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ABSTRACTS
2017 International Poultry Scientific Forum
Georgia World Congress Center, Atlanta, Georgia
January 30-31, 2017

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SYMPOSIA AND ORAL SESSIONS

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ABSTRACTS
2017 International Poultry Scientific Forum
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Milton Y Dendy Keynote Address

B-313 An Optimist's View on How We Will Maintain Broiler Gut Health and Performance in Today's NAE, Food Safety and FDA Regulatory Climate Charles Hofacre, *University of Georgia, Athens, Georgia, USA*

We have been growing broilers with the aid of antibiotics for over 40 years. These drugs have helped the broiler industry maintain the birds' intestinal health by many different bacteria insults but primarily *Clostridium perfringens*. There are many reasons broiler companies may choose to no longer routinely feed antibiotics in their broiler diets. There are also the new FDA regulations that remove the label claim for many antibiotics for performance enhancement, however, the labels allow for use in disease prevention. All of these changes may result in less routine use of in feed antibiotics.

I believe what this means is the broiler producers may have to evaluate alternative non-antibiotic products to maintain broiler intestinal health, alter production practices to lessen the intestinal insults and help educate their growers to what they can do to maintain performance and health without the routine antibiotic use. In addition, we still need to answer the question of whether the reduction in antibiotic use may result in greater intestinal disease resulting in greater levels of *Salmonella* and *Campylobacter* coming to the processing plant. We will discuss the antibiotic alternative products, the husbandry requirements and the impact of going to a no antibiotics ever program on bird health, performance and food safety.

*Author presenting paper

GS Denotes Graduate Student Competition
UG Denotes Undergraduate Presentation

Physiology

M1 The mRNA expression of the kappa opioid receptor in the pituitary and ovary of broiler breeder hens. Ashley Stephens*^{GS}, Martha Freeman, Adam Davis *University of Georgia*

The neuropeptide dynorphin (Dyn) is translated as preprodynorphin (Pdyn) and undergoes post-translational modification to its mature form, Dyn. Evidence suggests that Dyn acts through its receptor, the kappa opioid receptor (KOR), to negatively impact gonadotrophin-releasing hormone (GnRH) release in mammalian species. Previously our laboratory assessed Pdyn mRNA expression in pituitary and ovarian tissue of broiler breeder hens. Pdyn mRNA was detected in the pituitary as well as the ovary. Follicular expression was exclusive to granulosa cells with highest expression in the F1 follicle and the prehierarchical follicles. Thus, Pdyn could have an impact on follicular development. In order to elucidate potential functions of Pdyn, the current research assessed the mRNA expression of its receptor, KOR, in the pituitary and in the theca and granulosa tissues of preovulatory follicles of broiler breeder hens, 5 and 72 hours post-feeding. Individual theca and granulosa layers were separated from the F1-F4 follicles. Theca and granulosa cells were enzymatically separated from one another in the nonhierarchical follicles which were pooled by size into small yellow (5–12 mm in diameter) and large white (2–5 mm in diameter) follicle categories. The isolated theca and granulosa cells from each follicle size from 2 birds were combined to create 5 replicate samples for each cell type from each follicle size and post-feeding period. Likewise, the pituitary from 2 birds was combined to create 7 replicate samples for each post-feeding duration. Total RNA was extracted from the samples and DNase treated for 2-step real-time PCR analyses of KOR and GAPDH (control) mRNA expression. Taqman minor groove binding probes and primers for each gene were designed using Primer Express (Version 2.0, Applied Biosystems). While KOR mRNA was detected in the pituitary tissue, its expression did not differ based on fasting duration. In the F1 and F2 follicles, KOR mRNA was detected only in the theca of the F1 follicle 5 hours post-feeding whereas at 72 hours post-feeding, it was expressed only in the granulosa of the F1 and F2 follicles. Given that Pdyn and KOR mRNA are both detected in follicular tissue, the results suggest that locally produced Pdyn could regulate follicular development.

Key Words: granulosa, theca, pituitary, dynorphin

M2 The impact of a dietary yeast fermentation product derived from *Saccharomyces cerevisiae* on semen quality and semen microbiota of aged White Leghorn roosters Midian Nascimento dos Santos*^{GS}, Reshma Ramachandran, Kelley Wamsley, Aaron Kiess, Christopher McDaniel *Mississippi State University*

Dietary supplementation of yeast fermentation products (YP) derived from *Saccharomyces cerevisiae* has been examined in broilers and laying hens. However, limited information is available about the impact of YP on rooster reproductive performance. Thus, the objective of this study was to determine the effects of feeding different levels of YP on rooster semen quality and semen microbiota (yeast and bacteria). A common basal diet was formulated to meet or exceed NRC recommendations. A commercially available YP was included at either 0, 0.5 (manufacturer recommendations), or 1.0% of the diet. Sand was included in these diets at either 1, 0.5, or 0%, respectively, to keep nutrients provided by the basal diet consistent. Individually caged White Leghorn roosters (n = 63), 60 wk of age, were divided equally among the 3 diets. Individual semen samples were collected

weekly (8 wk) and analyzed for the sperm quality index (SQI), semen volume, sperm concentration, and sperm viability. Biweekly, semen samples were serially diluted and spread plated to detect yeast as well as total aerobic bacteria. Regression and correlation analyses of semen characteristics with dietary levels of YP and with microbiota counts, respectively, were considered significant at $P \leq 0.10$. Dietary YP did not increase yeast per billion sperm ($P = 0.17$). However, as the dietary levels of YP increased, there was a linear decrease in the SQI ($P = 0.07$) but a linear increase in bacteria per billion sperm ($P = 0.07$). Additionally, yeast per billion sperm was positively correlated with bacteria per billion sperm ($P < 0.0001$, $r = 0.56$). The decrease in SQI may be a result of the increase in bacteria per billion sperm with supplementation of YP, because the SQI was negatively correlated with bacteria per billion sperm ($P < 0.0001$, $r = -0.30$). Additionally, the SQI is a measurement of overall sperm movement, and, because all other semen characteristics were unaffected by dietary treatments, YP may reduce the SQI by reducing sperm motility. However, interestingly, sperm concentration ($P < 0.0001$, $r = -0.36$), live sperm concentration ($P < 0.0001$, $r = -0.36$) and semen volume ($P < 0.0001$, $r = -0.25$) were negatively correlated with bacteria per billion sperm. Possibly the increased number of bacteria per sperm, as a result of YP supplementation, is detrimental to semen quality due to the bacteria itself or their toxins and products. In conclusion, it appears that YP supplementation has an indirect and negative effect on semen quality because of an increase of bacteria per sperm.

Key Words: Semen, Bacteria, Yeast, Sperm quality index, Spermatozoa

M3 Relationship between sperm-egg penetration and the duration of fertility in Chinese painted quail hens (*Coturnix chinensis*) Reshma Ramachandran*^{GS}, Midian Nascimento Dos Santos, Christopher McDaniel *Mississippi State University*

A better understanding of sperm storage and release from the oviductal sperm storage tubules could yield better fertility in the poultry industry. Chinese painted quail are an excellent model for poultry reproduction research due to their small size and rapid sexual maturity. However, information regarding the duration of fertility and the minimum number of sperm-egg penetration (SEP) holes for maximum fertility is not available for this species. Therefore, the objective of this study was to determine the duration of fertility and the minimum SEP holes required for maximum fertility. For 60 breeding pairs, males were removed after obtaining at least 3 eggs for SEP per breeding pair. Afterwards, eggs were collected daily, and, on alternate days, eggs were analysed for SEP and fertility until SEP was 0 for 3 consecutive days. For SEP analysis, the perivitelline layer was examined microscopically for sperm holes in a 1.35 mm² area of the germinal disc. Eggs for fertility analysis were incubated, candled at 10 d and examined for hatch residue analysis. Regression analyses were used to examine the relationships of fertility and sperm-egg penetration with days post-male removal. Prior to male removal, the population distribution of SEP holes in individual eggs was skewed greatly to the right and ranged from 0-1900 holes with a median of 72 and a mean of 192 ± 293 . Additionally, great variation was also seen in the SEP population distribution for hen averages which ranged from 0-977 holes with a median of 105 and a mean of 181 ± 224 . A quadratic decline in SEP over days post-male removal was obtained, beginning at approximately 300 SEP holes and declining to 0 holes by 9 d. However, fertility declined linearly over days post-male removal, beginning at 95% and reaching 0% by 9 d. Therefore, the duration of fertility

was 9 d, and the minimum SEP for > 95% fertility was approximately 75 holes. In conclusion, Chinese painted quail appear to require more SEP to attain maximum fertility when compared to other avian species. It is possible that because such a large number of sperm are required to insure fertilization that, with each ovulation, the hen may release an excessive number of sperm from the sperm storage tubules, making sustained sperm storage very inefficient.

Key Words: Sperm-egg penetration, Fertility, Sperm storage, Hen, Chinese painted quail

M4 Evaluation of the role of maternally derived antibodies on the immunomodulatory capacity of Original XPCTM in broilers Juan Suarez Martinez^{*GS1}, Wen Chou¹, Rachel Blount¹, Luc Berghman¹, Donald McIntyre², Hilary Pavlidis², John Carey¹ ¹Texas A&M University; ²Diamond V

The poultry industry is currently searching for new strategies to maintain production levels while eliminating the use of antibiotics and maintaining bird health. This is a result of media and consumer pressure to limit the use of antibiotics in food production. The functional metabolites of Diamond V Original XPCTM (XPC) has been identified by our lab as a potential strategy to combat the problems faced in antibiotic free production. The objective of this study was to evaluate the role of maternally derived antibodies on the immunomodulatory capacity of XPC on antigen-specific humoral immune response in broilers. One-day old Ross 308 broilers (180) were randomly assigned to a factorial arrangement of three vaccination protocols and two diets (XPC or control (CON)). In the first protocol broiler chicks were immunized with live Newcastle Disease Virus (NDV) B1 strain vaccine at day 1. In the second protocol broiler chicks were vaccinated with live LaSota strain NDV vaccine at day 1. Both protocols received a secondary immunization with live LaSota strain NDV vaccine at day 21. Protocol three consisted of delaying immunizing the chicks until the level of maternal antibodies decayed below 2000 NDV titer level. Once the level of maternal antibodies was verified, broilers were immunized with live LaSota strain NDV vaccine. Antigen specific humoral immune response was assessed by NDV-specific IgY using ELISA on days 1, 7, 14, 21, 28, and 35. Cumulative feed conversion ratio, feed consumption, and body weights were also assessed. NDV-specific IgY titers were significantly different ($P < 0.001$) on days 21 and 28 between XPC and CON groups, with XPC birds reaching a higher and faster titer level one week post-secondary immunization in protocol 1. Protocol 3 resulted in birds reaching the highest NDV-titer level during the trial with XPC birds reaching a significantly higher NDV-titer level than CON birds ($P < 0.001$). No significant differences were observed between XPC and CON birds in protocol 2 and both reached the lowest NDV-titer level observed in the trial. Feed conversion was significantly higher ($P < 0.05$) in both treatments from protocol 3 compared to protocols 1 and 2. There were no significant differences observed in body weights or feed consumption between XPC and CON. Overall, the results indicate that the use of XPC favorably modulated the broiler immune system against NDV specific adaptive immunity. The level of maternal derived antibodies appeared to have a role on the impact of Original XPC on the adaptive immune system which is consistent with previous data from our lab.

