Metabolism and Nutrition: Feed Additives I

192 Effects of essential oil concentration and grain type on intestinal traits. K. Claassen*,1, M. J. Da Costa1, E. O. Oviedo-Rondón1, and B. Turner2,1North Carolina State University, Raleigh, 2DSM Nutritional Products, Parsippany, NJ.

The mode of action of essential oils (EO) as growth promoters is not fully understood. One experiment was conducted to evaluate the effects of EO concentration and grain type on broiler intestinal traits. Corn (C) and wheat (W) based basal diets were formulated to have similar nutrient composition within each dietary phase. The EO containing benzoic acid (Crina Poultry Plus) was added to each basal diet to have 0, 150, or 300ppm. Starter, grower, and finisher diets were fed from 0—14d, 15—35d, and 35—47d, respectively. At hatch, 720 Ross 708 male broilers were identified and placed in 72 floor pens. At the end of each dietary phase one broiler per pen was selected, sacrificed and the length of intestines, the weights of pancreas, duodenum, jejunum, and ileum, and the pH of the proximal duodenum contents were determined. Mucus digesta content was quantified using a colorimetric procedure. Data were analyzed as a 2x3 factorial design with grain type and EO concentration as main factors. Results indicated an interaction effect (P < 0.05) on pH at 47d, with EO increasing pH in chickens fed W diets, and reducing it in broilers fed C diets. Less mucus was observed in 47d chickens fed diets with 300ppm EO than in diets without EO. An interaction effect (P ≤ 0.05) was observed at 35d with less mucus in the C diets than in W diets at 300ppm EO. At 14 and 47d, the pancreas relative weight (RW) was bigger (P < 0.05) in C than in W. At 14d the pancreas RW was larger (P < 0.05) in chickens fed 300ppm EO than in those without EO, and at 47d pancreas RW of broilers from 150ppm diets was bigger than diets without EO. At 35d, the intestine was shorter in chickens fed 300ppm diets than fed 0 and 150ppm diets. At 47d, the intestine was longer in chickens fed C diets compared with W diets. At all collections, C chickens had bigger (P < 0.05) ileum RW than W. In general, the EO increased pancreas size, reduced intestinal length, and reduced mucus production, while C diets caused increased pancreas RW and intestinal length compared with W diets. It was concluded that EO may affect intestinal development and function with different effects depending on grain type.

Key Words: essential oil, broiler, grain type, intestinal traits

193 Benzoic acid and turmeric (Curcuma longa L.) meal supplementation altered the gut pH without influencing the growth performance or gross profile of the gastrointestinal tract of broilers. N. D. Dono,* N. H. Sparks, and O. A. Olukosi, Scottish Agricultural College, Avian Science Research Centre, Scottish Agricultural College, Edinburgh, UK.

Response of broiler chickens to benzoic acid (BA) and turmeric (Curcuma longa L.) meal (TM) supplementation using growth performance, intestinal pH, and gross profile of the gastrointestinal tract (GIT) as response criteria was investigated. At day old, 300 male Ross 308 chicks were assigned to 5 dietary treatments in a randomized complete block design. Each treatment has 6 replicate pens with 10 birds per pen. The diets were: 1) control (C) diet which met NRC (1994) nutrients requirements for broiler; 2) C plus BA added at 2 g/kg; 3) C plus TM at 10 g/kg; 4) C plus BA and TM added at 1 and 5 g/kg, respectively; and 5) C plus a BA and TM at 2 and 10 g/kg, respectively. On d 21, representative birds per pen were selected and euthanized by cervical dislocation. The pH of the crop, proventriculus, jejunum, ileum, and ceca contents were measured and the gross profile of the GIT was examined by measuring the length and weight of full and empty sections of the GIT. Feed intake, final body weight, weight gain, and gain to feed ratio were unaffected by the treatments. Compared with the C, BA supplementation at 2 g/kg reduced the pH (P < 0.001) of the contents of crop and jejunum. Combination of BA and TM at the rates of 1 and 5 g/kg reduced the pH (P < 0.001) of the crop, whereas combination at 2 and 10 g/kg reduced the pH (P < 0.05) of the crop, jejunum and cecal contents. The treatments had no effect on the weight of the gizzard, liver, and pancreas nor on the length of duodenum, jejunum, and ileum. The data from the current study indicate that dietary supplementation of BA and TM lowered the pH of the crop, jejunum, and ceca of 21 d old broiler and this reduction may encourage the colonization of the gut by beneficial microbes.

