The inclusion of high non-starch polysaccharide (NSP) feed stuffs in broiler diets limit optimal broiler performance. Dietary additions of NSP degrading enzymes may improve digesta viscosity, nutrient digestibility, and thus broiler performance. Objectives of the current study were to determine the effects of a corn-expressed recombinant carboxyhydrate (AC1) on broiler performance and digesta viscosity in diets containing high NSP ingredients through 21 d of age. A total of 720 Hubbard × Cobb 500 straight-run, day-old chicks were assigned to one of 6 dietary treatments. Each treatment consisted of 12 replicate pens of 10 birds each.

The positive control (PC) diet consisted of a standard corn and soybean meal formulation. The negative control (NC) diet was formulated with a 10% inclusion of wheat and 10% distillers dried grains with solubles (DDGS). This diet also contained 100 kcal/kg less metabolizable energy (ME) than the PC diet. Increasing inclusions of AC1 were applied to the NC diet to contain 50, 100, 200, and 400 U β-Glucanase (β-Glu-U) per kg of feed. Preliminary homogeneity in mash and pellet stability (80, 85, and 90°C pelleting) experiments demonstrated that AC1 was properly distributed during mixing (6% coefficient of variation) and was thermally stable (90% β-Glucanase activity following 90°C pelleting).

Bird performance and digesta viscosity were measured on d14 and d21. Feed intake (FI) was similar across all treatments throughout the study (P > 0.05). Live weight gain (LWG) was the highest for PC fed birds from d1–14; however, birds fed NC with 400 β-Glu-U/kg had similar LWG as PC (> 0.05). Day 1–21 feed conversion ratio (FCR) was the lowest for PC fed birds; however, birds fed NC with 400 β-Glu-U/kg had similar FCR as PC (P > 0.05). Birds fed the NC diet had lower LWG by 21 g and higher viscosity by 0.51cP than the birds fed the PC diet on d14 (P < 0.05), but treatment differences were not significant on d21 (P > 0.05). Birds fed the NC diet with either 200 or 400 β-Glu-U/kg had similar d14 digesta viscosity as birds fed the PC diet (P > 0.05).

These data indicate that NSP ingredients may have a greater impact on digesta viscosity early in broiler growth and that AC1 inclusion was efficacious to reduce viscosity and improve performance, particularly at higher doses (200 and/or 400 β-Glu-U/kg).

Key Words: broiler, NSP, viscosity, wheat, β-glucanase

134 Effects of increasing levels of a multicomponent enzyme on male broiler growth performance and nutrient digestibility. T. Lester1*, K. Brown1, R. Poureoslami2, K. Bregendahl2, and J. Lee1, 1Texas A&M University, College Station, TX, 2ADM Animal Nutrition, Decatur, IL.

An experiment was conducted to evaluate the effects of increasing levels of a multi-component enzyme containing xylanase and cellulase (Empirical NSP, ADM Animal Nutrition) in reduced energy diets on male broiler growth performance and nutrient digestibility. Cobb 500 male broiler chicks were placed in 7 experimental treatments consisting of a positive control (PC), negative control (NC; -132kcal/kg of PC), and 5 treatments with increasing levels of the multi-component enzyme (990; 1,980; 2,970; 3,960; or 4,950 units of xylanase per kg of feed). Each experimental treatment had 12 replicate pens with 33 animals per replicate. Three dietary phases were fed during the trial: starter (d 0–14, crumble), grower (d 14–28, pellet), and finisher (d 28–41, pellet). Body weight and feed consumption measurements were taken at the conclusion of each dietary phase and were used to calculate mortality-corrected feed conversion ratio (FCR). On d 28, 5 broilers per replicate were randomly selected and ileal contents were collected for the determination of ileal digestible energy (IDE) and nitrogen (IDN). Statistical comparisons were performed using a 2 × 2 × 2 factorial ANOVA. Interactions, were determined by a one-way ANOVA and differences (P ≤ 0.05) between individual treatment means were separated by Duncan’s Multiple Range Test. Multiple interactions were observed between factors for BW and mortality corrected feed conversion ratio (FCR), mainly present between xylanase and β-glucanase inclusion. Inclusion of both enzymes in the High AME diet suppressed feed consumption and BW at 18 d of age, while no differences in main effect means or individual treatment means were observed on d 34 or 42. Reducing the AME level of the diet increased (P < 0.001) starter phase FCR. During the grower phase, xylanase improved (P < 0.05) FCR in the low AME diet but no improvements were observed in the High AME-fed broilers. Cumulative FCR (d 1 to 42) was elevated (P < 0.05) in the Low compared with the High AME-fed broilers. Inclusion of xylanase in the Low AME diet reduced (P < 0.05) overall FCR to levels similar to the High AME no-enzyme fed broilers. Xylanase and β-glucanase inclusion reduced FCR compared with their respective controls but no additional improvement was observed with their combination. Interactions were also observed on energy digestibility on d 18 and 34. On d 18, combined enzyme administration in the Low AME diet increased (P < 0.05) IDE while no increase was observed in the High AME diet when enzymes were fed. On d 34, individual inclusion of xylanase or β-glucanase increased (P < 0.05) IDE values in the Low AME diet however only dual administration increased (P < 0.05) IDE of the High AME diet. On d 18 and 34, IDE was increased (P < 0.05) with xylanase or β-glucanase inclusion. These data highlight the ability of xylanase to improve performance in corn/soy diets and suggest that additional exogenous enzyme inclusion may not be necessary to further increase the response.