Key Words: Original XPC, Newcastle Disease, antibody titers, maternal antibodies, broilers

M5 Relationship between 4 day percentage breast yield and incidence of woody breast and white striping muscle myopathies Sara Orłowski^{*GS}, Joseph Hiltz, Barbara Mallman, Nicholas Anthony *University of Arkansas*

Embryonic and early post hatch muscle development and growth is primarily through hyperplastic growth and accumulation of nuclei through satellite cell contribution. Post hatch, muscle development transitions from hyperplasia to hypertrophic growth of fibers. Commercial selection for breast yield traditionally occurs at ages targeting hypertrophic rather than hyperplastic growth. This has resulted in the production of giant fi-

bers and concomitant challenges regarding muscle myopathies including woody breast and white striping. It has been hypothesized that selection for breast yield during the hyperplastic growth phase will result in an increase in the number of muscle cells and the number of nuclei at hatch and potentially impact muscle characteristics at processing ages. The current study investigates the relationship between 4 day percentage breast yield and incidence and severity of the woody breast and white striping myopathies based on sire family relationships in a randomly mated modern commercial broiler population. Average 4 day percent breast yield was calculated for 24 sire families (n=12 per sire family) over two separate hatches and separated into High (highest yielding 8 families $\geq 3.6\%$), Average (middle 8 families), and Low (lowest yielding 8 families $\leq 3.3\%$). A separate hatch of birds representing all 24 sire families was grown to 8 weeks of age, processed and evaluated for muscle myopathies. Throughout the growth period, the High sire family birds were heavier from 4 days to 6 weeks but the weight differences between the groups disappeared by processing day. The High sire families had the highest percent breast yield at 8 weeks (28.3 ± 0.2), while there was no difference between the Average (26.9 ± 0.2) and Low (26.8 ± 0.2) sire families. The High sire families also exhibited the most severe incidence of both woody breast (1.35 ± 0.08) and white striping (1.57 ± 0.06) when compared to the Average and Low sire families. There appears to be an association between early muscle growth and muscle characteristics at traditional processing ages.

Key Words: Broiler, Woody Breast, White Striping, Hyperplasia, Muscle Myopathies

M6 Broiler live performance and carcass yield is improved by dietary potassium and available phosphorous without an increased incidence of wooden breast. Matthew Livingston^{*GS}, John Brake *North Carolina State University*

Recent publications have described the abnormal meat quality characteristics of large fast growing broilers that exhibited wooden breast muscle (WBM). Previous studies have also found that broilers fed added dietary potassium (K) from potassium carbonate in the presence of greater levels of available phosphorous (AvP) exhibited a reduced incidence of WBM and improved live performance probably as the result of altered acid base balance as both of these ions have been reported to be intimately involved in the elimination of hydrogen ions that were produced during rapid growth. The present study was conducted to further investigate the interaction of dietary K and AvP observed in previous studies. The hypotheses was that broilers fed added K and AvP would exhibit similar or greater growth rate and live performance without detrimental effects on WBM. There were 512 Ross male broilers chicks distributed among 32 pens and fed a common starter diet to 14 d. From 15 d to 35 d they were fed four grower diets containing either 0.76% or 0.96% levels of K and 0.40% or 0.45% levels of AvP followed by finisher diets containing 0.76% or 1.06% levels of K and 0.35% or 0.41% levels of AvP in a 2 x 2 factorial design of differing levels of K and AvP. Carcass data and WBM scores were collected at 42 d while BW, BW gain, feed consumption, and FCR were collected weekly to 49 d. Broilers fed greater levels of dietary K exhibited greater ($P < 0.05$) BW, BW gain, and improved overall FCR at 49 d. Moreover, broilers fed the higher levels of both K and AvP exhibited greater ($P < 0.05$) breast muscle yield. WBM scores were improved ($P < 0.05$) at 42 d by added K. These data indicated that both added K and AvP supported a larger more efficient broiler without an increase in WBM.

Key Words: woody breast, meat quality, potassium, phosphorus

M7 Noni (Morinda citrifolia) modulates the expression of hepatic lipogenic genes in chronic heat stressed broilers Joshua Flees^{*UG}, Elizabeth Greene, Walter Bottje, Sami Dridi *University of Arkansas*

Heat stress (HS) is devastating for poultry production and sustainability from its strong adverse effects on growth performance, well-being, body composition, and intermediary metabolism. It has been reported that HS alters lipid metabolism in broilers, however the underlying molecular mecha-

nism is still unknown. As liver is the main site for *de novo* fatty acid synthesis (lipogenesis) in chickens, we aimed to determine, in the present study, the effect of chronic HS on the expression of hepatic lipogenic genes and to assess if the tropical medicinal plant Noni modulates these effects. Broilers (480 males, 1 d old) were randomly assigned to 12 environmental chambers; each divided into 2 pens with separate feeders and water lines. Chicks (20 per pen) were fed a corn-soy based diet (Control) or one containing 2 g dried Noni plant/kg feed (Noni) and brooded under thermoneutral conditions for 21 d. On d 22, temperature was increased to 35 C in 8 chambers and maintained for 3 wk, with the remaining 4 chambers maintained at 25°C. Randomly selected broilers (1/pen) were humanely euthanized (cervical dislocation) and liver samples flash frozen in liquid nitrogen for subsequent gene expression analysis. Expression of specific hepatic lipogenic genes was carried out by real-time quantitative polymerase chain reaction (qPCR). Data were analyzed by 2-way ANOVA with temperature and diet as the main effects. Means were compared by Tukey's multiple comparison test and considered significant at $P < 0.05$. HS down-regulated the hepatic mRNA expression of Fatty Acid Synthase (FAS), Acetyl CoA Carboxylase alpha-(ACC α), Malic Enzyme (ME), and ATP Citrate Lyase (ATP-CL) genes compared to TN conditions. This effect seemed to be independent of lipogenic transcription factor Sterol Regulatory Element Binding Proteins 1 and 2 (SREBP-1/2) and their cleavage regulatory protein (SCAP). The decrease in lipogenic gene expressions under HS was more pronounced in birds receiving the Noni-supplement diet. Further investigation is warranted to assess effects of HS and the Noni diet on lipogenic pathway protein expression and enzyme activity.

Key Words: heat stress, lipogenesis, noni, gene expression

M8 Evaluation of objective digital methods for determination of Pectoralis major muscle cross-sectional area for use in estimation of skeletal muscle fiber number Austin Lock^{*UG}, Kathryn Meloche, Jessica Starkey *Auburn University*

Increased demand for chicken breast meat has been largely responsible for the intense genetic selection of modern commercial broilers for genotypes exhibiting greater breast yields. Selection for breast meat yield has resulted in increases in both total fiber number and fiber cross-sectional area (CSA). Effective and efficient estimation of the total number of muscle fibers in the Pectoralis major (PM) muscle is essential to evaluating the impact of various nutritional and management strategies on broiler skeletal muscle development and growth. Because the fibers in the PM muscle do not run parallel to the length of the muscle, the accurate determination of the total number of fibers in the PM muscles of broiler chickens presents a challenge. To investigate digital imaging methods to efficiently determine the CSA of PM muscles still attached to the bone, PM muscles of 14-d-old broilers were cut perpendicular to the direction of the myofibers, painted with purple dye, and blotted onto tissue paper. Blots were then photographed with a ruler to facilitate image software calibration. Three digital methods were used to determine the CSA of the PM muscles from the blot images ($n = 72$). Digital image analysis methods chosen for comparison were: 1) a Nikon Elements software macro created to produce an automated binary image CSA analysis method (AUTO); 2) ImageJ software using a researcher to determine the blot boundaries for inclusion in the CSA calculation (IMJ);

3) GIMP2 software used to overlay a 1 cm x 1 cm grid on the blot image which were then enumerated by a researcher to facilitate the calculation of CSA for each blot (GRID). Researcher was not a significant fixed effect ($P > 0.05$) and the variation in CSA was similar among all methods. Both the IMJ and GRID methods and returned lower CSA values compared to the AUTO method ($P < 0.0001$). The length of time required to analyze each image was significantly reduced by using the AUTO method which took 10.6 s per image compared to both IMJ and GRID which required 40.8 and 50.2 s per image, respectively ($P < 0.0001$). Overall, the AUTO method is the most efficient objective digital method for determining PM muscle CSA and will be useful for our future research in the area of broiler muscle development and growth.

Key Words: digital image analysis methods, muscle fiber number, muscle cross-sectional area, broiler chicken

M9 Protein expression for zona pellucida protein B2 in two genetic lines of turkey hens that differ in fertility Josh Steed^{*GS}, Andrew Benson, Adam Davis *University of Georgia*

The ovulated ovum in avian species is surrounded by a protein layer called the inner perivitelline layer (IPVL). For successful fertilization, sperm must attach to and penetrate the IPVL. The IPVL contains the zona pellucida (ZP) family of proteins and members of this family of proteins possess sperm binding activity. In avian species the ZP protein(s) that serve as the sperm receptor have not been identified. Previously our laboratory characterized the mRNA expression of ZPB2 in granulosa cells from the germinal disc (GD) and nongerminal disc (NGD) regions of the F1 follicle in two lines of turkey hens selected for over 40 generations for either increased egg production (E line) or increased body weight (F line). The F line hens have lower fertility than E line hens and the expression of the mRNA for ZPB2 is greater in GD than in NGD granulosa cells. The goal of the present research was to determine if these differences in ZPB2 mRNA expression are reflected at the protein level in the IPVL layer which contains secreted proteins from the granulosa cells. Protein was isolated from GD and NGD sections of the IPVL of freshly laid eggs from eighteen, 46 week old hens from each genetic line. The individual GD and NGD sections were combined from 3 eggs for each line such that 6 replicate GD and NGD samples existed for each genetic line. One dimensional gel electrophoresis was performed using stain free technology, and subsequent gels were transferred to PVDF membranes for Western blot analysis. A polyclonal antibody (rabbit-anti-chicken) against ZPB2, and a HRP conjugated secondary antibody (goat-anti-rabbit) were used for the Western blot analyses. Chemiluminescent detection in combination with Chemidoc XRS+ software was used to quantify relative ZPB2 expression with protein normalization and volume analysis performed using Image Lab Software (BioRad). Protein expression of ZPB2 in the IPVL was significantly greater in GD than NGD regions. There was no difference in the overall protein expression of ZPB2 in the IPVL of F and E line eggs. The results suggest that the higher protein expression of ZPB2 in the GD region of the IPVL may account for the preferential binding of sperm at the GD and that ZPB2 is a component of the sperm receptor in avian species.

Key Words: fertilization, sperm receptor, follicle

Processing & Products I

M10 Effects of divergently selected broiler lines on meat color and aerobic microbial growth under simulated retail display Famous Yang^{*GS}, Sara Orlowski, Fred Pohlman, Nicholas Anthony *University of Arkansas*

Meat quality abnormalities such as pale, soft, and exudative (PSE) meat and dark, firm, and dry (DFD) meat have been shown to affect meat quality attributes. The purpose of this study was to compare the effect of genetic selection for PSE/DFD-like conditions on meat color and aerobic microbial

growth under simulated retail display. An experiment was conducted in two trials and the results were combined. The broiler lines used were a random bred control (RBC), high L* (HMC), and low L* (LMC) meat color lines. Broilers were reared to 6 weeks of age, processed and deboned at 4 h post-mortem. Whole boneless skinless breasts were selected from each line and meat pH was measured at 24 h postmortem. Breasts were weighed, packaged, displayed under simulated retail conditions, and sampled on days 0, 1, 2, 3, 4, and 6 for instrumental color. Aerobic plate counts (APC) were sampled on days 0 and 6 of display. The HMC line had the lowest pH and

the LMC line had the greatest pH. There was a difference in instrumental color between all broiler lines; most notably, HMC was lighter (L^*), least red (a^*), yellower (b^*), and greater in hue angle [$\tan^{-1}(b^*/a^*)$] and in saturation index [$(a^{*2}+b^{*2})^{0.5}$] than the other lines. On the other hand, LMC was darker, redder, and lower in hue angle than the other broiler lines. Oxy-myoglobin proportion differed by broiler line with LMC being highest, and HMC lowest. Display day also had an effect on instrumental color with L^* greater at day 0 and 1, a^* greater at day 4 and 6, b^* greater at day 4 and 6, hue angle greater at day 6, and saturation index greater at day 4 and 6. The LMC and RBC lines had greater APC than HMC. In addition, there was a line by display day interaction for APC with LMC having greater CFU/g, RBC having intermediate CFU/g, and HMC having the lowest CFU/g at display day 6. Broiler lines selected for PSE or DFD condition respond differently in both meat color and aerobic microbial growth under simulated retail display.

