights were improved ($P < 0.05$) in male broilers versus female broilers, but female broilers had optimal ($P < 0.05$) feed conversion and livability. Although all treatment diets met adequate minimum levels of essential amino acids, treatment diets containing L-Thr had lower nutrient levels of CP, Ile, Arg, Val, and Trp. Formulating diets adequate in essential amino acids to contain up to 600g/ton of L-Thr does not affect growth or carcass attributes of commercial broilers.

Key Words: Threonine, Broiler, Amino Acid

197 Male and female broiler responses to low and adequate dietary threonine on nitrogen and energy balance. W. A. Dozier, III*[1], E. T. Moran, Jr.[1], and M. T. Kidd[2], [1]*Auburn University, AL ,* [2]*Mississipi State University, MS.*

Mucus associated with the intestine and digestive enzymes from the pancreas have extensive amounts of threonine. Presumably, mucus and enzyme formation would decrease when birds receive feeds low in threonine to adversely affect nutrient recovery. This study compared nitrogen and energy utilization of male and female broilers fed diets previously shown to be either deficient or adequate in threonine for males late in development. A total of 750 male and female broilers were randomly distributed into 30 floor pens of an open-sided house and provided diets that met NRC (1994) nutrient recommendations from placement until 6 wk of age. At 42 d, 48 birds (24/sex) were removed from the floor pens and individually caged in raised wire batteries. Each bird was given feed that was formulated to contain either 0.52 or 0.74% total threonine with 18% CP and 3,200 kcal ME/kg. The treatment structure consisted of a 2 × 2 factorial arrangement with 12 replications per treatment. Two 24-h excreta collection periods were conducted on Days 46 and 54 to measure nitrogen and energy recovery. On Day 46, males receiving 0.74% threonine had an advantage in retention of nitrogen (38.8 vs. 21.5%; $P \leq 0.05$) and recovery of AME_n 3.40 vs. 3.24 kcal/g; $P \leq 0.05$) but energy retention was not significantly ($P \leq 0.05$) different from those given the lower level. Dietary threonine did not affect nitrogen retention with females at Day 46, but contrary to expectation low threonine at 54 d

provided an advantage in nitrogen utilization (19.9 vs. 8.8%; $P \leq 0.05$) over females consuming the higher level. Dietary ME measurements with females were similar at both threonine concentrations and ages. Threonine need appears to be considerably more extensive with males than females, and inadequacies with males that exceed repercussion on N-balance also create conditions that reduce the recovery of ME.

Key Words: Amino Acid, Broiler, Threonine

198 Ideal ratio (relative to lysine) of tryptophan and threonine for chicks during the second and third week of life. A.B. Batal*, T.M. Parr, N.R. Augspurger, C.M. Parsons, and D.H. Baker, *University of Illinois, Urbana, IL USA*.

Three bioassays were conducted to determine the ideal ratios of Trp and Thr to Lys. Young male crossbred chicks (New Hampshire x Columbian) were fed diets based on corn gluten meal and synthetic amino acids (AA) that could be made singly deficient in Lys, Trp, or Thr. Diets for all assays contained 3,400 kcal ME/kg, and L-glutamic acid was used to make all diets (within and among assays) equal in protein at 23.8% of the diet. When fully fortified with each limiting AA, growth performance of chicks fed the corn gluten meal diet was equivalent to that observed with a 23% CP Met-fortified corn-soybean meal diet. True digestibility assessment of corn gluten meal in cecectomized roosters facilitated dose-titration studies (six dose levels for each AA) so that least squares fitted one-slope broken-lines and quadratic regression equations could be calculated to establish inflection points for both weight gain and gain:feed. Four battery pens of four chicks were fed one of six AA dose levels during the period 8 to 22-d posthatching. Weight gain and gain:feed responded quadratically ($P < 0.01$) to increasing doses of digestible Lys (0.68 to 1.28%), Trp (0.09 to 0.24%), and Thr (0.41 to 0.81%). Broken-line least squares analysis predicted breakpoints for gain and gain:feed, respectively, of: Lys (0.85, 0.96%), Trp (0.16, 0.16%), and Thr (0.53, 0.53%). Requirement estimates based on quadratic regression fits (90% of upper asymptote) predicted requirements for gain and gain:feed, respectively, of: Lys (0.97, 1.03%), Trp (0.19, 0.18%), and Thr (0.61, 0.62%). Regardless of curve-fitting method, gain:feed requirements for Lys (but not Trp or Thr) were much higher than weight gain requirements. Using the higher of the broken-line requirement estimates for gain and gain:feed, ideal ratios (% of Lys) were: Lys (100), Trp (17), and Thr (55). The Trp ratio is similar but the Thr ratio is lower than previous estimates made in our laboratory.

Key Words: Tryptophan, Lysine, Threonine

199 Ideal ratio (relative to lysine) of isoleucine and valine for chicks during the second and third week of life. T.M. Parr*[1], A.B. Batal[1], N.R. Augspurger[1], and D.H. Baker[1], [1]*University of Illinois*.