Key Words: xylanase, β-glucanase, energy, broiler, performance
at any of the measured time points. The FCR was increased \((P < 0.05)\) with the reduction of energy in the NC diet as compared the PC fed broilers in each of the 3 phases of production and cumulatively from d 1 to 42. Inclusion of a multi-component enzyme was beneficial to FCR, leading to a significant reduction \((P < 0.05)\) in d 1 to 42 FCR in broilers fed all levels of the multi-component enzyme with exception of the highest level. The IDE was the highest for the PC fed broilers, as expected, and higher \((P < 0.05)\) than NC fed broilers. Enzyme inclusion increased \((P < 0.05)\) IDE value of the diet at all levels of inclusion compared with the NC broilers with exception of the highest inclusion rate (4,950 xylanase units per kg feed). Quadratic regression analysis indicated significant impacts of the multi-component enzyme on FCR and IDE with maximum response between 1,980 and 2,970 units of xylanase per kg of feed. These data demonstrate the benefits of a new multi-component enzyme containing xylanase and cellulase providing guidance on dosage rate.

**Key Words:** broiler, energy, xylanase, cellulase, digestibility

### 135 Efficacy of carbohydrase enzymes in diets varying in ingredient composition when fed to coccidiosis vaccinated broilers. B. Bodle, M. Jackson, and S. Rochell, University of Arkansas, Fayetteville, AR, Huvepharma Inc., Peachtree City, GA.

An experiment was conducted to investigate the effects of 2 carbohydrase enzymes on growth performance, apparent ileal nutrient and energy digestibility (IDE), and processing characteristics in coccidiosis-vaccinated broilers fed diets containing animal protein meal (APM) or all vegetable-based (VEG) diets. Four APM or VEG diets included: 1) a positive control (PC), 2) a negative control (NC), 3) the NC diet + a multi-carbohydrase enzyme (HZY) (Hostazyme, Huvepharma, Inc.), and 3) the NC diet + a novel combination of HZY and an α-galactosidase (XAG) (Huvepharma, Inc.) for a total of 8 dietary treatments. Treatments were maintained across starter (0 to 14 d), grower (15 to 28 d), and finisher phases (29 to 42 d), and in each phase, negative control diets were formulated to contain 100 kcal/kg less apparent metabolizable energy than the PC diet. Animal protein-based diets contained 7.0% of an animal protein blend in the starter, 3.5% animal protein blend + 3.5% feather meal in the grower, and 2.5% animal protein blend + 2.5% feather meal in the finisher, and all diets within a phase were formulated to be isonitrogenous. Titanium dioxide was used as an indigestible marker for the determination of ileal digestibility. All birds received a 2x dose of a live coccidiosis vaccine (Advent, Huvepharma Inc.) by oral gavage immediately before placement. Eight replicate floor pens of 26 Cobb 500 male broilers per treatment were placed. Overall FCR (0 to 42 d) was lower \((P < 0.01)\) for birds fed VEG diets than for birds fed APM diets, with no difference in BWG between these groups. Compared with birds fed the NC diets, birds fed the PC diets had lower \((P < 0.01)\) overall FCR and similar BWG in both the APM and VEG groups. No effects \((P > 0.05)\) of enzyme inclusion were observed on overall growth performance. Carcass and breast yields were higher \((P < 0.01)\) for broilers fed VEG diets than for those fed APM diets, with no differences \((P > 0.05)\) among birds fed PC, NC, or enzyme-containing diets. At 14 d, IDE was not different between APM and VEG-fed broilers, but was 128 and 161 kcal/kg lower in NC diets than in PC diets for the APM and VEG groups, respectively. Inclusion of HZY and XAG increased \((P < 0.05)\) IDE of the APM NC diet by 178 and 90 kcal/kg, respectively, but did not influence \((P > 0.05)\) IDE of the VEG NC diet. Inclusion of HZY and XAG also improved \((P < 0.05)\) N digestibility of the APM NC diet, but not the VEG NC diet \((P > 0.05)\). In conclusion, feeding VEG diets promoted superior growth performance and processing yields compared with APM-fed broilers. Although enzyme inclusion improved IDE and N digestibility of the APM diet, this did not translate to improved performance.