Key Words: meat color, broilers, pH, microbial growth, retail display

M11 Higher stocking densities decrease turkey performance without altering meat quality Carol Wu^{*GS}, Matthew Livingston, Hernan Cordova-Noboa, Albaraa Sarsour, Brooke Bartz, Ken Anderson, Edgar Oviedo-Rondon, Jesse Grimes, Kimberly Livingston *North Carolina State University*

Consumers are concerned for the well-being of animals raised for meat production. However, some in the livestock industries are concerned that significant changes in production systems to improve animal welfare will deleteriously impact animal performance and meat quality. Poultry stocking density is at the center of this conundrum as increasing space per bird may reduce facility revenue; yet increased space may improve the birds' performance and consequently the meat quality. Therefore, we investigated how 4 different stocking densities (4.56 (T1), 4.18 (T2), 3.8 (T3), 3.42 (T4) ft²/bird) affected turkey performance and meat quality. Male poults (960) were obtained from a Butterball hatchery (Goldsboro, NC) the day of hatch. Poults were randomly assigned to pens representing 1 of 4 treatments with 4 replicate pens/treatment and 60 poults/pen. From 0-5 weeks of age, all birds were reared at the same density. Density treatments began at 5 weeks of age that were obtained by changing pen size thereby holding the pen population constant. All pens were provided with the same typical commercial feed rations and had the same feeder and water space per bird. Birds and feeders were weighed at 0, 5 and 20 weeks of age to determine body weight (BW), BW gain, feed intake (FI), and feed conversion ratio (FCR). In addition, 12 birds per treatment (3/pen) were harvested to determine hot carcass weight, carcass cut up yield (breast major, breast minor, legs, thighs, wings, breast skin, and carcass frame), 24 h pH, 72 h drip loss, and cook loss. All data were analyzed utilizing the general linear model procedures in JMP[®] (SAS, Cary, NC). A linear regression of stocking density on BW and FCR was used to determine the effect of density on performance. During the trial, there was no difference in FI. However, based on these equations (FCR: $2.226-0.0298*FT$, BW: $17.215+0.568*FT$) as stocking density was decreased (i.e. ft²/bird increased), BW ($P<0.05$) and FCR ($P=0.08$) improved. Interestingly, increased stocking density did not adversely affect carcass yield, carcass cut up yield, 24h pH, drip loss or cook loss ($P>0.05$). In conclusion, as density is decreased for turkeys, performance is improved. However, there were no deleterious effects of stocking density on meat quality.

Key Words: turkey, stocking density, performance, meat quality

M12 Impact of scalding duration and scalding water temperature on broiler processing wastewater loadings Caitlin Harris^{*GS1}, Kevin Gottilla¹, Dianna Bourassa², Jeff Buhr³, Brian Kiepper¹ *¹University of Georgia; ²Auburn University; ³USDA-ARS US National Poultry Research Center*

The effects of scalding water temperature and immersion time on impact to poultry processing wastewater (PPW) loading were evaluated following the slaughter of commercially raised broilers. Based on previous research,

the hypothesis was that immersion time would have a significant impact on PPW loading compared to water temperature. On 3 separate weeks (trials), feed withdrawn broilers were weighed, shackled, electrically stunned, and bled for 2 min ($N = 240$ broilers, 80 broilers/trial). During each trial, 20 broilers were assigned to one of four immersion scalding temperature/time protocols: Hard Scald/Short Time (60°C for 1.5 min), Hard Scald/Long Time (60°C for 3 min), Soft Scald/Long Time (53°C for 3 min), or Soft Scald/Short Time (53°C for 1.5 min). Each batch was scalded in 3 successive scalding tanks set at the same temperature. Immediately following each treatment batch, a representative 1L sample of PPW from each 740L scalding tank was collected and placed on ice. The water in each scalding tank was emptied, the tanks rinsed, refilled, and reheated between each batch. All samples were stored at 4°C and analyzed for concentration (mg/L) of chemical oxygen demand (COD), total solids (TS) and total suspended solids (TSS). Resulting concentration data were used to calculate the corresponding PPW load value in grams per kilogram of live weight (g/kgwt). Post-feed withdrawal mean live weights for the 3 trials were 2.321 kg, 2.496 kg, and 2.546 kg. Results showed that the mean TS PPW load in scalding Tank 1 produced during the Long Time treatments (2.580 g/kgwt) was significantly ($P\leq0.05$) higher than the Short Time treatments (1.770 g/kgwt). No other significant differences were found when comparing temperature or time treatments for any of the parameters tested. Scald tank position within the 3-tank sequence also had a significant impact on PPW loading. In all treatments combined, the first scald tank had significantly ($P\leq0.05$) greater COD (1.056 g/kgwt), TS (2.177 g/kgwt) and TSS (0.384 g/kgwt) mean loading compared to the second and third scald tanks, which were not significantly different from each other. Results confirmed the hypothesis that scalding immersion time (3 vs. 1.5 min) has a significantly greater impact on TS PPW loading rates than water temperature.

Key Words: wastewater loading, immersion scalding, scalding temperature, immersion time

M13 Identification and characterization of antimicrobial resistance of Campylobacter from shell eggs from different commercial laying hen housing systems Estefania Novoa Rama^{*GS1}, Matthew Bailey¹, Deana Jones², Richard Gast², Kenneth Anderson³, Jagpinder Brar¹, Rhonda Taylor¹, Manpreet Singh¹ *¹Purdue University; ²USDA-ARS; ³North Carolina State University*

Campylobacter is a widely spread pathogen in poultry and the leading cause of foodborne illnesses worldwide, causing an estimated economic burden of \$1.9 billion only in the US. The objective of this study was to determine the effect of housing systems on prevalence and antimicrobial resistance of *Campylobacter* recovered from commercial laying hens. Environmental and eggshell samples were collected from 5 different housing types over a 15-month period. Eggshell samples were segregated based on laying location. Sample sites for environmental swabs included system wires, nest box and scratch pads. A total of 174 isolates were recovered from different housing types consisting: 53 isolates from enriched cages, 47 from free-range housing, 36 from cage-free housing, 20 from conventional cages and 18 from enrichable cage, and identified as presumptive *Campylobacter* spp. by serological tests. Biochemical identification followed by a real-time PCR assay confirmed 55% ($n = 96$) of isolates as *Campylobacter* spp. Hens from conventional cages had the highest *Campylobacter* prevalence (65%) followed by cage-free raised hens (61%), while those raised in enrichable cages had the lowest prevalence (44%). All confirmed isolates were tested for antimicrobial resistance following the antimicrobial dilution susceptibility testing method developed by the National Antimicrobial Resistance Monitoring System (NARMS) and resistance patterns were evaluated based on housing type. Susceptibility to antimicrobials was determined based on breakpoint levels established by the Clinical and Laboratory Standards Institute (CLSI). Overall, resistance to tetracycline was most frequently displayed among all *Campylobacter* isolates (57%), followed by clindamycin (2%) and telithromycin (2%). In a comparison of resistance patterns according to housing type, isolates recovered from conventional cages showed a higher resistance to tetracy-

cline (67%). Simultaneous resistance to two antimicrobials agents was only observed for 3% of isolates. Based on the results, housing systems do not appear to have any impact on antimicrobial resistance of *Campylobacter*, however, further relationship of the isolates and the housing types needs to be characterized to determine sources on shell eggs.

Key Words: *Campylobacter*, laying hens, eggs, Antimicrobial resistance

M14 Assessment of *Campylobacter* populations in broiler carcasses from a facility using organic and conventional processing methods Matthew Bailey*^{GS}, Rhonda Taylor, Jagpinder Brar, Carmen Velásquez, Estefania Novoa Rama, Manpreet Singh *Purdue University*

Foodborne infections caused by *Campylobacter* are an important food safety issue for the poultry industry, and estimates have placed this pathogen as one of the top causes of foodborne illnesses. Interventions to reduce *Campylobacter* during poultry processing, such as application of antimicrobials, are crucial to achieve a safer final product. In this study, two methods of processing (conventional and organic) were tested to compare the effect on presumptive *Campylobacter* populations in a commercial setting. Samples were collected from a commercial facility on 16 separate days over a 1-year period; 8 of these sampling days were during conventional processing and 8 were during organic processing. Fecal grab samples (n=5) were collected from incoming birds and carcass rinses (n=5) were collected at 7 different processing steps (total 35 carcasses). Presumptive *Campylobacter* populations were assessed by plate count method using Campy-Cefex agar, and populations for each processing method were compared at each processing step using general linear models. Incoming Campy-Cefex populations were higher ($p<0.05$) on conventional processing days ($3.7 \log_{10}$ CFU/mL) than on organic processing days ($2.8 \log_{10}$ CFU/mL). However, there was no difference ($p>0.05$) in populations between processing methods after chill, with both methods reducing populations to less than $0.4 \log_{10}$ CFU/mL for water- and air-chilled carcasses. These results demonstrate the equal effectiveness of conventional and organic processing methods for reduction of *Campylobacter* on broiler carcasses. Additionally, the drastic reduction in presumptive *Campylobacter* populations between the initial processing steps and the post-chill steps reinforces the importance of processing interventions in producing a safer product.

Key Words: *Campylobacter*, broiler, processing, organic

M15 Homologous stress adaptation, antibiotic resistance, and biofilm formation of *Salmonella* Heidelberg on different food-contact surfaces following exposure to sub-lethal chlorine concentrations Tomi Obe*^{GS}, Rama Nannapaneni, Chander Sharma *Mississippi State University*

This study tested the ability of *Salmonella enterica* serovar Heidelberg (ATCC 8326) to adapt to the homologous stress of sodium hypochlorite (chlorine) by exposing it to increasing concentration of chlorine in tryptic soy broth (TSB) starting at 125 ppm with 25 ppm daily increments. *Salmonella* Heidelberg demonstrated an acquired tolerance to chlorine with the adapted cells growing in concentrations up to 400 ppm of total chlorine in TSB. In addition, the chlorine stressed *Salmonella* Heidelberg cells (starting at 200 ppm and above) exhibited rugose morphology on tryptic soy agar (TSA) plates at 37°C. The MIC of chlorine for adapted (rugose and smooth) cells was determined to be 550 ppm and 500 ppm, respectively whereas the MIC for non-adapted cells was 450 ppm. The biofilm forming ability of adapted (rugose and smooth) and non-adapted cells was examined using standard crystal violet assay in 96 wells polystyrene microtiter plates and stainless steel coupons at 37°C and room temperature. The rugose cells, in contrast to the smooth variant (adapted and non-adapted), showed the ability to form strong biofilms ($p \leq 0.05$) on polystyrene plates at 37°C and room temperature. Rugose cells were able to form more biofilms as compared to smooth and control on steel surface as well. The antibiotics susceptibility patterns of adapted (rugose and smooth) and non-adapted cells was tested using 8 different antibiotics according to the CLSI guidelines. There was no difference observed in antibiotics resistance of adapted cells (rugose and smooth) as compared to control. The findings of

this study suggest that exposure to sub-lethal chlorine concentration during the cleaning and sanitization procedure can result in tolerant-*Salmonella* cells, which may attach strongly to food-contact surfaces.