Key Words: benzoic acid, turmeric meal, growth performance, gut, broilers

194 The effect of processing, aflatoxin, and AB-20 in peanut meal based diets fed to turkey pouls. J. E. Nixon*,1 J. L. Grimes1, J. P. Davis2, and B. L. White2,1North Carolina State University, Raleigh, 2USDA, ARS, Market Quality and Handling Research Unit, Raleigh, NC.

A novel process for adding value to aflatoxin contaminated peanut meal (atox-PM) has been developed. A bentonite clay (AB20) was used to sequester aflatoxin while simultaneously extracting water-soluble protein from atox-PM. A co-product of this process is the insoluble PM (ipM) which could be used as a feed ingredient. In this study 336 LW hen pouls were placed in 48 battery cages for 3 wk (8 dietary trt, 6 cages/trt) with 7 birds/cage. A common basal was made with all ingredients except PM, hulls, sand, and AB20, which were added accordingly to the 8 respective diets. Atox-PM (191ppb) before processing, i-PM derived from processing and a low atox (99ppb) control PM (clean-PM) were evaluated. All diets contained 36% PM, were isonitrogenous and isocaloric and were: clean-PM; clean-PM+AB20; atox-PM; atox-PM+AB20; iPm; iPm processed with 2 levels of AB20; and iPm with AB20 added post-processing. Body weight (BW), feed intake(FI), and feed conversion(FC) were determined at wk 1, 2, and 3. At 3 wk the heart, spleen, gizzard, kidney, liver, pancreas, and the bursa were collected from 4 birds/pen and relative weights (RW) determined as were liver colors(L* a* b*). Body weight at wk 1, 2, and 3 were higher in birds fed PM diets compared with those fed iPm diets. The 2 diets containing iPM processed with AB20 resulted in the lowest FI (P < 0.0001) throughout the trial compared with all other diets. FC at 1—2 and 0—2 wk was improved for PM diets compared with the iPm diets. Birds fed atox-PM diets had the lowest liver RW (P < 0.0001) compared with those fed iPm and clean-PM diets. The iPm diets resulted in higher pancreas RW (P < 0.0001) compared with other diets. Birds fed atox-PM without AB20 had the highest spleen RW (P < 0.0001) compared with those fed other diets. Feeding the atox-PM and iPm diets resulted in livers with higher b* (yellow coloration; P < 0.0001) which could be attributed to fat deposition resulting from aflatoxin metabolism. In conclusion, the iPm was an inferior feed ingredient compared with PM before processing. Although AB20 addition resulted in significant in vitro atox reduction, this ingredient minimally impacted bird performance.

Key Words: aflatoxin, peanut meal, processed peanut meal, feed additive, turkey
195 Effect of yeast cell product (CitriStim) supplementation on broiler performance and intestinal immune cell parameters during an experimental coccidial infection. R. Selvaraj1, M. Sifri2, and R. Shanmugasundaram1, 1Ohio Agricultural Research and Development Center/The Ohio State University, Wooster, 2Archer Daniels Midland Alliance Nutrition Inc., Quincy, IL.

This experiment studied the effect of CitriStim, a commercial killed whole yeast cell prebiotic, on broiler performance, fecal coccidial oocyst count, Tregs, CD4+ and CD8+ percentages and IL-10 and IL-1 mRNA amounts in the spleen and cecal tonsils during an experimental coccidial infection. One-day-old broiler chicks were fed a corn and soybean meal based diet supplemented with 0, 0.1 or 0.2% CitriStim for 21 d. At 21 d of age, birds were challenged with 1 X 10^6 live coccidia oocysts. Birds fed 0.2% CitriStim had 68% (P < 0.05) and 38% (P < 0.05) higher (%) shedding and increased villus:crypt depth in the small intestine during an experimental coccidial infection. Birds fed 0.2% CitriStim had 7-fold higher (P < 0.05) IL-10 mRNA and 3-fold higher (P < 0.05) IL-1 mRNA than the birds fed 0% CitriStim. Birds fed 0.2% CitriStim had 21% (P < 0.05) % and 23% (P < 0.05) reduction in fecal oocyst count, respectively than the birds fed 0% CitriStim. Birds fed 0.2% CitriStim had 7-fold higher (P < 0.05) IL-10 mRNA and 3-fold higher (P < 0.05) IL-1 mRNA than the birds fed 0% CitriStim. Birds fed 0.2% CitriStim had 23% (P < 0.05) villus:crypt depth ratio in the jejunum than the birds fed 0% CitriStim. Tregs, CD4+ and CD8+ percentages in cecal tonsils and spleen did not differ (P > 0.05) between treatment groups. It could be concluded that feeding CitriStim improved broiler bird production parameters, decreased fecal oocyst shedding and increased villus:crypt depth in the small intestine during an experimental coccidial infection.