**Key Words:** carbohydrase, digestibility energy, animal protein, all-veg, broiler

### 136 Enhancing nutrient utilization of broiler chickens through supplemental enzymes. K. J. Boboga, J. Wilson, A. Cowieson, and T. Woyengo, South Dakota State University, Brookings, SD, DSM Nutritional Products, Belvidere, NJ, DSM Nutritional Products, Kaiseraugst, Switzerland.

The objective was to determine effects of adding phytase, amylase, and a cocktail of non-starch polysaccharide degrading enzymes (NSPase) individually or in combinations to corn-soybean meal-based diet for broilers on apparent ileal digestibility (AID) of nutrients and dietary AMEn value. Four hundred and 80 male broiler chicks were divided into 80 groups and fed 8 diets in a completely randomized design (10 groups/diet) from d 15 to d 21 of age. The diets were basal diet unsupplemented or supplemented with phytase (1,500 FTU/kg; Ronozyme HiPhos), amylase (80 KNU/kg, Ronozyme HiStarch) and NSPase (75 g/metric ton, Ronozyme Multigrain) individually or in all possible combinations. The basal diet contained the phytase at 1,000 FTU/kg, and was formulated to meet the NRC (1994) recommended nutrient requirements for broiler chickens except for ME, Ca and non-phytate P, which were reduced by 150 kcal/kg, 0.18%, and 0.15%, respectively. Data were subjected to ANOVA using the MIXED procedure (SAS Inst. Inc., Cary, NC) with cage as random term. Treatment means were separated by the probability of difference. Addition of phytase to the basal diet increased \((P < 0.05)\) AID of P from 40.4 to 59.3%. Addition of amylase, NSPase or a combination of amylase and NSPase to the phytase-supplemented basal diet further increased \((P < 0.05)\) AID of P to 63.4, 69.9 and 67.3%, respectively. Addition of amylase, phytase or a combination of amylase and NSPase to the basal diet did not affect dietary AMEn value. However, addition of NSPase alone or a combination of phytase and amylase or of phytase and NSPase to the basal diet improved \((P < 0.05)\) dietary AMEn value from 3,203 to 3,339, 3,309 or 3,289 kcal/kg, respectively. In conclusion, it is more beneficial (with regard to AID of P and dietary AMEn) to add amylase and NSPase to phytase-supplemented diets for broilers. Because the basal diet contained phytase at 1,000 FTU/kg, the increase in AID of P due to supplemental phytase (1,500 FTU/kg) indicate that supplemental phytase at 2,500 FTU/kg is more beneficial with regard to improving AID of P than supplemental phytase at 1,000 FTU/kg.

**Key Words:** amylase, broiler, fiber-degrading enzyme, nutrient digestibility, phytase

### 137 Effects of calcium and phosphorus level in a diet containing phytase on male broiler performance and breast meat yield. M. Williams, C. Coufal, K. Smith, P. Lessard, J. Broomhead, and J. Lee, Texas A&M University, College Station, TX, Agrivida Inc., Woburn, MA.