Key Words: *Salmonella*, sodium hypochlorite, adaptation, rugose, biofilm

M16 Using image measurements of broiler carcass to identify severity of woody breast online Xiao Sun*^{GS1}, Barbara Mallmann², Dawn Koltes², Karen Christensen², Casey Owens² ¹Nanjing Agricultural University; ²University of Arkansas

Global attention has been drawn to the woody breast (WB) myopathy in modern poultry industry which is observed a distinct hardness of raw fillets. Developing methods to identify WB online would be valuable to the industry in efforts to sort product. This study was conducted to determine effectiveness of image measurements of broilers carcass surfaces to identify WB carcasses prior to deboning and additionally evaluate the relationship to live bird, carcass and fillet WB scores. Total 435 birds processed at 63d and deboned at 3h postmortem. Birds (n=274) were scored for WB of live birds (LWB), before evisceration (EWB) and the final WB score of deboned fillets, respectively. Before evisceration, individual carcass high definition images were collected using a digital camera and black background. Six features (F1 to F6) were measured using Image J software on each carcass image (F1: width of breast (cranial region); F2: length from base of tail to tip of keel; F3: length from central drum to breast; F4: width of breast from F3 point on breast; F5: distance between tip of keel and F4; F6: angle between F5 measurements, to describe the shape of the caudal breast tip;). In this study, whole breast fillets scored in 3 woody categories (NORM, MILD and SEV, n=30/group) were collected for breast weight and compression force (CF) measurement, all features of each corresponding carcass image were recorded as described before. The LWB and EWB highly correlated with WB score ($r=0.64$ and 0.78 , respectively; $P<0.0001$). Breast weight and F1 were greater ($P<0.05$) in SEV and MILD carcass than NORM. CF, F1, F4, and F6 were greater ($P<0.05$) in SEV than MILD and NORM which were also different ($P<0.05$). F2, F3 and F5 were lower in SEV than NORM ($P<0.05$) while MILD was intermediate. The results of this study suggest that WB may be identified on the carcass level using carcass imaging and therefore may potentially be used as tool for online detection for WB before deboning or further processing. However, more flocks representing various strains and ages also need to be evaluated.

Key Words: woody breast, broiler, vision grading, online detection, image

M17 Evaluating a novel bioelectric impedance analysis technology for the rapid detection of Wooden Breast myopathy in broiler breast filets Avery Kennedy-Smith*^{UG1}, Laura Bauermeister¹, Meredith Johnson¹, M. Keith Cox², Amit Morey¹ ¹Auburn University; ²Seafood Analytics

Currently, no rapid and objective measurement exists to detect the presence of Wooden Breast (WB) in poultry. This proof-of-concept research was conducted to evaluate the effectiveness of bioelectric impedance analysis (BIA) to distinguish between WB and normal broiler breast filets. Freshly deboned broiler breast filets (n=90) were obtained from a local processing plant and had been sorted into wooden and normal categories by plant workers. The filets were further re-sorted into the categories normal (N) and severely wooden (SW) by a trained technician using manual palpation methods. SW breasts were characterized by the tactile observation of excess cohesion and hardness throughout the filet. BIA values were obtained by applying a specialized Certified Quality Reader (CQR) for BIA on the ventral side of the filet. Cook loss was determined on filets by cooking to an internal temperature of 74° C. Filets were packaged individually and stored at 4° C overnight for texture analysis. Toughness was determined by using the TA.XT2i Texture Analyzer (Texture Technologies Corp., UK), equipped with a 50 kg load cell, and the BMORS method. Data was analyzed using ANOVA with Tukey HSD to determine significant differences at $P<0.05$. Filets categorized as SW and N had significantly ($P<0.05$)

different electrical impedance, cook loss and peak counts. This is the first study demonstrating that bioelectric impedance analysis can be used as a simple yet rapid method for the detection of WB in broiler filets.

Key Words: wooden breast, woody breast, bioelectric impedance, meat quality, meat texture

M18 Effect of extended deboning time and subsequent storage on the breast meat quality of fast-growing big broilers Meredith Johnson*, Avery Kennedy-Smith, Laura Bauermeister, Amit Morey *Auburn University*

Fast-growing big broilers breast muscle often exhibits wooden breast and white striping myopathies causing meat quality issues such as high cook loss, tough texture and lower marinade retention. Toughness of the meat and subsequent meat quality issues can also be due to unresolved rigor mortis and slow rate of post-mortem proteolysis. The objective of this study was to investigate the effects of extended deboning times and storage on the quality of broiler breast meat. Broiler breast fillets (total n=810) obtained from a local poultry processor included freshly deboned (2-3 h post slaughter) wooden and normal breast butterfly fillets from broilers >8 lbs, breast fillets from medium sized birds (6-8 lbs) as well as fillets deboned at extended post-slaughter times (16, 20 and 24 h). Fillets deboned at extended times (n=90/treatment) were stored at 4°C overnight. The left-side of the butterfly breast fillet was analyzed for color, cook loss and drip loss. Texture of cooked fillets was measured using the Blunt Meullenet-Owens Razor Shear (B-MORS) method. Statistical differences between the freshly deboned, extended deboned and stored fillets were determined using ANOVA with Tukey's LSD at $P < 0.05$. Data indicated that the wooden breast fillets had a higher cook loss than normal fillets and the ones from medium sized broilers. Texture (peak force and area) of the fillets from all the extended debone times was lower compared to the freshly deboned (2-3 h post-slaughter) breast fillets indicating tender fillets due to proteolysis. Results from the study can be used by the poultry companies to reduce the breast meat texture issues from fast-growing big broilers.

Key Words: Debone

M19 Utilization of ultrasonography as a tool to detect the wooden breast myopathy in live broilers Sergio Vieira*, Sergio Vieira, Liris Kindlein, Tamara Ferreira, Catarina Stefanello, Silvana Caldas, Gabriela Santiago, Natália Serafini *UFGRS*

The wooden breast (WB) is polyphasic myodegeneration and regeneration that leads to a variable amount of interstitial connective tissue accumulation and fibrosis in the breast muscle. An experiment was conducted to evaluate the effectiveness of utilizing ultrasound (US) images of breast muscle of broiler chickens subjected to different feed restrictions programs such that WB could be predicted in vivo. A total of 1,800 Cobb x Cobb 500 slow feathering male broiler chicks were placed in 72 floor pens using a completely randomized design with 6 treatments, 12 replicates of 25 birds each. Diets were pelleted and feed restrictions were of 50, 60, 70, 80, 90, and ad libitum from 8 to 49 d. All birds were evaluated by ultrasonography every week from 7 to 49 d with the US probe placed on the skin surface parallel to the keel as well as cranial and caudal to the ribcage. Mean gray values were calculated from the obtained histogram (black to white scale from 0 to 255, respectively) and breast depth. All birds were wing banded at hatch. At 14, 21, 28, 35, 42, and 49 d, 1 bird per pen was slaughtered and breast muscle was weighed when visual degrees of WB were provided by a 3 subject panel. Deboned breast fillets (*Pectoralis major*) were submitted to a 4 subject panel evaluation to provide scores of WB (0 = normal breast, 1 = mild hardening in the upper, 2 = moderate hardening in the upper and/or lower part of the fillet, 3 = severe hardening, and 4 = severe hardening with hemorrhagic lesions, increased volume, and presence of yellow fluid). Echogenicity of breast fillets increased with broiler age and also as WB severity increased ($P < 0.05$). The WB scores 3 and 4 presented higher ($P < 0.05$) echogenicity at 35, 42, and 49 d. Values of echogenicity at 35, 42, and 49 d were 81.0, 98.1, and 94.8 in breast fillets with WB score 4

whereas corresponding values for score 1 were 77.6, 86.8, 85.5, respectively. The WB score 0 was not observed at 35, 42, and 49 d. Correlations among WB scores and depth were 0.77, 0.65, and 0.61 at 35, 42, and 49 d, respectively ($P < 0.001$). Additionally, correlations between WB scores and echogenicity and WB scores and breast weight were 0.41 and 0.42 at 42 d and 0.43 and 0.49 at 49 d, respectively ($P < 0.05$). Ultrasound images can be utilized to predict the WB occurrence in broilers.

Key Words: broiler, feed restriction, myopathy, ultrasound, wooden breast

M20 Wooden Breast myopathy development in broilers subjected to feed restriction: growth performance, serologic profile, and meat quality Liris Kindlein*, Liris Kindlein, Sergio Vieira, Catarina Stefanello, Tamara Ferreira, Stella Valle, Cristina Simões, Vinícius Nickel *UFGRS*

A study was conducted to evaluate growth performance, WB occurrence, serum profile, meat quality parameters, and histomorphometric measurements of broiler chickens subjected to feed restriction and affected with different scores of WB myopathy. A total of 1,800 Cobb x Cobb 500 male chicks were placed in 72 floor pens, in a completely randomized design with 6 treatments, 12 replicates and 25 birds each. Birds were fed pelleted diets with six feed restrictions of 50, 60, 70, 80, 90, and 100% from 8 to 49 d. Birds and feed were weighed weekly to determine BWG and FCR. At 21, 28, 35, 42, and 49 d, 1 bird per replication (n = 360) was slaughtered and given visual WB scores (0 = normal breast, 1 = mild hardening in the upper, 2 = moderate hardening in the upper and/or lower part of the fillet, 3 = severe hardening, and 4 = severe hardening with hemorrhagic lesions, increased volume, and presence of yellow fluid). In the overall period and weekly, the BWG, carcass and commercial cuts yield decreased linearly ($P < 0.05$) with the feed restriction. From 8 to 49 d, the FCR was higher ($P < 0.05$) when broilers were fed with 50 and 60% of feed consumption compared to 70, 80, 90%, and ad libitum feed consumption. Wooden breast presented linear responses to performance variables and decreased in broilers submitted to higher feed restrictions. Scores 3 and 4 presented higher cooking loss and minimum fiber diameter ($P < 0.05$) when compared to the normal breast meat from 21 to 49 d. Normal breast fillets had lower fiber density (fibers/cm²) compared to the WB score 3 and 4 ($P < 0.05$). At 42 d, shear force (MORS) and shear energy (MORSE) decreased ($P < 0.05$) in breast fillets with score 2, 3, and 4 when compared to WB score 0. Higher enzyme concentrations ($P < 0.05$) were observed with scores 3 and 4 when compared to WB score 0. Increasing feed consumption improved performance and carcass traits as well as induced the severity of WB. In conclusion, the increased severity of WB resulted in breast fillets with higher serum CK, ALT, and LDH concentrations, cooking loss, and minimum fiber diameter in broilers from 28 to 49 d. Determinations of serum enzymes can be also used to predict the WB occurrence in broilers.

Key Words: breast meat, broiler, fiber diameter, serum enzymes, wooden breast

M21 Poultry industry and cultural tour of Spain: international experience through an embedded course in the college of agricultural sciences. Nuket Acar*, Paul Patterson, Michael Hulet, Jaime Prudencio *The Pennsylvania State University*

The agricultural workforce is more diverse than ever; thus, providing our students global and cultural opportunities are a must. The goal of this Animal Science course at Penn State was to provide student participants a deeper understanding of the poultry industry in Spain as part of the E.U.; to spark an interest in the host country and its culture; and, to heighten their confidence in traveling abroad. Overall 7 undergraduate and 3 graduate students enrolled in the 2-credit course which included 15 weekly lectures with a 10-day travel component in Spain. Before the trip we discussed commercial and backyard poultry production practices in the U.S. versus Spain; agricultural traditions; and Spanish history, religion, and language. The student participants were required to choose a cultural and poultry industry related topic to both write a term paper and to give an oral presenta-

tion following the trip as part of their course grade. Madrid and Barcelona were the beginning and ending cities for the study tour while we visited Toledo, the Basque Region: Vittoria-Gasteiz, Donostia, Guissona, and Tarazona for their significant egg and broiler production, feed mill operations, and agricultural commodities. Private industry, government, and university representatives showcased their poultry and research facilities in these regions. It was valuable to compare commercial poultry facilities to small layer and meat bird farms in the outskirts of these major cities and rural areas. The “cassero” living concept is still favored by small scale meat/egg production units in rural regions, like the Basque country. A post trip questionnaire indicated that 3 out of 10 participants never had a travel abroad experience before this trip. Three of the 10 participants spoke moderately well Spanish while 2 others had some skills in Spanish. Eighty percent of students expressed a strong interest in traveling to another country related to work or pleasure but not necessarily long-term working and/or living abroad. One student is taking an advanced level Spanish course towards a minor in Spanish following the trip. The students expressed 100 percent satisfaction with the trip and a positive attitude and openness towards other cultures. There has been a 58% increase in taking study abroad courses for the last 10 years in our college which clearly shows that our students are eager to gain global competency. Overall, student participants expressed gaining significant benefit from this short-term study tour in terms of having “increased appreciation for other cultures, confidence in traveling abroad, and interest in returning and exploring Spain and/or Europe further in the future”.

