7 Oxidation of energy substrates by enterocytes of 0- to 42-day-old chickens. W. He, K. Furukawa, H. Leyva-Jimenez, C. Bailey, and G. Wu, Texas A&M University, College Station, TX.

Glutamate, glutamine, and aspartate are known to be major energy substrates for mammalian enterocytes, but little is known about metabolic fuels in avian enterocytes. In the present study, enterocytes isolated from 0, 7, 21, and 42-d-old broiler chickens were used to determine the rates of oxidation of amino acids, fatty acids and glucose. Enterocytes were incubated at 40°C for 30 min in Krebs-Henseleit bicarbonate buffer (pH 7.4) containing 5 mM D-glucose and one of the following: 0.5, 2 and 5 mM L-[1-14C]glutamate; 0.5, 2 and 5 mM L-[1-14C]glutamine; 0.5, 2 and 5 mM L-[1-14C]aspartate; 0.5, 2 and 5 mM L-[1-14C]alanine; 0.5 and 2 mM L-[1-14C]palmitate; 0.5, 2 and 5 mM [U-14C]propionate; 0.5, 2 and 5 mM [1-14C]butyrate; or D-[U-14C]glucose. At the end of the incubation, [14CO2] produced from each [14C]-labeled substrate was collected into SolueneTM for counting. Data were statistically analyzed by one-way or tw-way ANOVA. Rates of oxidation of each substrate by enterocytes from all age groups of chickens increased progressively with increasing extracellular concentrations. The rates of oxidation of glutamate by enterocytes from 0- to 42-d-old chickens was limited in enterocytes from all age groups of chickens. Based on metabolic pathways, the oxidation of glutamate produced more ATP than any other substrates during the postnatal growth of chickens. Collectively, our results indicate that glutamate is the major metabolic fuel in enterocytes of 0- to 42-d-old chickens. Because of limited uptake of arterial glutamate by enterocytes, dietary (enteral) glutamate is essential to maintain the integrity and function of the chicken small intestine.

Key Words: energy substrates, small intestine, oxidation, glutamate, chickens


To understand the degradation of amino acids within the broiler, stable isotopes and indirect calorimetry are used in combination to determine pre-systemic and systemic metabolism as well as whole body oxidation through decarboxylation. A total of 1000 Cobb 500 chicks were divided into 20 pens (50 chicks/pen) to determine the rate of CO2 produced (VCO2) through stable isotopes and indirect calorimetry. Broilers were fed a common starter diet (0–10d) and grower diet (10–21d) with different ratios of methionine and cysteine, ranging from deficient to excess. Metabolic chambers, the average VCO2 produced by whole body oxidation was 336.37 mmol/min/kg BW. Results from IV infusion of [1-13C] sodium bicarbonate revealed CO2 peaked by 10 min and was expired by 60 min. VCO2 was determined to be 338.13 mmol/min/kg BW through this method. Bicarbonate infusion had an APE of 0.035 (P < 0.0001). Examination of IV and IG methods revealed IV infusion had a higher APE (0.004 vs 0.003, respectively) (P = 0.0065) compared with IG infusion, which suggests parenteral uptake allows more efficient delivery than enteral. Additionally, recovery of 13CO2 was 12% higher in IV infusions compared with IG infusions. Each of the 3 methods, regardless of delivery, prove useful in determining energy expenditure in broilers, considering compartmental and whole body oxidation is necessary for understanding metabolism.

Key Words: broiler, bicarbonate, indirect calorimetry, stable isotopes, CO2

9 Developmental changes in the activities of enzymes for polyamine synthesis in chickens. K. Furukawa, W. He, H. Leyva-Jimenez, C. Bailey, F. Bazer, M. Toyomizu, and G. Wu, Texas A&M University, College Station, TX, 1Texas A&M University, College Station, TX, 2Tohoku University, Sendai, Japan.