Key Words: CitriStim, yeast, prebiotic, IL-1, production

196 Effects of feeding Saccharomyces cerevisiae fermentation product to broiler breeder hens and their progeny. J. Broomhead1, S. Frankenbach*, S. Oates2, and W. Berry, 1Diamond V, Cedar Rapids, IA, 2Auburn University, Department of Poultry Science, Auburn, AL.

Cobb 500 broiler breeder females (n = 760) and their progeny were utilized to determine the effects of feeding a Saccharomyces cerevisiae fermentation product (Diamond V Original XPC™) on breeder and progeny performance. Day-old pullets were assigned to treatments (Control or XPC) in the pullet facility and reared as per the appropriate primary breeder guidelines. At 19 wk of age, birds were transferred to the breeder house. Poststimulation began at 21 wk of age and dietary treatments continued until 55 wk of age. Each treatment contained 10 reps with 37 hens and 4 males/rep. Chicks (n = 378/hen treatment) were separated within hen treatment into 2 dietary treatments (4 total treatments; 9 reps/treatment; 21 chicks/rep). Progeny treatments were: 1) no XPC (CON), 2) XPC fed to progeny only, 3) XPC fed to breeder only, or 4) XPC fed to both breeder and progeny. Progeny performance was measured as body weight, uniformity and yield of carcass and parts at 42 d of age. Breeder data was analyzed using Repeated Measures model of JMP. Progeny data was statistically analyzed as control (CON) vs. treatment (TRT; XPC fed to progeny, breeder or both). Overall egg production was not statistically different (P = 0.21; Control = 65.5% or 138 eggs/hen; XPC = 67.0% or 141 eggs/hen). The XPC fed hens came into production faster with greater (P < 0.01) egg production the first 3 weeks of lay and tended to maintain higher egg production from 47 to 55 wk (P = 0.17). Progeny 24 d BW (P = 0.33; CON = 2.479 g; TRT = 2.531 g) was not statistically affected by treatment but uniformity tended to be improved (P = 0.19; CON = 13%; TRT = 12%). Carcass weight and breast meat weight (g/bird) and yield (%) were greater (P < 0.05) in the TRT birds in contrast to the CON birds. Feeding XPC to broiler breeder hens may improve egg production, while feeding XPC to breeders and/or progeny may improve uniformity and processing yield in progeny.

Key Words: Saccharomyces cerevisiae fermentation product, broiler breeder, egg production, processing yield

197 Effect of supplementation of prebiotic mannan-oligosaccharides and a probiotic mixture on growth performance of broilers subjected to chronic heat stress. M. U. Sohail1,2,3, E. M. Hume2, J. A. Byrd2, A. Ijaz3, H. Rehman1, and D. J. Nisbet2, 1University of Veterinary and Animal Sciences, IUB, Bahawalpur, Pakistan, 2ARS, USDA, College Station, TX, 3University of Veterinary and Animal Sciences, Lahore Pakistan.

The present study was aimed at elucidating the effects of supplementing mannan-oligosaccharides (MOS) and a probiotic mixture (PM) on growth performance, intestinal histology and corticosterone concentrations in broilers kept under chronic heat stress (HS). Four hundred and 50 1-d-old chicks were divided into 5 treatment groups and a fed corn-soybean diet ad-libitum. The temperature control (CON) group was held at the normal ambient temperature. Heat stress broilers were held at 35 ± 2°C from d 1 to the conclusion of the study, at d 42. Heat stress groups consisted of: HS-CONT fed the basal diet; HS-MOS fed the basal diet containing 0.5% MOS; HS-PM fed the basal diet containing 0.1% PM; and HS-SYN (symbiotic) fed 0.5 MOS and 0.1% PM in the basal diet. Broilers were examined at d 21 and 42 for body weight gain (BWG), feed consumption, feed efficiency, serum corticosterone concentrations, and ileal histology. The results revealed that the CONT group had higher (P < 0.01) BWG, feed efficiency and feed consumption on d 21 and 42, compared with the HS groups. Among supplemented groups, the HS-MOS had higher (P < 0.05) BWG and feed efficiency compared with the HS-CONT group. On d 21 and 42, the HS-CONT group had higher (P < 0.05) serum corticosterone concentrations compared with the CONT and supplemented groups. The CONT group had higher (P < 0.05) villus height, width, surface area and crypt depth, compared with the HS-CONT group. On d 21, the HS-PM had higher villus width and surface area compared with HS-CONT group. Whereas, on d 42, the HS-SYN had higher villus width and crypt depth compared with the HS-CONT group. These results showed that chronic HS reduces broilers production performance, intestinal micro-architecture and increases adrenal hormone concentrations. Supplementation of MOS probiotic and a probiotic can partially lessen the effects of chronic heat stress and improve performance.