Key Words: Spain, study tour, poultry industry, global competency

M22 MSU Poultry Science takes New Zealand! Mary Beck*, G. Tabler, Kelley Wamsley, Aaron Kiess *Mississippi State University*

In May, 2016, four faculty members took 8 students (7 undergrads and 1 grad) to New Zealand on a 3-cr Maymester Study Abroad. Why New Zealand? New Zealand (NZ) is unique in the world in being free of the three major exotic poultry diseases – Avian Influenza, Newcastle Disease and Infectious Bursal Disease (IBD) – which makes it one of the healthiest places in the world to raise chickens. In addition, commercial production practices differ considerably from the U.S. and the mix of English and Maori cultures is unique and fascinating. Pre- and post-discussions, journals, and term papers ensured a sound base of knowledge of our systems and provided a good evaluation of student learning and self-discovery. Christchurch was the beginning of the tour and Auckland the end. Elements of the tour included meetings at 2 universities (Lincoln and Massey), with lectures and student-student interactions; meetings with industry representatives and the ED of the Poultry Industry Association of NZ leadership; tours of 2 broiler farms and a feed mill; attendance at the XVIIIth annual New Zealand Poultry Industry Meeting, where 3 of us gave invited talks; and an overnight in a Marae on a Maori village with traditional food and ritual performances. Students had ample time for exploring on their own and enjoyed a number of recreational tours and activities, such as Hobbiton, TiriTiri Matangi Wildlife Sanctuary, a sustainable vineyard, the NZ Treaty Grounds, a bird recovery center, horse-back riding, kayaking, hiking, and seal-watching. Our 2 drivers, one a Maori tribal leader himself, were wonderful resources and gave us deep insight into NZ and Maori history and culture. Lodging

in “Backpackers” (hostels) gave insight into student life in NZ. Half of the students had never flown before and none had been abroad. One-hundred percent indicated that their comfort zones had been pushed at times, that their horizons had been expanded, that the trip was more than worth it; none knew beforehand what to expect. The student who struggled the most with comfort-zone issues stated, “My mind has been opened up to so many new things. I will definitely have to set the bar a little higher for myself now. I learned so much about different cultures and how people live. But even more so I learned a lot about myself.” These themes were echoed through all of the journals and papers. The group formed lasting friendships with each other and with the New Zealanders. The goals of this study abroad were exceeded beyond our expectations, with regard to expanding students’ knowledge of poultry production in a disease-free country and with regard to expanded horizons as shown by self-reflections in journals and papers.

Key Words: Study abroad, New Zealand, poultry production, Maori

M23 Mexico Broiler Production Study Abroad: Development of Cultural and Educational Critical Thinking Opportunities C.Z. Alvarado*, C.A. Bailey *Texas A&M University*

Chicken is projected to soon become the most-consumed meat globally. In 2014r, with the emphasis of global expansion, the Poultry Science Department (POSC) at Texas A&M University embarked on a cultural and educational journey to develop the first poultry study abroad this study abroad because of rich history as well as importance to the MX broiler industry. Several major companies are located there including our corporate program sponsor Pilgrims-MX. Queretaro is one of the top three states of MX poultry production and it, along with Guanajuato, are important historically for MX Independence. Within the state of Guanajuato is San Miguel de Allende where Hacienda Santa Clara has been rebuilt as an educational and cultural center for students to travel and study abroad. This center is centrally located close to broiler production and processing facilities, close to historical San Miguel de Allende, and also contains over 300 culturally diverse art pieces from famous MX artists so students can immerse themselves in culture while at the Hacienda. Students are offered two courses at the undergraduate and graduate level: an intensive and comparative on-site study of integrated broiler production in Central MX including rearing and husbandry, housing and equipment, nutrition, flock health, and processing and a cultural differences course studying how these differences relate to production practices, processing practices, product development and retail choices. Student assignments include debriefing sessions, presentations, reaction papers, reflection journals, and cultural assignments. Reflections and reaction assignments reveal a deeper understanding of global broiler production practices and even greater appreciation for culture and the impact of culture on behavior, especially consumer choices at grocery stores and markets. In addition, traveling, learning, and living in close quarters have allowed our students to better understand team work and personality styles. The number of students attending study abroad increased in 2015 and is expected to increase in 2016. Building upon this success, the POSC at Texas A&M is currently exploring new global study abroad options in other poultry important countries.

Key Words: Study abroad, Poultry Science, Mexico, Broiler Production

Pathology

M24 Survey of Mycoplasma synoviae prevalence and economic impact in the Middle East and North Africa area Husam Bakri^{*1}, Entisar Al-Hallaq² ¹MSD-Animal Health-Middle East; ²MSD-Animal Health-Regional Service Lab

The bacteria *M. synoviae* (MS) is a member of the *mycoplasma* genus. It causes disease in the joints, bones, respiratory tract and oviduct of birds. A MS infection can result in big economic losses due to a drop in egg production and eggshell quality. During last few years, it was noticed that some

layer and breeder flocks faced a drop in egg production of ~10%, some after the peak, while other before reaching the peak of production, along with poor eggshell quality. Publications from A. Feberwee et al* describes the association of MS with egg quality/shell problems in layers and breeders. Therefore, it was believed that it was valuable to investigate the prevalence of MS in the regions.

Blood samples have been collected from the Middle East and North African area from flocks suffering from production drops, respiratory signs,

and poor eggshell quality. Also, samples were taken from broilers showing respiratory problems.

Blood samples were analyzed using serology-ELISA technique to detect the disease presence. Blood samples were collected from layers and breeders. At age < 16 weeks, 10% of the samples were found positive; While at age > 16 weeks, ~ 45% of the samples were found positive. Moreover, 4% of broiler samples were positive. In addition, effect of its impact on economy was estimated.

From above, it was concluded that field challenge with MS was found during rearing and production in layers and breeders, in addition to its presence in broilers. The flocks were treated but the treatments were not sufficient to control the disease, taking into consideration the economic cost also.

Key Words: M. synoviae, prevalence, Middle East & North Africa, production drop, economic impact

M25 Serological monitoring of broiler breeders in Tehran province against avian influenza A. Rahimi*¹, Saeed Charkhar¹, Alireza Bahonar², Shaban Rahimi³, Hossein Ebrahimi³ ¹Science and Research Branch of Islamic Azad University; ²Tehran; ³Tarbiat Modares University

Due to the outbreak of acute respiratory diseases in some poultry farms and the impact of some viral agents that cause respiratory diseases in Tehran province, the serological assay of broiler breeder farms in 2014-2015 was conducted to monitor the antibody titer against avian influenza (AI-H9N2), using hemagglutination inhibition (HI) test. A total of 661 serum samples were collected 2 times (at the pick of egg production and 45-50 weeks of age) for AI HI test. Data were analyzed using T-test and means procedures of SAS software. Statements of statistical significance were based on (P<0.05). Age of sampling had significant effect (P<0.01) on AI titration, the highest AI antibody was observed at 35 weeks of age. AI titer varied between 1 to 11, with less distribution at 42 weeks of age. According to the results of this study, the serological monitoring of the broiler breeder farms in Tehran province against avian influenza represents the herd encounter with live virus (H9N2) during experimental period (September 2014 to September 2015).

Key Words: Avian influenza, broiler breeder farms, serological monitoring

M26 Effects of new bacterial multistrain probiotic as antibiotics on growth performance of broiler chicken challenge with E.coli(O78) Nagwa Shalaby*¹, Abeer Abd El-Baky² ¹Animal Health Research Institute, Provincail, Laboratory.; ²Faculty Veterinary Medicine.

The objective of this study investigate the effect of new bacterial multistrain probiotic (Gro-2- Max[®]) contain *Pedococcus acidilactici*, *Pedococcus pentosaceus*, *Acetabacter acetii* and *Bacillus amyloliquifaciens* as antibiotics in broiler chickens challenge with *E.coli* (O78). The study carry out on 126 one day old and average weight 42gm commercial (Arbor Acres) broiler chicks which divided equally into 6 groups ,each group replicated into three replicate. Gro-2-Max[®](Pro)was added in ration at a rate of 50mg/Kg and in drinking water at a rate of 1g/liter during 24 hours for 5 days continues. Antibiotics, enrofloxacyen10%(Enr) were used 1ml /1L water during 24 hours for 5 days continues. First group negative (NC) was no treatment no infected. Groups 2,3,4,5 and 6 were infected with *E.coli* at 14DOBC. Group2 (Gp2) positive Gp(PC) was no treatment and infected with *E.coli*. Gp3was treatment with Pro supplement in fed from 1-42 DOBC (prophylactic Gp).Gp4.5 and 6 were treatments (T) in drinking water for 5 days after appear symptoms of infection. Gp4 was treatment with Pro alone, Gp5 treatment with Pro plus Enr and Gp 6 was treatment with antibiotics Enr alone. All groups were put under observation during period of experimental 42days. Evaluation of chicken performance including; feed intake (FI), body weight gain (BWG), feed conversion rate (FCR), mortality, immune index and enumerate bacterial count in ilium and cecum. The result recorded in Gp3(prophylactic) and all Gps treatment in drinking water either with Pro ,Pro+Enr or Enr had significant increased in FI, BWG and better

FCR than PC group at 5,12 and 19DPT.The mortality percentage in all treatment groups in drinking water had decreased than PC group. *Lactobacillus* count was increased and decreased *E.coli* count in ilium and caecum than PC Gp2 at 5day post treatment (DPT) and 19DPT. Immune index in all treatment groups in water had recorded significant increased in weight and index of Thymus than Gp PC at 28DOBC. The prophylactic Pro in Gp3 had significant increased weight and index of thymus and spleen at 9DPI and 5DPT respectively than PC group. Conclusion, the multistrain probiotic (Gro-2-Mad) can use as prophylactic in feed and treatment for 5 days in drinking water after infection with *E.coli*

Key Words: Arbor Acres, Broiler chickens, Probiotic, Caecum, Immune index

M27 Detection of Gallibacterium and Avibacterium paragallinarum serovar C-1 isolates from layers in México. Nancy Christy*¹, Sergio Carrasco², Vladimir Morales³, Edgardo Soriano⁴ ¹Boehringer Ingelheim; ²Avicampo; ³Solutions in Immunology and microbiology SIM; ⁴Universidad Autónoma del Estado de México

Gallibacterium is a Gram-negative bacteria associated with a variety of signs such as respiratory problems, necrosis in livers, peritonitis, salpingitis, hemorrhagic and ruptured follicles and a drop in egg production of chickens. *Avibacterium paragallinarum* is the causative agent of infectious coryza, an upper respiratory disease of chickens associated with increased number of culls and reduced egg production (10-40%).

In México, isolates of *Avibacterium paragallinarum* serovar C-1 were isolated across the period from 2008 to 2010 from infectious coryza-vaccinated layers.