Three bioassays were conducted to determine the digestible Lys, Ile and Val requirement of male crossbred (New Hampshire x Columbian) chicks during the period 8-20 days posthatching. The chicks were fed semi purified diets based on corn gluten meal (CGM) and amino acids (AA) that could be made singly deficient in Lys, Ile or Val. Diets for all assays contained 3,400 kcal ME/kg, and L-glutamic acid was used as a source of non-specific amino nitrogen to make all diets (within and among assays) equal in protein at 23.8 % of the diet. When fully fortified with each limiting AA, growth performance of chicks fed the CGM diet was equivalent to that observed with a 23% CP Met-fortified corn-soybean meal diet. True digestibility assessment of CGM in cecectomized roosters facilitated dose-titration studies (six dose levels for each AA) so that least squares fitted one-slope broken lines could be calculated to establish inflection points for both weight gain and gain:feed. Each AA dose level in each assay was fed to four battery pens of four chicks. Quadratic ($P < 0.01$) responses to each AA occurred when graded levels of digestible Lys (0.68 to 1.28 %), Ile (0.45 to 0.95 %) or Val (0.51 to 1.06 %) were fed. Breakpoint requirement estimates for gain and gain:feed, respectively, were : Lys (0.85, 0.97 %), Ile (0.59, 0.58 %) and Val (0.74, 0.74 %). Using the higher of requirement estimates for gain and gain:feed, ideal ratios (% of Lys) were : Lys (100), Ile (61) and Val (76). The Ile ratio was lower but the Val ratio was similar to previous estimates made in our laboratory. Breakpoint requirement estimates for gain and gain:feed were similar for all AA evaluated except Lys, where the requirement for feed efficiency was substantially higher than that for weight gain. Quadratic regression fits to the data so that 90 % of the upper asymptote could be calculated predicted higher requirements than those predicted from the breakpoint of the broken-line responses.

Key Words: Ideal Ratio, Isoleucine, Valine

PSA Nutrition: Feed Ingredients I

200 Bioavailability of zinc and copper lignosulfate complexes in broiler chicks. J.L. Grimes, J.W. Spears, and J.L. Godwin*, *North Carolina State University, Raleigh, NC, USA*.

Chickens are usually fed inorganic minerals to meet their mineral requirements. However, organic chelated minerals have been shown to be more bioavailable in some studies than inorganic forms. Two trials (T1 & T2) were conducted to determine the bioavailability of Zn and Cu from lignosulfate complexes (LSC) relative to feed grade sulfate forms. In each trial there were 24 pens with 7 male chicks per pen. In T1, the treatments were as follows: 1) Control - no supplemental Zn (10.1 ppm Zn analyzed); 2) 7.5 ppm supplemental Zn from $ZnSO_4$; 3)15 ppm supplemental Zn from $ZnSO_4$; 4)7.5 ppm supplemental Zn from Zn LSC; 5)15 ppm supplemental Zn from Zn LSC, and 6) 7.5 ppm supplemental Zn from Zn proteinate. In T2, the treatments were as follows: 1) no supplemental Cu (2.22 ppm Cu analyzed); 2) 1 ppm supplemental Cu from $CuSO_4$-$5H_2O$; 3)3 ppm supplemental Cu from $CuSO_4$-$5H_2O$; 4)1 ppm supplemental Cu from Cu LSC, 5)3 ppm supplemental Cu from Cu LSC, and 6)1 ppm supplemental Cu from Cu proteinate. The experimental design was a completely randomized design. In T1 on d 21, tibia Zn (TZ) and plasma Zn (PZ) were determined using four chicks per pen. In T2 on d 21, blood hemoglobin (Hb), liver Cu (LCu), bile Cu (BCu), and plasma Cu (PCu) were determined using four chicks per pen. Feed consumption, by pen, and BW were measured at d 0, 7, 14, and 21. Orthogonal contrasts were made to compare the effect of level and source of mineral on performance parameters in each trial. In T1, increasing dietary levels of Zn from all sources resulted in increased BW, BWG, TZ, and PZ. There was no effect of source on BW, BWG, TZ, or PZ. FC was improved by supplemental dietary Zn while source had no effect. In T2, there was no effect of level or source of Cu on BW, BWG, FC, or LCu. Both level and source of Cu increased BCu. Chicks fed the lower $CuSO_4$ level had higher BCu than those fed a similar level of Cu LSC. Hb and PCu were increased by supplemental Cu from both sources. Dietary Zn and Cu LSC were similar in bioavailability to feed grade Zn and Cu sulfates.

Key Words: Zinc, Copper, Bioavailability

201 Evaluation of tetrabasic zinc chloride and tribasic copper chloride for growth promotion and toxicity in chicks. M.E. Persia*, C.M. Parsons, and D.H. Baker, *University of Illinois, Urbana, IL USA*.

Concerns associated with increasing antibiotic resistance of bacteria have cast a negative shadow on the use of sub-therapeutic levels of antibiotics as growth promoters in animals. With increasing legislation prohibiting the use of antibiotic growth promoters, other methods of growth promotion should be explored. High levels of both Zn and Cu have been used in swine diets to promote growth, and high levels of Cu have been used to a lesser extent in poultry diets. The objective of this study was to evaluate two new Zn and Cu compounds, Tetrabasic zinc chloride (TBZC) and Tribasic copper chloride (TBCC), for growth promoting effects and maximum tolerable levels that can be fed in corn-soybean meal diets to chicks. In the first experiment, TBZC (61.8% Zn) was fed at levels of 0, 0.05, 0.10, 0.15, 0.30, 0.50, and 1.00% added Zn. In a second experiment, TBCC (59.8% Cu) was fed at levels of 0, 0.015, 0.025, 0.05, 0.075, and 0.10% added Cu. Feed grade $CuSO_4$ was also added to supply 0.10% Cu for comparison. In both experiments, four replications of five New Hampshire x Columbian chicks were fed each diet from 8 to 22 days of age. The experiments were conducted in batteries that were left dirty from previous chick exposure. In the TBZC experiment, no differences were seen in weight gain or feed efficiency from feeding up to 0.15% supplemental Zn. A significant reduction in weight gain and feed efficiency occurred at 0.30% added Zn and higher levels. The 1.00% Zn treatment also resulted in increased mortality. In