The objective of the current study was to evaluate the effects of calcium (Ca) and phosphorus (P) level in a diet containing super-dose levels of phytase (4 lb/ton GrafNzyme; 4500 FTU/kg, analyzed in pelleted feed) on male broiler performance and breast meat yield. The experimental design consisted of a 3 (Ca reductions; 0.11, 0.13, and 0.15%) × 2 (P reductions; 0.12 and 0.15%) factorial yielding a total of 6 dietary treatments. Each treatment included 10 replicates with 21 Ross 708 male broilers placed per replicate (1260 broilers total). The dietary program...
coarse limestone diets resulted in greater feed intake and improved FCR as expected. Fine limestone improved FCR in the starter phase but did not affect digestibility of Ca, P, and amino acids at 33 d of age. Phytase supplementation of low AvP (0.3%) diets improved 
P reductions with Ca by P interactions observed through d 28 and 42 
< 0.05) was observed in d 28 BW because in the higher Ca diet (~0.11%), reducing P by 0.15% increased BW but in the lower Ca diet (~0.15%), reducing P by 0.15% reduced BW. Increasing the reduction of P from 0.12% to 0.15% increased starter feed conversion ratio (FCR; P < 0.05). Calcium reductions from 0.11% to 0.13% improved FCR (P < 0.05) during the grower (1.442 vs 1.424) and finisher phase (1.663 vs 1.639), with further 0.15% Ca reduction being intermediate (1.432 and 1.655, respectively). The lowest cumulative FCR’s (d 28, 42 and 49) were observed with 0.13% Ca or 0.12% P reductions with Ca by P interactions observed through d 28 and 42 (P < 0.05), resulting from increased FCR with 0.15% P reduction, but only in 0.15%Ca reduction. No impacts of mineral level were observed on processing weights or yields except for an increase (P < 0.05) in tenderloin weight with 0.15% P reduction. Birds fed −0.13% Ca and −0.15% P had lower d 28 percent tibia ash (P < 0.05) compared with other diets. These data illustrate the importance of utilizing the correct Ca and P matrix value to maximize the broiler performance.

Key Words: broiler, phytase, calcium, phosphorus

138 Effect of limestone particle size, available phosphorus, and phytase supplementation on live performance and apparent ileal digestibility of calcium, phosphorus, and amino acids of male broilers chickens. D. Joardar* and J. Brake, North Carolina State University, Raleigh, NC.

This experiment investigated the effects of limestone particle size, available phosphorus (AvP) and phytase on live performance, tibia bone ash, and apparent ileal digestibility of calcium (Ca), phosphorus (P), and amino acids of male broiler chickens in a floor pen study. Two particle sizes of limestone were defined as fine (~0.2 mm) and coarse (~0.9 mm) by using the US sieve method. The analyzed Ca concentration of both limestone sources was similar (~395 g/kg). Eight experimental diets were formulated using fine and coarse particle sizes of limestone, 0.3% and 0.45% levels of AvP, and 1000 and 2000 FYT levels of phytase in a 2 × 2 × 2 design. Each experimental diet was randomly assigned to 6 replicate pens with 16 birds per pen and fed consecutively starter (0–16 d) and grower (17–33 d) diets. Apparent ileal digestibility of Ca, P, and amino acids were determined at 33 d using titanium dioxide (5 g/kg) as an indigestible marker. Bone ash was also determined at 33 d. Dietary phytase supplementation of low AvP (0.3%) diets improved (P ≤ 0.05) BW gain, feed intake, and FCR at 16 d. Subsequently, BW gain, feed intake, and bone ash were improved (P ≤ 0.05) at 33 d by the phytase supplementation. Fine limestone improved (P ≤ 0.05) FCR at 16 d while coarse limestone improved (P ≤ 0.05) feed intake and digestibility of Ca, P, and amino acids at 33 d of age. Phytase supplementation of low-AVP diets improved live performance and bone ash, as expected. Fine limestone improved FCR in the starter phase but coarse limestone diets resulted in greater feed intake and improved digestibility of Ca, P and, AA at 33 d of age. These data suggest that particle size of dietary limestone should be an important consideration when formulating broiler diets.