The importance of *Gallibacterium* as a pathogen is not clearly understood. Isolates have been obtained from pure culture and mixed infections of lesions in poultry, however, the co-infection between *Gallibacterium* and *Avibacterium paragallinarum* isolates has not been reported.

During 2016, two suspected clinical cases of Infectious Coryza were confirmed by bacteriological and molecular identification of *Avibacterium paragallinarum*. The clinical signs of all two cases were nasal discharge; conjunctivitis with swelling of the sinuses, face and wattles; decreased feed and water intake with reduced egg production. At necropsy, hemorrhages were in mucous membrane of nasal passage and trachea. Additionally, isolates of *Gallibacterium* was confirmed by Gram staining, motility, catalase and cytochrome oxidase activity and to confirm the identification PCR specific test and sequencing of 16S rRNA gene were used. Samples were submitted to Universidad Autónoma del Estado de México for the analysis.

This paper report the prevalence of *Avibacterium paragallinarum* serovar C-1 isolates in infectious coryza-vaccinated layers. And the simultaneous presence of these in co-infection with *Gallibacterium* isolates. The prevalence of *Avibacterium paragallinarum* serovar C-1 continues in México and it's important to vaccinate flocks in order to avoid egg drops caused by Coryza. *Gallibacterium* also could be part of the problem of egg drop in the flocks, that's the importance of the diagnostic and evaluate if it's necessary to include in a vaccination program.

Key Words: Gallibacterium, Avibacterium paragallinarum, Serovar C1, Coryza

M28 Frequency and persistence of fecal shedding of Salmonella Enteritidis by experimentally infected laying hens housed in enriched colony cages at different stocking densities Richard Gast*¹, Rupa Guraya¹, Deana Jones¹, Kenneth Anderson², Darrin Karcher³ ¹USDA-ARS; ²North Carolina State University; ³Purdue University

Human *Salmonella* Enteritidis infections are often linked with consuming contaminated eggs, so the prevalence of this pathogen in egg-laying poultry is an important risk factor for public health. *Salmonella* persistence and transmission in commercial egg producing flocks are influenced by the complex environmental influences exerted by management practices

and housing facilities. In recent years, alternatives to traditional cage-based housing for laying flocks have been developed in response to the animal welfare implications of poultry housing systems, but the food safety consequences of poultry housing are not completely understood. The present study determined the effects of different bird stocking densities on the frequency and persistence of *S. Enteritidis* fecal shedding in groups of experimentally infected laying hens housed in colony cages enriched with perching and nesting areas. In replicate trials, groups of laying hens were placed at two stocking densities (648 and 973 cm²/bird) in enriched colony cages and (along with a group housed in conventional cages at 648 cm²/bird) orally inoculated with doses of 1.0×10^8 cfu of *S. Enteritidis*. At 10 weekly intervals after inoculation of the hens, voided fecal samples were collected from trays beneath each cage and cultured to detect *S. Enteritidis*. Fecal shedding of *S. Enteritidis* was detected for up to 10 wk post-inoculation by hens in all three housing treatment groups. The overall frequency of positive fecal culture results was significantly ($P < 0.05$) higher in conventional cages than in enriched colony cages (at the lower stocking density) for all sampling dates combined (45.0% vs. 33.3%) and also for samples collected at 4-9 wk post-inoculation. Similarly, the frequency of *S. Enteritidis* detection in feces from conventional cages was significantly greater than from enriched colony cages (at the higher hen stocking density) for all samples combined (45.0% vs. 36.7%) and at 6 wk post-inoculation. However, there were no significant differences between the two hen stocking densities for enriched colony cages in their associated frequencies of *S. Enteritidis* recovery from feces. These results suggest that stocking density is not the only influence that housing systems exert on the susceptibility of laying hens to *S. Enteritidis* colonization of the intestinal tract.

Key Words: Salmonella Enteritidis, laying hens, enriched colony cages, stocking density, fecal shedding

M29 Influence of chlorine induced sub-lethal oxidative stress on homologous stress adaptation and biofilm formation in *Listeria monocytogenes* Mohit Bansal^{*GS}, Rama Nannapaneni, Chris McDaniel, Chander Sharma *Mississippi State University*

The objective of this study was to determine whether the sub-inhibitory concentration exposure of sodium hypochlorite can influence homologous stress adaptation and biofilm formation ability of *Listeria monocytogenes* strains, FSL F6-154 (serotype 1/2a) and Scott A (serotype 4b). *L. monocytogenes* cells were exposed to increasing (20 ppm/day) sub-inhibitory concentrations (SIC) of total chlorine from 250 ppm to 375 ppm in tryptic soy broth (TSB). Minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) of the cells exposed to chlorine and control (not exposed to chlorine) were determined at 250 (1/2 MIC), 330 (2/3 MIC) and 375 (3/4 MIC) ppm of chlorine by macro-dilution method. The biofilm forming ability of chlorine treated and control cells were determined by crystal violet assay in 96 well microtiter polystyrene plates at 37°C for 48 hours. Both experiments were replicated three times. The MIC and MBC values of the both the strains exposed to sub-lethal chlorine were 600 ppm and 700 ppm as compared to MIC and MBC values of 500 ppm and 600 ppm for control cells, respectively at all three concentrations tested, indicating that *L. monocytogenes* planktonic cells can develop resistance to chlorine after exposure to sub-lethal chlorine concentrations. The chlorine induced oxidative stress significantly ($p < 0.05$) reduced biofilm forming ability of both the strains on polystyrene surface as compared to control cells. Further, higher anti-biofilm effect of chlorine was observed at 330 (2/3 MIC) and 375 (3/4 MIC) ppm concentration for both the oxidative stressed and non-stressed cells in the presence of chlorine for Scott A strain ($p < 0.05$). Scanning electron microscopy revealed that the continuous exposure of chlorine induces morphological changes in bacterial morphology and biofilm structure of *L. monocytogenes*. The findings from the study indicate that continuous exposure of chlorine induces homologous stress adaptation and reduces biofilm forming ability of *L. monocytogenes*.

Key Words: Sub-lethal oxidative stress, Sodium hypochlorite, Biofilm, *Listeria monocytogenes*

M30 Effect of age, strain, sex, and incubation temperature on severity of chicken breast myopathy ("woody breast") in broiler chickens Laura Chen^{*GS1}, Luke Borst¹, Edgar Oviedo-Rondon¹, Albaraa Sarsour¹, Alejandro Cordova-Noboa¹, Michael Wineland², John Barnes¹ ¹*North Carolina State University*; ²*Private consultant*

"Woody breast" affecting the superficial pectoral muscle (*pectoralis major*, breast muscle, "fillet") is a myopathy (muscle disease) of increasing economic significance in broiler chickens. It is characterized by concurrent muscle degeneration, necrosis, and regeneration (a polyphasic myopathy); lymphocytic phlebitis (inflammation of veins); and fascicular fibrosis (scarring). The underlying cause is unknown, but possibilities include growth rate, nutritional deficiencies, and infectious agents (viruses). In this study, the effect of age, strain, sex, and incubation temperature on the severity of woody breast was examined. Eggs from each of 3 modern broiler crosses and the unselected Athens Canadian random bred broiler chicken were randomly divided equally between two incubators. The temperature profile in one incubator was kept constant, which was representative of single stage incubation, while the second incubator maintained a "Lo-Hi" temperature profile representative of multi-stage incubation. At 2, 4, 6, and 8 weeks of age, 20 chickens (10 males and 10 females) per strain and incubation temperature profile were euthanized ($n = 160$). Samples of breast muscle from the shoulder area were taken, fixed, processed, and stained with hematoxylin and eosin. Myocyte (muscle cell) degeneration and regeneration and lymphocytic phlebitis were scored on a scale from 1 to 4, with 1 normal and 4 severe. Severity of woody breast increased with age and was statistically correlated with both body weight and strain ($p < 0.05$). The correlation between chicken strain and woody breast severity is most likely due to the higher body weights of modern broiler breeds, consistent with current literature. There was no consistent statistical correlation between woody breast severity and sex or incubation temperature profile ($p > 0.05$). Muscle lesion scores were strongly correlated with lymphocytic phlebitis ($p < 0.05$). In conclusion, both body weight/strain and lymphocytic phlebitis, but not sex or incubation profile, were strongly correlated with the severity of woody breast. These findings indicate woody breast is an example of a growth-associated myopathy and that impaired blood flow to the muscle may result from lymphocytic phlebitis and contribute to the disease. The cause of lymphocytic phlebitis, which at times was remarkably severe, remains to be determined.

Key Words: Woody breast, lymphocytic phlebitis, broiler chicken, histopathology, myopathy

M33 Defining the progressive manifestation of wooden breast in the Pectoralis major of commercial broilers from 21 through 46 days of age to objectively correlate stage/severity of WB with growth parameters. Jacqueline Griffin^{*GS}, Macdonald Wick *The Ohio State University*

The objective of the current study was to develop a ranking system based on distinct changes associated with the ontogeny of the wooden breast (WB) myopathy, establish correlations with growth parameters and define predictors for stage/severity of WB. Commercial broilers ($n=27$) were sampled every other day from day 2 through 46. Traits measured included body weight (BW), breast muscle (*P. major* and *P. minor*) weight and yield. The length, width, and depth measurements were also obtained for both muscles. Several myopathic changes were observed in the *P. major*, beginning with white striping (WS) and subsequently WB. These distinct myopathic changes were used to define a ranking system for the progression of WB as follows; 1) white striping (WS), 2) spot surface hemorrhages, 3) intramuscular hemorrhages and 4) ischemic muscle. Image analysis of the intact *P. major* prior to sample collection was later used for assigning a rank (1-4) based on the presence of these distinct myopathic attributes. Using rank as the dependent variable, we determined the correlation between rank and BW or muscle traits to determine which descriptive traits might serve as potential predictors for stage/severity of WB (Rank). All data was analyzed on an individual bird basis so each day was treated independently. Breast muscle dimensions were measured using ImageJ. Data were analyzed us-

ing the PROC GLM procedure in SAS 9.4, with individual bird as the experimental unit and image rank as the main effect. BW and muscle traits (*P. major* and *P. minor* weight, yield, length, width, depth) were initially included in the model as independent variables. Backwards elimination was performed until a significant model was reached. *P. major* depth was a consistent predictor of myopathy severity throughout the experiment. *P. major* weight was only significant on days 18-21 and BW was only significant on day 23. Rank frequency distribution by day showed a progressive increase in birds with higher ranks during later stages of growth. When testing for the significance of day and growth parameter interactions, *P. major* depth was the only significant predictor. The current study developed a ranking system suggesting *P. major* depth as the primary predictor for stages/severity of WB from 25-46 days of age.

Key Words: Pectoralis major, wooden breast, white striping, commercial broiler, ontogeny

M34 Prevalence and severity of osteochondrosis in the free thoracic vertebra is independent of body weight in broiler chickens Laura Chen*^{GS}, Albaraa Sarsour, Alejandro Cordova-Novoa, Mitsu Suyemoto, Edgar Oviedo-Rondon, John Barnes, Luke Borst *North Carolina State University*

Osteochondrosis (OCD) is the result of a disturbance of endochondral ossification in articular cartilage and has been identified as a cause of lameness in several animal species, including chickens. In addition to causing lameness, OCD lesions are an important predisposing factor for bacterial infections that target joints, including pathogenic *Enterococcus cecorum*. The goal of this study was to compare prevalence and severity of free thoracic vertebra OCD in three modern broiler chicken crosses (strains A/A, A/B, and C/C) with Athens Canadian random bred (ACRB) chickens as a control group. The effect of sex, body weight, and incubation temperature conditions on OCD were also investigated. Two incubation temperature profiles were examined, one that maintained a constant ambient temperature, representative of single stage incubation, and the other that maintained a "Lo-Hi" temperature profile representative of multi-stage incubation. At 2, 4, 6, and 8 weeks of age, 20 chickens (10 males and 10 females) per strain and incubation temperature profile were euthanized (n = 160). The free thoracic vertebrae and its articulations with the notarium and synsacrum were harvested, fixed, processed, and stained with hematoxylin and eosin. OCD severity was scored on a scale of 1 (normal) to 4 (osteochondrosis dissecans). Overall OCD prevalence ranged from 76.1 to 93.4% amongst all strains. No significant difference in OCD severity was detected between the two incubation temperature profiles in any strain (p>0.05). No significant differences in OCD severity were detected among male chickens in any of the broiler lines examined (p>0.05). Female birds from one modern commercial broiler cross (A/A) as well as the ACRB strain had statistically significant lower mean OCD scores (p<0.05), consistent with a sex-linked protective effect from OCD in these strains. No association with body weight and OCD was detected (p>0.05). These findings indicate that OCD is common in broiler chickens and is present at similar prevalence in broilers with modern genetics and the ACRB broilers, representative of 1950's broiler genetics. In mammalian species, OCD is not associated with a fast growth rate; similarly, these data indicate that overall body size and growth potential are not linked to OCD severity in broilers. Further work to identify genetic basis for sex-linked protection from OCD in some broiler strains is needed.