Key Words: chronic heat stress, probiotics, corticosterone, villus height, mannan-oligosaccharides

198 Effects of mannan oligosaccharide on growth performance, intestinal morphology and gut microbial population of broilers raised under suboptimal environmental conditions. M. Pourabedin*, B. Baurhoo1, Z. Xu2, E. Chevaux2, and X. Zhao1, 1McGill University, Montreal, QC, Canada, 2Lallemand Animal Nutrition, Milwaukee, WI.

High stocking density and cold temperatures are common factors that affect broiler growth and gut physiology on Canadian broiler farms. A
study was conducted to evaluate whether a mannan oligosaccharide (MOS) prebiotic could alleviate such detrimental effects in broiler production. A total of 1344 male broiler chicks were randomly assigned to 1 of 4 dietary treatments (6 pen replicates; 56 broilers / pen), and grown over a 35-d experimental period. Dietary treatments included: 1) an antibiotic-free diet (CON); 2) MOS (diet 1 + 1g/kg AgriMOS, Lallemand Inc.); 3) VIRG (diet 1 + 16.5 mg/kg virginiamycin); 4) MAV (diet 1 + MOS + virginiamycin). To induce sub-optimal growing conditions, birds were raised at higher stocking densities of 16 birds/m², i.e., 20% above recommendations, cold temperatures of 20°C starting at 10 d of age, i.e., 4°C lower than the optimal temperature. In addition, 0.5% guar gum was added into all diets to increase intestinal digesta viscosity. Body weight and feed intake were measured weekly throughout 35 d. At d 16 and 26, 1-cm segments of the jejunum and ileum (6 birds / treatment) were used in morphological analyses, whereas fresh cecal contents were assayed for lactobacilli, bifidobacteria and E. coli. Feed efficiency was not affected by any dietary treatment. But, MOS depressed (P < 0.05) body weight at 35 d, possibly due to reductions in feed intake. Both intestinal villi height and goblet cell numbers per villus were increased (P < 0.05) in birds fed MOS or MAV at d 26. MOS also increased (P < 0.05) cecal lactobacilli and bifidobacteria populations in contrast to VIRG, but E. coli loads were not different among all dietary treatments. In conclusion, under conditions of this study, MOS conferred intestinal health benefits to broilers by increasing beneficial bacteria populations, villi height and goblet cell numbers of the intestines. Therefore, dietary MOS may alleviate the detrimental effects of sub-optimal growing conditions on broiler productivity and health.

Key Words: mannan oligosaccharide, antibiotic, gut microflora, environmental stress, broiler

199 Performance of layers fed Original XPC during elevated environmental temperatures. J. Broomhead¹, W. Michael*¹, and K. Anderson², ¹Diamond V, Cedar Rapids, IA, ²North Carolina State University, Raleigh.

Eleven white and 7 brown strains (approximately 21 weeks of age; 13 replicates per dietary treatment per strain; n = 468) were utilized to determine the effects of feeding Saccharomyces cerevisiae fermentation product (Diamond V Original XPC) to laying hens during periods of elevated temperatures on egg production, size and quality. Hens were fed 0 or 0.75 kg XPC/metric ton. The average maximum daily temperatures in Salisbury, North Carolina for June, July, and August, 2010 were 90, 91, and 89°F, respectively. Egg weight and size were recorded monthly from all eggs collected during a 24 h production period. Percentages of eggs within each size category and egg quality was determined using USDA standards. Data was analyzed separately for white and brown strains using a SPLIT- PLOT design in JMP. For white and brown strains, hen day and hen housed production, average egg weight and percentage of extra large plus large eggs (XL+L) was greater (P < 0.05) for hens supplemented with XPC during July and overall (June, July, and August). Percentage of medium size eggs and feed conversion (feed intake/egg mass) were lower (P < 0.05) for white and brown hens supplemented with XPC during July. Percentage of grade A eggs was higher with XPC supplementation for both white (P < 0.05) and brown (P < 0.08) hens overall. White strain hens supplemented with XPC had greater feed intake and lower percentage of check eggs during overall summer months (P < 0.05). In July, percentages of grade A eggs increased (P < 0.05) and check eggs decreased (P < 0.05) in white hens fed XPC. Period by XPC treatment interactions were observed (P < 0.05) in hen day and hen housed production for brown hens, egg weight and XL+L eggs for white hens, and feed conversion and medium eggs for both groups of hens. Results indicate that supplementation of Original XPC during elevated environmental temperatures can improve egg production, size and quality in white and brown strains of laying hens.