Key Words: amino acids, bone ash, broiler, limestone, digestibility

139 The long-term effects of dietary available phosphorus and calcium, and phytase supplementation on bone mineralization in laying hens. K. Pongmanee*1, K. Nadeau1, C. Wyatt2, R. Van Wyhe3, and D. Korver1, 1University of Alberta, Edmonton, AB, Canada, 2AB Vista, Plantation, FL.

Phosphorus and calcium play important roles in laying hen bone health. There is a lack of information on bone mineralization in hens fed low available phosphorus (aP) and calcium diets, and supplemented with phytase in the long term. The objective was to determine the effect of dietary aP and Ca, and an enhanced *Escherichia coli* 6-phytase supplementation on bone characteristics from 0 to 74 wk of age. White egg layer pullets (n = 400) were obtained at 1 d of age, housed in one of 50 pullet-rearing cages (n = 8 per cage) and moved to individual cages (n = 50 to 52 per treatment) at 19 wk of age in a completely randomized design. Pullets were allocated to 5 dietary treatments: positive control (PC), a nutritionally complete corn-soy-canola-based diet phase-fed according to the primary breeder management guide; a negative control (NC) diet similar to the PC diet with reduced aP (by 0.15% of the diet) and Ca (by 0.16% of the diet); and the NC diet supplemented with either 300, 600 or 1,200 FTU phytase/kg. At each of 6, 15, 18, 42, 54, 64, and 74 wk of age, body weight (BW), feed intake (FI), and after 18 wk, egg production (EP) were measured. Femurs were excised post-mortem from 8 to 10 birds per treatment. The left distal femur was scanned using quantitative CT (QCT) to determine total, cortical, and trabecular bone mineral density (BMD) and bone cross-sectional area. Bone mineral content (BMC) was calculated by multiplying BMD by bone cross-sectional area. Bone breaking strength (BBS) and bone ash of the right femur were determined. Data were analyzed by 2-way ANOVA using the Mixed procedure for the main effects of diet and age, and their interaction. Correlation coefficients (r) among bone traits were measured. Differences were considered significant at P ≤ 0.05. The NC birds had lower BW than the PC birds, but 1,200 FTU phytase/kg increased BW back to the level of the PC. Neither aP and Ca levels nor phytase affected FI or EP. Throughout the laying cycle, the NC+600 FTU phytase/kg tended to increase BBS (P = 0.058) and bone ash (P = 0.062). The NC diet reduced total BMD (404.34 ± 4.24 mg/cm^3) and cortical BMC (15.03 ± 0.15 mg/mm), but 600 FTU phytase/kg restored the total BMD (434.34 ± 7.68 mg/cm^3) and cortical BMC (16.84 ± 0.53 mg/mm). The r between BBS and total bone ash was low (r = 0.36; P < 0.001), likely due to the influence of non-structural medullary bone, while r of BBS and cortical BMC was 0.69 (P < 0.001). The significant correlations between total bone ash and trabecular BMD, total BMD, and total BMC were 0.95, 0.92, and 0.88, respectively. Supplementation of 600 FTU phytase/kg allowed for reductions aP and Ca by 0.15% and 0.16% of the diet, respectively, and prevented bone loss in laying hens.

Key Words: phosphorus, phytase, bone mineralization, laying hen

140 Assessment of superdosing phytase on broiler phosphorus digestibility, ileal digestible energy and bone mineralization. J. Wane*1, M. Coelho2, A. Troescher3, P. Ader3, and W. Kim1, 1University of Georgia, Athens, GA, 2BASF Corporation, Humble, TX, 3BASF, Lampertheim, Germany.