Key Words: enterococcal spondylitis, osteochondrosis, musculoskeletal, histopathology, broiler chicken

M35 Occurrence of dorsal cranial myopathy in broiler chickens in seasons and its impact on public health Fernanda do Prado*^{UG}, Sergio Vieira, Liris Kindlein *UFRGS*

Economic losses have been caused due to condemnation or downgrading of carcasses for dorsal cranial myopathy (DCM) that causes damage in the *Anterior latissimus dorsi* muscle (ALD) and condemnns on slaughter lines.

The objective of this study was to determine the occurrence of DCM in broiler chickens in seasons and its impact on public health through microbiological analysis. The data were collected from records by the Federal Inspection Service of the occurrence of partial condemnation of carcasses of broilers slaughtered in a slaughterhouse located in southern Brazil in the period of one year, totalizing 76,529,136 birds. Moreover, the meteorological data had been considered registered for the National Institute of Meteorology. Bacteriological analysis was performed on 60 samples of ALD muscle with lesion (30) and without lesion (30). Samples were collected from slaughter lines and then bacteriologically tested of public health interest for the presence and counts of total bacterial count, *Salmonella spp*, *Campylobacter spp*, *Listeria monocytogenes*, *Staphylococcus aureus*, *Escherichia coli*, and total Coliforms. The data had been analyzed statistical through analysis of variance and test of Tukey (P< 0.001) through the program SAS, considering the weight of the carcass as co-variable. In the summer was verified lesser percentage of condemnns (0.14%) when comparative to another's seasons (0.40; 0.41; 0.37; autumn, winter, spring, respectively), however in the spring showed lesser incidence when compared with the winter. *Salmonella spp*, *Campylobacter spp*, and *Listeria monocytogenes* were absent in carcasses with and without lesions. There was not a significant difference between muscle with lesion and without lesion samples in relation to total coliforms count (7.8×10^3 and 8.8×10^2 UFC/g, P=0.19), *Staphylococcus aureus* (1.5×10^2 and 5×10^1 UFC/g, P=0.45), and *Escherichia coli* (6.4×10^3 and 3.3×10^2 UFC/g, P=0.35), so all bacterial agent had lower scores recommended by the legislation. We can conclude that the occurrence of dorsal cranial myopathy is influenced by the weather, with higher occurrence in winter and autumn. Furthermore, we can be said that this myopathy does not offer risks related to microbiological agents of interest in public health.

Key Words: condemn, myopathy, seasonality, microbiologic, carcass

M36 Effects of Eimeria challenge and feed outage on growth performance and gut health of broilers Juxing Chen*, Frances Yan, Vivek Kuttappan, Mercedes Vazquez-Anon *Novus International Inc.*

Coccidiosis and feed outage have been reported to be as common predispose factors for chronic necrotic enteritis. A floor pen study was conducted with 828 day-old male broilers to evaluate the effect of *Eimeria* challenge and feed outage on growth performance and gut health. The study consisted of 4 treatments – T1: Negative control with coccistat (NC), T2: NC+ feed outage, T3: *Eimeria* challenge, T4: *Eimeria* challenge+feed outage, each with 9 replicate pens of 23 birds each. T2 and T4 birds were subjected to 24-hr feed outage twice a week starting on d18. T3 and T4 birds were orally gavaged with a coccidiosis vaccine at 5X the recommended vaccination dose on d 14. A common nutritionally complete typical US corn soybean meal based broiler diets were formulated for starter (0-14 d), grower (14-29 d), and finisher (29-42 d) phases and fed for all birds. All diets were pelleted, and starter diet was crumbled after pelleting. Data were subject to one way ANOVA; means were separated by Fisher's protected LSD test. A P-Value ≤ 0.05 was considered statistically different. Both *Eimeria* challenge and feed outage reduced BW on d21, 28 and 41, gain on d21 and d28, and increased FCR on d21 and 28. The growth performance of birds challenged with *Eimeria* and/or feed outage started to catch up during finisher phase. *Eimeria* challenge alone increased *Eimeria acervulina* lesions and serum lactose; reduced skin yellow color, jejunal FABP2, FABP6 and MUC2 gene expression at 1 week post challenge (d21). Feed outage after 1 week (d21) increased serum endotoxin regardless of *Eimeria* challenge and feed outage after 4 weeks (d41) reduced skin yellow color and duodenal FABP6 in the absence of *Eimeria* challenge. Combination of *Eimeria* challenge and feed outage increased serum α1 acid glycoprotein (d21 and d41) and duodenal IL1β gene expression (d41). In summary, combination of *Eimeria* challenge and feed outage induced more severe gut inflammation than either challenge alone, and both challenge conditions alone or in

combination could be used to test the efficacy of feed additives in growth performance and gut health in broilers.

Key Words: Eimeria challenge, feed outage, inflammation, gut health, broiler

M37 Differential necrotic enteritis models for evaluation of candidate interventions Juan Latorre*¹, Whitney Briggs², John Barta³, Guillermo Tellez¹, Billy Hargis¹, Lisa Bielke² ¹University of Arkansas; ²Ohio State University; ³University of Guelph

Necrotic enteritis (NE) is now understood to be a multifactorial disease that causes economic losses of around \$2 billion in the poultry industry. Seemingly unrelated neonatal challenge with *Salmonella* Typhimurium (ST) at hatch is known to increase the level of NE-related mortality using an *Eimeria maxima* (EM) and *Clostridium perfringens* (CP) challenge in published studies. When a more virulent EM (M6 Strain) was used in ST positive chicks, followed by a mixed CP challenge on d5 and d6-post EM administration, NE related mortality reached 40 vs. 0% and 39 vs. 0% in the positive challenge group compared to negative controls ($P < 0.05$) in Exp 1 and 2. However, using a genetically and immunologically distinct and less virulent EM (Guelph strain) in the same model, only modest lesion scores (Exp. 3: 2.0 vs. 0) and no impact on mortality (0%) were induced.

Nevertheless, during the 5-days post-challenge, using the less virulent EM strain in Exp. 3, BWG was reduced by 25% during the first 5 days following EM administration, and a further 86.8% during the subsequent 3 days following CP challenge when terminated at peak morbidity with negative impact in feed conversion (1.949 vs. 1.586) in the positive control group ($P < 0.05$). Additionally, in Exp. 3, gut integrity was reduced in the challenged group showing an increased level of serum FITC-d (203.2 \pm 27.9 vs. 15.0 \pm 6.90 ng/mL) and bacterial translocation to the liver (2.27 \pm 0.49 vs. 0.61 \pm 0.49 Log₁₀ cfu/g) in comparison to the non-challenged group ($P < 0.05$). When this model was extended until d35 of age using the EM Guelph strain challenge, BWG for the control chicks was 2133 g and 1925 g for the challenged chicks, suggesting that compensatory gain and full absorptive capacity of the gut epithelium had not recovered in Exp. 4. In the urgent search for antibiotic alternatives, some intervention candidates may be more likely to promote recovery of the enteric epithelium whereas others may be more protective for the inflammation-induced shock and high acute mortality associated with the more virulent challenge. Consideration of appropriate models for different candidate interventions may be important in future studies.

Key Words: Necrotic enteritis, Eimeria maxima, Virulence, Models, Interventions

SCAD I

M38 Looking for alternative to breast injections in broiler breeder pullets? An evaluation of local reactions of a killed vaccine applied to the thighs and drums. Jessica Hockaday*^{GS1}, Phil Stayer², David French², Erin Riley², Buddy Clark³, Martha Pulido¹, Chance Brett², Mickey Gault² ¹Mississippi State University College of Veterinary Medicine; ²Sanderson Farms, Inc.; ³Ceva Animal Health

The goal of this study was to evaluate how local reactions of the legs, focusing on the thigh and drum, from a killed multi-variant viral vaccine could be used in pullet vaccination programs as a suitable alternative to breast injections. Evaluation of lameness, body condition, gross lesions as well as histopathology were tabulated and assessed at two weeks and four weeks post vaccination.

Three different groups totaling 35 sex slip males were vaccinated at 15 weeks of age using one a killed multi-variant viral vaccine. The vaccinated birds were identified using a blue dye on the dorsal aspect of their bodies and three colors (yellow, green and orange) on their ventral side to easily identify the birds throughout the study. Group 1 (Yellow) was vaccinated in both the right and left drums, Group 2 (Orange) was injected in both thighs and Group 3 (Green) was injected in the right thigh and left drum. Injections of 1.0ml were only administered into the right leg and 0.5ml dose into the left leg to ensure proper evaluation of the vaccine dosing. The groups were placed back into the pullet flock after being vaccinated. The farm manager and the technical service manager monitored the birds for lameness and death during the four week duration of the study. None of the vaccinated birds included in this study were found lame or deceased in the barn. Half of the identified birds were collected after two weeks post injections and the remainder at four weeks. Both legs of each bird were dissected, photographed, measured, and lesions scored.

Detailed findings and conclusions will be presented.

Key Words: pullet vaccines, killed-vaccine, leg-injection

M39 Experimental infection of egg laying chickens with Clostridium perfringens strains isolated from Focal Duodenal Necrosis lesions. Ana Villegas*^{GS1}, Francisco Uzal², Robert Moore³, Charles Hofacre¹, Margie Lee¹, Monique Franca¹ ¹University of Georgia; ²University of California; ³MIT University

Focal duodenal necrosis (FDN) is an intestinal disease observed in egg laying chickens, characterized by multifocally distributed mucosal erosions mainly observed in the duodenal loop. It has a worldwide distribution and it is considered one of the top 5 disease concerns of the table egg industry in the USA. Affected flocks exhibit low egg weights and poor egg production performance. Previous studies have associated this condition with different *Clostridium* species; *C. colinum* and *C. perfringens*. We have isolated different *Clostridium perfringens* strains from FDN lesions. The objective of this study was to try to reproduce FDN by experimentally infecting egg laying chickens with different *Clostridium perfringens* isolates. Two experimental trials were conducted using commercial chickens. Chickens in the challenge groups received *Clostridium perfringens* daily for 7 to 8 days via oral gavage. Birds were fed with a diet containing distillers dried grain solubles (DDGS) at a concentration of 8.5%, an ingredient usually included in the diet of egg layer flocks affected with this disease. Birds were euthanized and necropsied following inoculations. Gross lesions were evaluated, lesions were scored and samples were collected for histopathology and bacteriology. Mild gross lesions characterized by hemorrhages and mucosal erosions and frothy duodenal contents were seen in some birds from challenged groups. *Clostridium perfringens* was recovered from some samples that showed gross lesions. Histopathology revealed lymphoplasmacytic and heterophilic enteritis, mucosal hemorrhages, epithelial cell sloughing and rare enterocyte necrosis in duodenal samples from birds challenged with *C. perfringens*. These results reveal that *Clostridium perfringens* strains isolated from FDN samples can cause mild duodenal lesions in experimentally infected chickens. Additional studies need to be performed to try to reproduce the characteristic gross and microscopic lesions seen in field cases of FDN.