Key Words: layers, Saccharomyces cerevisiae fermentation product, heat stress, egg production

200 Efficacy of Sympatic (Bacillus subtilis QST 713) in broiler chickens for growth promotion and control of necrotic enteritis. D. R. Jimenez,* G. B. Tactacan, J. K. Schmidt, and M. J. Miille, AgraQuest Inc., Davis, CA USA.

There is significant pressure from global regulatory agencies to identify opportunities to reduce antibiotic usage and maintain the effectiveness of specific drugs through the development of alternative treatment options for animals. Bacillus-based probiotics represent a significant opportunity to address this issue. Bacillus subtilis QST 713 is the active ingredient in several registered and trademarked products that are sold internationally. Studies were designed to obtain data on the effects of feeding diets containing various levels of Bacillus subtilis QST 713 in broiler chickens using simulated commercial pens to evaluate growth, feed conversion, and weight gain. Table 1 shows data from a non-challenged pen study recently completed at Southern Poultry Research. In this study the feed conversion and weight gain were not significantly different from birds treated with a commonly used antibiotic growth promoter (AGPs) or 2 other direct fed microbials. Additional studies have recently been completed in battery cages to evaluate the effect of Bacillus subtilis QST 713 in birds challenged with Eimeria maxima oocysts, live coccid vaccine, and infectious Clostridium perfringens. Mean weight gain, feed consumption, feed conversion, and mortality showed a similar trend. Real-time PCR has been used to verify the dose dependent effect of QST 713 treatment and detect changes in the populations of lactobacillus as well as other commensal flora. Feed conversion, weight gain, and NE lesion score generally show a positive dose response to a range of QST 713 formulations and treatments. Additional work has shown QST 713 to be safe and efficacious when used in combination with commonly used coccidiostats, and AGPs. A growing body of work is showing that QST 713 is an efficacious, cost effective option to antibiotic growth promoters when used in the conventional broiler chicken production systems, worldwide.

Table 1.

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LSD: 0.050.

Key Words: Bacillus, probiotics, antibiotic growth promoters, Clostridium, direct fed microbial

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Beneficial effects of Lactobacillus bulgaricus broiler production have been reported and many strains of Lactobacilli are utilized in direct-fed microbial or probiotic products. This study was conducted to investigate probiotic mechanism of 2 Lactobacillus strains using gnotobiotic chicks. All birds (Ross308) were hatched as germ-free chicks in 4 gnotobiotic isolators from jejunum tissues collected at d-14 and used for qPCR quantification of gene expression (IL-1, IL-6, IL-8, MUC2, PCNA, TLR2, TLR4, SGLT-1, PepT1) relative to average of PRDX6 and GAPDH. Data were analyzed by ANOVA with 4 treatments including BS alone (BA), BS plus R19/R32 (BL), conventionalized (CV) and conventionalized plus R19/R32 (CL). Means were separated by Tukey’s HSD test. Final body weight was highest (P < 0.05) in both R19/R32 inoculated groups. R19/R32 also increased relative liver weight (P < 0.001). Conventional microbiota increased relative liver weight (P < 0.001), bursa weight (P < 0.01) and length of small intestine (P < 0.01). R19/R32 reduced expression of TLR2 (P < 0.05), TLR4 (P < 0.001), MUC2 (P < 0.05) and PepT1 (P < 0.05). Conventionalization increased PCNA (P < 0.01), IL-1 (P < 0.05) and IL-8 (P < 0.001) significantly higher. In contrast, R19/R32 decreased expression of IL-1 (P < 0.05) and IL-8 (P < 0.06). In conclusion, Lactobacillus reuteri R19 and R32 improved body weight gain of young broilers in combination with Bacillus subtilis alone or a conventional microbiota. Gene expression analysis suggests R19/R32 may improve growth by lowering inflammatory response.