We previously reported superdosing of phytase at 3000FTU/kg to a reduced calcium, available phosphorus (aP) and metabolizable energy
(ME) diet increased broiler performance (2018, IPPE). To gain a better knowledge of superdosing phytase effect on a nutrient deficient diet (reduced Ca, AvP and ME), samples from previous experiment were further analyzed to evaluate the effect of superdosing phytase on phosphorus digestibility, ileal digestible energy (IDE) and bone ash. A total of 1,150 one-day old Cobb 500 male broilers were randomly allocated into 5 dietary treatments with 10 replicates and 23 birds each. Dietary treatments consisted of 1) positive control (PC) with all nutrients meet or exceed Cobb 500 nutrition manual; 2) negative control (NC) with 90 kcal/kg metabolizable energy (ME), 0.15% calcium and available phosphorus reduction from PC; 3) standard phytase dose control with 1,000 FTU/kg phytase addition on the top of NC (PC1); 4) reduced ME control with 200 kcal/kg ME reduction from NC (NC1); and 5) superdosing phytase with a dietary addition of 3,000 FTU/kg phytase on the top of reduced ME control (T1). The study was conducted as a completely randomized design and all data were analyzed by a one-way ANOVA. At d 28 and d 42, 5 birds from each replicate were sacrificed. Ileal digesta (d 28 and d 42) and left tibia (d 28) were collected for further analysis to evaluate the effect of superdosing phytase on a nutrient deficient diet (reduced Ca, AvP and ME), samples from previous experiment were collected from each bird before feeding experimental diets.

Broilers received 1 of 3 experimental diets formulated to contain 0, 400, and 1,200 FTU/kg, respectively, in Diets 1, 2 and 3. Diet 1, the positive control, was formulated to contain 0.76% calcium and 0.36% non-phytate phosphorus, whereas calcium and non-phytate phosphorus concentrations in Diets 2 and 3 were 0.16 and 0.15% lower than Diet 1, respectively. Blood was collected from 20 to 240 min at 20-min intervals with a final blood collection at 480 min to determine plasma inositol concentrations. Following blood collection, birds were sacrificed and gizzard and ileal digesta were collected to evaluate IP ester destruction. Plasma inositol concentration of broilers was not different (P = 0.34) among the dietary treatments at each time point from 0 to 480 min. A cubic increase (P = 0.023) of plasma inositol concentration of broilers from 20 to 240 min was observed, regardless of the dietary treatments. The concentration of IP6 in broilers provided the 1,200 FTU/kg diet was 1/3 (P < 0.01) of the IP6 concentration in birds with 400 FTU/kg diet both in the gizzard (1,264 vs. 4,176 nmol/g) and ileal digesta (13,472 vs. 33,244 nmol/g). Similarly, the addition of 1,200 FTU/kg increased (P < 0.01) inositol concentrations in the gizzard and ileal digesta of broilers by 2.5 (2,703 vs. 1,071 nmol/g) and 3.5 (16,485 vs. 4,667 nmol/g) fold, respectively, compared with adding 400 FTU/kg. The reduction and increase of IP6 and inositol concentrations in the digesta of broilers demonstrated that phytase addition at 1,200 FTU/kg is more effective in destroying IP esters than adding 400 FTU/kg. However, these responses did not translate to increased plasma inositol concentrations, which warrants further investigation.

**Key Words:** broiler, phytase, inositol, inositol phosphate

---


This study was designed to evaluate the effect of meat and bone meal (MBM), phytase (PHY) and antibiotics (AB) on bone integrity and hematomatological indices of chickens during necrotic enteritis (NE). Ross 308 male day-old chicks (n = 672) were fed 8 diets in a 2 x 2 factorial arrangement of treatments. There were 6 replicates per diet and 14 birds per replicate. Factors were: MBM (0 or 60 g/kg in S, 50 g/kg G/F), AB (0 or 100 mg/kg Zn bacitracinplus 60 mg/kg salmoinycin) and PHY (Quantum Blue 5G; 500 (using matrix values) or 1500 FTU/kg (with 500 matrix values). Wheat – SMB based diets were fed to 42 d. All birds were challenged with 5000 unattenuated sporulated oocysts each of *E. acervulina*, and *E. maxima* and 2,500 sporulated oocysts of *E. brunetti* (Bioproperties Pty Ltd.) on d 9, and 10/cfu C. perfringens Strain EHE-NE18 (known to express NetB toxin) on d 14 and d 15. On d 16, blood samples were taken from 2 birds per pen. On d 42, femur, tibia and toe were excised from 2 birds per pen after euthanasia. Bone breaking strength (BS) was measured using Instron Universal texture analyzer. Data were subjected to 2-way ANOVA using Minitab 18.1. Means with significant differences were separated by Tukey’s HSD test at a probability level of 0.05. Main effects for blood: none vs AB - erythrocytes (2.06 vs 2.21 10^9/ml), hemoglobin (11.22 vs 12.16 g/dl) and packed cell volume (22.12 vs 23.90 10^3/ml); 500 vs 1500 phytase white blood cells (60.03 vs 72.65 10^3/ml) with no interactions detected (P > 0.05). None vs MBM platelets (1.97 vs 1.02 10^11/ml) with an AB x PHY interaction detected (P < 0.05). Without AB, with PHY increased from 500 to 1500 there were increased platelets and with AB, additional PHY decreased platelets. Main effects for bone: none vs MBM, toe ash% (10.6 vs 11.4), tibia ash% (44.1 vs 45.7), tibia BS N (354 vs 415), femur ash% (42.4 vs 44.4), femur BS N (300 vs 336). Across MBM, AB x PHY interac-
tions were detected. The addition of AB increased toe ash% with 500 PHY but not with 1500 PHY ($P < 0.05$). Without AB, tibia wt % was increased when PHY was increased from 500 to 1500 but with AB there was no change ($P < 0.05$). These results show that birds given AB during necrotic enteritis had more erythrocytes with higher hemoglobin content and greater packed cell volume compared with those receiving no AB. The greater platelet count and tibia wt % in birds receiving high phytase without AB indicate benefits of high PHY on wound repair and bone mineralization during NE challenge. The addition of MBM improved many bone integrity parameters during NE challenge.