Polyamines (putrescine, spermidine and spermine) are essential to DNA and protein syntheses and, therefore, the rapid growth and development of chickens. However, metabolic pathways for polyamine synthesis in avian tissues are largely unknown. In mammals, polyamines are produced primarily from arginine-, proline-, and glutamine-derived ornithine in a cell-specific manner and, to a lesser extent, arginine-derived agmatine in certain tissues (e.g., ovine conceptus). However, in chickens, expression of arginase is relatively low in all tissues, pyrroline-5-carboxylate synthase is absent from the intestine, and no data are available regarding proline oxidase (POX) in any tissues. Therefore, this study was conducted to determine developmental changes in (1) the activities of enzymes (measured at 40°C under optimal conditions) for polyamine synthesis; and (2) concentrations of polyamines in chicken tissues. Kidney, jejunum (without luminal contents), leg muscle, liver, pancreas and plasma were collected from 0-, 7-, 21- and 42-d-old broiler chickens. Polyamines and enzymatic products were determined using our established HPLC and UV/VIS spectrophotometric methods. Data were statistically analyzed by one-way ANOVA. Results indicate that arginase and POX activities were present only in the mitochondrial fraction of the kidney in 0- to 42-d-old chickens. Renal POX activity was greater (P < 0.01) on Day 7 compared with Day 0, but no change in renal arginase activity was detected during this period (P > 0.05). Arginine decarboxylase and agmatinase were not detected in any tissues examined. Spermidine was the most abundant polyamine in all tissues and plasma of chickens. Interestingly, the concentrations of putrescine,
polymamines, arginine, proline, chicken, development

10 An in vivo technique for measuring the digestion rate of dietary proteins fed to poultry. D. D. S. Bryan*, D. Abbott, and H. Classen, University of Saskatchewan, Saskatoon, SK, Canada.

The rate and extent of protein digestion are relevant to broiler performance and health, but information is lacking on the rate of digestion for common high-protein feed ingredients. An in vivo technique is proposed for measuring the digestion kinetics of protein sources fed to poultry. The method is a modification of the standardized ileal digestible assay. Using a completely randomized design, 360 male broilers at 14 days of age were assigned to 60 battery cages and fed semi-purified diets composed of wheat starch (N-free) or wheat starch with either blood meal (BM), canola meal (CM), corn distillers dried grains with solubles (CDDGS), corn gluten meal (CGM), feather meal (FM), fish meal (FM), meat and bone meal (MBM), porcine meal (PM) or soybean meal (SBM). Feed intake (FI) was measured for 24 h before digesta sampling on day 21. Amino acid (AA) digestibility was determined for the proximal and distal sections of jejunum and ileum. The FL and indigestible marker of the diet were used to calculate the mean retention time (MRT) of digesta in each section of the small intestine. The MRT and AA digestibility along the small intestine were modeled to the first order kinetic curve using the PROC NLIN procedure of SAS 9.4 and the resulting rate constant (kd) data were analyzed as a one way ANOVA. Differences were considered significant when P ≤ 0.05. Protein source affected the rate of AA digestion with average Akd values for meals ranging from 0.166 to 1.841. The results demonstrated differences in AA kd among and within protein sources. For example, FM had the highest digestion rate for most of the AA evaluated among the protein sources, while CDDGS had the lowest. Methionine had the lowest kd of the AA in CDDGS, however, methionine along with lysine had the highest kd compared with the other AA in FM. In conclusion, dietary protein source affects the digestion kinetics of AA along the small intestine of broilers. This parameter may influence how AA from various protein sources are utilized for muscle deposition after they are digested and absorbed.

Key Words: digestion rate, soybean meal, corn gluten meal, corn distiller dry grain with solubles, amino acids

11 Protein turnover and performance parameters for modern commercial broiler strains fed varying levels of dietary amino acids and metabolizable energy. G. Mullenix1, J. England1, K. Hilton1, M. Schlumbom1, J. Caldas2, A. Kalinowski3, V. Naranjo4, and C. Coon1, 1University of Arkansas, Fayetteville, AR. 2Cobb-Vantress, Siloam Springs, AR. 3Evonic, Essen, Germany. 4Evonic Nutrition & Care, Hanau, Germany.