Key Words: broiler, germ free, Lactobacillus

Supplementation of direct fed microbial as an alternative to antibiotic on growth performance, immune response, microbial population, and ileal morphology of broiler chickens.

An experiment was conducted to investigate the supplementation of direct fed microbial (DFM) as an alternative to antibiotic on growth performance, immune response, cecal microbial population, and ileal morphology of broiler chickens. A total of 800 1-d-old straight run broiler chicks (Ross x Ross) were randomly allotted to 4 dietary treatments with 4 replicate pens per treatment (50 birds/replicate pen) for 35 d. The 4 dietary treatments are: a corn-soybean meal diet (Control); 0.1% virginiamycin, as an antibiotic growth promoter (AGP); 0.1% direct fed microbial which contained Lactobacillus reuteri (DFM 1); and 0.1% direct fed microbial which contained a mixture of Lactobacillus reuteri, Bacillus subtilis and Saccharomyces cerevisiae (DFM 2). Results showed that dietary AGP and DFM supplementation significantly increased (P < 0.05) the BW gain of broilers during 0 to 21 d. The feed intake was reduced, while the feed conversion was improved significantly when birds were fed DFM 2 at 0 to 7 d of age. The white blood cell and monocyte levels were significantly higher in DFM 2 group compared with control. In addition, feeding DFM significantly (P < 0.05) increased the plasma immunoglobulin levels where higher concentration was observed in DFM 2 as compared with those of the other treatments. Neither DFM nor AGP treatments affected the cecal Lactobacillus and Salmonella content; however, cecal E. coli content significantly decreased in broiler chickens fed DFM and AGP. The ileal villous height, width and total thickness of muscularis externa were significantly increased when birds were fed DFM compared with AGP and control. These results indicate that the dietary supplementation of DFM increases the growth performance of birds at an early age, stimulates immune response, decrease the number of E. coli, and improves the ileal morphology of broiler chickens. Thus, DFM could be a viable source of alternative to antibiotics in the broiler diets.

Key Words: direct fed microbial, growth performance, immune response, intestinal morphology, broiler chickens

Effect of two strains of Lactobacillus on morphological characteristics and gene expressions of 14-day-old chicks in conventional and germ-free environments.


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Dose response of an essential oil blend in young broilers fed rye wheat based diet. F. Yan,* J. Dibner, M. Vazquez-Anon, and C. Knight, Novus International Inc., St. Charles, MO.

A total of 504 male broilers were used in a battery study to evaluate effect of a synthetic 1:1 thymol carvacrol blend (NEXT ENHANCE 150, a trademark of Carotenoid Technologies, S.A.) on growth performance and gut health of broilers fed rye wheat based diet and challenged with mixed species of Eimeria on d 0. A rye wheat and soybean meal based diet was formulated to meet or exceed nutrient requirements of broilers. To this basal diet, the essential oil blend was added at various levels to provide 0, 15, 30, 60, or 120 ppm essential oils, in which half was thymol and half was carvacrol. BMD at 50 g per ton and a nonstarch polysaccharides (NSP) degrading enzyme cocktail (xylanase, β-glucanase, and α-galactosidase; CIBENZA CSM, Novus International, Inc.) at 500 g per ton served as positive controls. Each diet was fed to 9 replicate pens of 8 birds from 0 to 29 d of age. Growth performance was measured at d 7, 13, 21, and 27. Serum uric acid and α-1 acid glycoprotein on d 12, ileal Clostridium perfringens on d 14, plasma glutathione peroxidase activity on d 15, ileal Lactobacilli on d 28, and digesta viscosity on d 29 were determined. Essential oil blend increased weight gain and feed intake of broilers when dosed at 15, 30, or 60 ppm, whereas BMD and NSP enzymes significantly increased weight gain, feed intake and improved FCR (P < 0.0001). Digesta viscosity was reduced only by NSP enzymes (P = 0.0074). Ileal Lactobacilli was increased by essential oil in a quadratic dose dependent manner and by NSP enzymes, whereas BMD decreased ileal lactobacilli in comparison to essential oil or NSP enzymes (P = 0.0008). Serum uric acid, α-1 acid glycoprotein, and plasma glutathione peroxidase activity were not significantly affected by dietary treatments (P > 0.05). The study demonstrated that essential oil, NSP enzymes, and antibiotic all have potential to improve overall growth performance of broilers in the face of gut health challenges, but through different mechanisms.

**Key Words:** broiler, gut health, essential oil