**Key Words:** meat and bone meal, phytase, hematology, bone, necrotic enteritis

### 143 Comparison of two net energy (NE) calculations for broilers fed an exogenous amylase and a composite enzyme. K. Hilton*, J. England, P. Maharjan, G. Mullenix, C. Coon, A. Beitia, and J. Weil, University of Arkansas, Fayetteville, AR.

A total of 612 male broilers were randomly allocated to 3 treatments according to a randomized complete block design experiment with 4 replicates per treatment. Each pen was provided feed and water ad libitum throughout the grow-out period. The treatments tested were: 1) Negative control – negative basal diet without enzymes (NC), 2) Negative control + composite enzyme, 3) Negative control + composite enzyme + amylase (recommended level). At ages 12, 26 and 48 average treatment BW was determined and birds were selected within one standard deviation of mean BW and moved to the respiratory chambers for heat production (HP) determination. Chicks were evaluated during the starter phase from 13 to 14d, grower 27–28d and finisher 50–51d of age. A total of 48, 20 and 8 total birds from each treatment were evaluated during the starter, grower and finisher phases, respectively. All chicks evaluated at different ages were obtained from the same flock at the same time. Birds were moved to the respiratory chambers 1d before evaluation for a period of adaptation. Heat production (HP) kcal = 3.872*VO$_2$ (L/d) + 1.195 VCO$_2$ (L/d) (Farrell, 1974) was measured for 1d. After HP was measured, fasting heat production (FHP) was measured for 24h. Heat increment was determined (HI) = HP – FHP (Farrell, 1974). Body composition was measured on d7, 14, 21, 28, 35 and 49 by dual energy x-ray absorptiometry (DEXA) to determine net energy gain ($\text{NE}_g = \text{protein grams} \times 5.66 + \text{fat gain grams} \times 9.35$). Data was analyzed using JMP Pro 13 (SAS, 2016). Two NE equations were compared. Classic NE (kcal) = ME-HI versus Arkansas NE (kcal) = $\text{NE}_g + \text{NEm}$, where NEm (net energy maintenance) = HP – HI. Data was analyzed using JMP Pro 13 (SAS, 2016). $\text{NE}_g$ was significantly impacted by the addition of exogenous composite enzymes in the starter and grower phases ($P < 0.0002$), with NC + composite enzyme producing 100 and 447 kcal/kg respectively, more than NC birds. Arkansas NE increased with the addition of composite enzyme compared with Arkansas NE for the NC diet alone. Arkansas NE recovered an average of 92% calories, with NC plus composite enzyme producing the highest NE value because Classic NE only recovered 84%. This experiment indicates the addition of exogenous composite enzymes increases the $\text{NE}_g$ of broilers. Furthermore, when NE is expressed as NEm + $\text{NE}_g$ more calorie recovery is possible, because more calorie value is given to body composition than calories lost as heat increment.

**Key Words:** enzyme, amylase, net energy, body composition