The objective of this study was to see how modern commercial broiler strains synthesize and degrade protein when fed varying dietary amino acid and metabolizable energy levels. Protein turnover was determined at 22d, 35d and 42d through intravenous flooding-dose of 15N-phenylalanine by fractional synthesis rate (FSR) and fractional breakdown rate (FBR). Delta values or difference between FSR and FBR were calculated for the experimental trial periods. Body weight (BW), average daily gain (ADG), feed conversion ratio (FCR), and protein turnover were evaluated. Grams of digestible Lysine per Mcal was used to compare the nutrient density across both trials. Two trials with 2 thousand 25 Cobb MX × Cobb 500 and Ross YP × Ross 308 were placed in 90 pens (n = 45 birds/pen) for the study. Commercial starter and grower feed were fed 1–10d and 11–22d, respectively. Five experimental finisher diets were fed 22–42d in pellet form (9 reps per strain/diet) in each trial. The varying amino acid finisher diets were isoenergetic (3125 kcal/kg) and formulated to the ideal amino acid recommendation of AMINChick®/2: 0.80%, 0.90%, 1.00%, 1.10% and 1.20% dLys, respectively. Other first limiting amino acids were held at a constant ratio to dLys level: Met+Cys, 0.76; Thr: 0.65; Val: 0.80; Ile: 0.71; Arg: 1.05, and Trp: 0.16. The finisher metabolizable test diets were iso-nitrogenous and formulated to different AMEn levels: 2800, 2925, 3050, 3175 and 3300 kcal/kg. All diets were formulated to AMINChick®/2 recommendations, with dLys set at 1.00% and other amino acids set as a ratio to dLys. There were significant differences from strain (P = 0.0479) and diet (P < 0.0001) for BW at 42d in both trials. Both lines had a similar starting FSR (≥40%) and FBR (≥35%) of mixed skeletal muscle protein for the start of the studies at d22. Line A had a higher FSR and FBR in the response to ME (17.01% and 13.22%) while Line B had a significantly higher FSR of 15.27% and FSR of 18.31% for skeletal muscle at 42d in the AA trial. FSR and FBR tended to increase as gLys/Mcal increased in the diets, with the exception of the lowest ME level diet. Delta FBR revealed a significant line × diet interaction (P = 0.0204) in the AA trial. There was a significant 7.29% FSR and 7.15% FBR difference between the lowest and highest energy diets at 42d, (P = 0.0002, P = 0.0005). The AA trial suggests that FSR increased 6.73% from the 80% AA diet up to the 110% AA diet (20.44%) at d35. These trials suggest both strains synthesize and degrade more protein when fed increasing levels of amino acids per Mcal. Energy deficient diets (2800 kcal ME) can significantly limit muscular synthesis and degradation even if the gLys/Mcal is higher.

Key Words: protein turnover, broiler, infusion, synthesis, degradation

12 Ideal ratio of valine for Ross 308 male broiler chicks in growing period. A. H. Seyedi*, E. Safaryi, Tabriz University, Tehran, Iran. 2Uremia University, Tehran, Iran.

A bioassay was conducted to determine the ideal ratio of digestible valine relative to lysine (dig Val/Lys) for male Ross 308 broiler chicks from 8 to 21 days of age. Valine-deficient corn-soybean meal basal diets (3030 MEn kcal/kg) contained 20.8% crude protein and 0.70 ideal ratio dig Val/Lys for experimental period. To evaluate ideal ratio of dig Val/Lys of male broiler chicks based on growth performance, a total of 600 male broiler chicks were assigned to 6 treatments with 5 replicate using a completely randomized design. Dietary ideal ratio of dig Val/Lys was supplied in 6 treatments from 0.70 to 0.95 for the experimental period. Straight broken line Regression analysis indicated that ideal ratio of dig Val/Lys at 0.80 in diet maximized body weight gain; whereas 0.79 improved feed conversion ratio and 0.90 minimized the feed intake. Quadratic broken line Regression analysis showed that ideal ratio of dig Val/Lys at 0.86 of the diet maximized body weight gain, whereas 0.84 optimized feed conversion ratio. Feather free body weight, all analyzed body composition parameters and protein retention in body were significantly affected by the increasing ideal ratio of dig Val/Lys in basal diet (P < 0.01). Broiler chickens fed with 0.85 of ideal ratio of dig
Val/Lys had the maximum protein retention ($P < 0.01$). Results indicate that a ratio of dig Val/Lys of 0.86 should be adequate for improving Ross 308 broiler chick’s performance.

**Key Words:** broiler, broken line, valine, weight gain