Key Words: focal duodenal necrosis, Clostridium perfringens, experimental infection, egg laying chickens

M40 Comparison of vaccination for coccidiosis and the use of dietary Salinomycin on broilers Jarred Oxford^{*GS1}, Ivan Alvarado², Manuel Da Costa¹, Gene Pesti¹ ¹University of Georgia; ²Merck Animal Health

Vaccination for coccidia has been hypothesized to induce better feed efficiency in the later stages of the life of broiler chickens in the presence of field-strain coccidial challenge. The improved feed efficiency could be similar to improvements from increasing the dietary energy level. The objective of this study was to evaluate the effects of early immunity for coccidiosis on the performance of commercial broilers fed diets with different energy levels, with and without coccidial challenge. Data were analyzed as a 2x2x2 factorial arrangement of treatments with: 1) vaccination at 1 d of age or dietary Salinomycin (SAL) from 0 to 28 d of age; 2) Standard or reduced dietary energy (-50 kcal finisher and -80 kcal withdrawal) and 3) coccidial challenge through feed, or not, at day 22. There were 4 dietary phases: starter (0-16 d), grower (16-28d), finisher (28-34d), and withdrawal (34-48d). Three thousand one hundred and sixty-eight, day-old chicks were divided into 96 pens making six pens of 33 chicks per gender per treatment. Body weight (BW), feed intake and feed conversion ratio (FCR) were measured at 16, 28, 34, and 48 d of age. There were significant differences in 28 day FCR ($P=0.008$) based on challenge status (1.564 vs. 1.505 for revaccinated or not chicks, respectively). There were no significant differences in BW, gain, or feed intake at 28 days of age. By 34 d of age the effect of challenge was still significant, 1.612 vs. 1.558, respectively ($p=0.019$), but not at 48 d, 1.766 vs. 1.727, respectively ($p=0.063$). At 48 d the effect of vaccinating at d of age versus feeding SAL for 28 d had only very small effects on BW (3775 vs. 3817g, $p=0.344$) and FCR (1.748 vs. 1.745, $p=0.870$). Reduced dietary energy in the finisher and withdrawal feeds increased FCR at 48 d (1.762 vs. 1.731, $p=0.130$). There were no significant interactions of dietary energy level and any of the performance parameters at 48 d ($0.843 > p > 0.406$). The results show that dietary energy did not have a significant effect on any of the parameters studied; and that the challenge on d 22 impacted the FCR and final BW regardless of initial coccidiosis control measure. Day of age vaccination resulted in very similar performance as feeding an anticoccidial drug.

Key Words: coccidia

M41 Effect of salinomycin inclusion on performance and coccidiosis control in vaccinated broilers Ivan Alvarado^{*1}, Gene Pesti², Manuel Costa² ¹Merck Animal Health; ²University of Georgia

One thousand eighteen hundred one-day-old commercial broiler chickens were vaccinated at day of age by coarse spray with Coccivac B52. After vaccination, chickens were randomly assigned to four treatment groups according to the age at which salinomycin was initially included in the feed (starting at 13, 21 or 28 days of age or no inclusion). At 21 and 28 days of age, all the groups were challenged by administering a pre-established dose of *E. acervulina*, *E. tenella* and *E. maxima* in the feed. Development of immunity was evaluated 7 days after challenge (28 and 35 days of age, respectively). Body weight, feed consumption and feed conversion were obtained at 13, 21, 28 and 35 days of age. Carcass composition was determined at 35 days of age. In general, increased body weight, lower feed intake and lower feed conversion were observed in vaccinated broilers fed diets containing salinomycin. At 28 and 35 days of age, significantly higher ($p < 0.02$) body weights were observed in the 13 d salinomycin group versus the 28 d salinomycin and no salinomycin groups. Significantly lower ($p < 0.001$) feed conversion was observed in the 13d salinomycin group versus the no salinomycin group. Significantly higher *E. tenella* macroscopic scores and *E. tenella/E. maxima* microscopic scores were observed in the 21 d salinomycin, 28 d salinomycin and no salinomycin groups versus the 13 d salinomycin group. No significant differences in macroscopic and microscopic lesion scores were observed at 35 days of age. With the exception of legs weight, not significant differences in carcass composition were observed among groups.

Key Words: Coccivac B52, Salinomycin, Coccidiosis, Performance, Immunity

M42 Anticoccidial Efficacy of All Natural Feed and Water Additives administered to turkeys infected with a mixture of Eimeria meleagridis, E. gallopavonis, and Eimeria adenoids. Greg Mathis^{*1}, Brett Lumpkins¹, John Schleifer², Troy Lohrmann² ¹Southern Poultry Research, Inc.; ²Quality Technology International, Inc.

Currently in the USA, for turkey Coccidiosis control there are 5 available drugs and no vaccines, which is greatly limited compared to those available for chicken Coccidiosis. Thus there is a need for products that will provide a reduction in turkey coccidiosis. The objective of this study was to determine improvements in performance and a reduction in coccidiosis when a feed additive combination product Enterobac (ENT) (probiotic /prebiotic/botanical) or a water treatment Refresh (REF) (probiotic/vitamin/electrolyte supplement) is administered to young turkeys throughout the study period. A randomized block design with 8 replications of 8 commercial female turkey poults per cage was used, and $P < 0.05$ was used to determine the level of significance. All birds were fed a commercial grade turkey starter diet, which was used for the dietary treatments. The treatments were T1 nonmedicated (NM) non-challenged (NMNC), T2 NM challenged (NMC), T3 ENT 2lb/t, non-challenged (ENT-NC), T4 ENT 2lb/t, challenged (ENT-C), T5 REF, non-challenged (REF-NC), T6 REF, challenged (REF-C), T7= T3+T5, and T8= T4+T6. At 12 days of age (d0), turkey poults were placed in battery cages and issued either feed or water treatments *ad libitum*. On d2, all challenged birds, were orally dosed with *E. meleagridis*, *E. gallopavonis*, and *E. adenoides*. On d7, 8, and 9, fecal material in droppings pans were scored (DS) based on increasing evidence of infection (0-3). Birds and feed by pen were weighed at d0 (placement) and d9. Oocysts per gram (OPG) fecal material was determined by cage from fecal material collected d7-9. The coccidiosis infection was a high challenge as determined by reduced performance and high DSs and OPGs. The coccidial challenge significantly ($p < 0.05$) reduced performance (lower wt. gain and increased FCR) for all challenged treatments compared to non-challenged treatments. Performance for all of the challenge birds was not significantly improved with ENT, REF or combination. However, ENT and REF significantly lower DSs and OPGs than NM-C. The T8 combination significantly lowered DS and OPGs. This study demonstrated that administering Enterobac in the feed or Refresh in the water has the potential to aid in the reduction of turkey coccidiosis.

Key Words: E. meleagridis, E. gallopavonis, E. adenoides, Coccidia, Turkey

M43 Effects of various anticoccidials as bio-shuttle alternatives for broilers under a necrotic enteritis challenge Manuel Da Costa^{*1}, Kalen Cookson¹, Steve Davis², Sam Hendrix², Jon Schaeffer¹, John Dickson¹ ¹Zoetis, U.S. Poultry; ²Colorado Quality Research

Bio-shuttle programs have become a useful strategy to minimize necrotic enteritis (NE) losses in coccidia vaccinated broilers by reducing Eimeria cycling in the presence of a *Clostridium perfringens* (CP) challenge. For certain antibiotic free (ABF) markets, bioshuttle programs that incorporate coccidia vaccination followed by a chemical anticoccidial may represent an effective approach for controlling coccidiosis. The objective of this study was to explore the utility of chemical anticoccidials in a bio-shuttle program when broilers face a NE challenge.

Study design: A total of 1,536 Cobb 500 male chicks were spray vaccinated with an attenuated coccidia vaccine at hatch and placed in 48 floor pens. There were 6 grower (14 to 28d) dietary treatments: 1) BMD[®], 2) Deccox[®], 3) Robenz[®], 4) Zoamix[®], and 5) Control (no feed additive). Birds and feed were weighed at the end of each dietary phase for performance evaluation. Mortality was recorded daily for adjusted feed conversion ratio (FCR) calculation. At 16d of age birds were challenged with a CP culture ($>10^8$ cfu/bird) isolated from a field outbreak. In addition 12 birds per pen were tagged for further NE lesion scoring at 19 and 22d of age. All hypothesis tests were conducted at the 0.05 level of significance using two sided tests.

Results (Table 1): Overall, BMD resulted in heavier birds and lower FCR (1.357) at 28d. Birds fed the Deccox, Robenz, and Zoamix had intermediate FCR, with the controls presenting the highest value (1.408). The NE lesions were only significantly reduced by BMD at 19 and 22d. Feeding BMD significantly lowered post-challenge mortality (1.00%), whereas Zoamix (10.3%), Robenz (14.5%), and Deccox (15.5%) had intermediate values, in relationship with the controls (19.0%).

Discussion: In conclusion, BMD resulted in better performance (5 FCR points), lowered NE lesions, and spared mortality caused by CP challenge plus cocci vaccine (control). Nevertheless, even though the anticoccidials did not completely reduce the effects of CP on performance (Robenz and Zoamix lowered FCR in 2 and 3 points, respectively) and NE lesions, they did mitigate the effects on mortality, showing potential to be used in bio-shuttle programs for controlling coccidiosis in ABF production systems.

Table 1. Effects of BMD®, Deccox®, Robenz®, and Zoamix as bio-shuttle alternatives for broilers under a necrotic enteritis challenge

Treatment	NE lesion scores		NE mortality (16-28d)	Performance (28d)	
	19d	22d		BW (kg)	adjFCR
BMD	1.0 ^b	0.9 ^b	1.03 ^c	1.214 ^a	1.357 ^c
Deccox	1.6 ^a	2.7 ^a	15.52 ^{ab}	1.188 ^{ab}	1.393 ^{ab}
Robenz	1.6 ^a	2.4 ^a	14.48 ^b	1.146 ^b	1.387 ^b
Zoamix	1.6 ^a	2.4 ^a	10.34 ^b	1.158 ^{ab}	1.379 ^b
Control	1.6 ^a	3.2 ^a	18.97 ^a	1.153 ^{ab}	1.408 ^a

^{a,b,c} $P < 0.05$

Key Words: Necrotic enteritis, BMD, Deccox, Robenz, Zoamix

M44 Effectiveness of a yeast cell wall in commercial layers against intestinal and ovary colonization of *S. enteritidis* Charles Hofacre^{*1}, Glycon Santos², Melina Bonato², Greg Mathis³, Roy Berghaus¹ ¹The University of Georgia; ²ICC; ³Southern Poultry Research Group

Statement: *Salmonella enteritidis* is reported by the CDC to be one of the leading causes of food borne illness due to *Salmonella* and is especially important for layers due to a higher incidence of egg transmission. Yeast cell wall (YCW) high in B-glucans and MOS have been demonstrated to agglutinate *Salmonella* so they won't colonize the intestines. **Design:** This study utilized 200 Hyline W-36 pullets that were 10 weeks of age and obtained prior to any inactivated *S. E.* vaccines. Pullets were housed in individual commercial layer cages. Treatments began at 10 weeks of age and were T1: Commercial pullet diet only; T2: Commercial pullet diet plus 0.5 kg/metric ton of IMW 50® (YCW-MOS product). At 12 weeks of age all pullets were light stimulated, then at 16 weeks each bird was orally gavaged with 3.0×10^9 cfu/pullet of a nalidixic acid resistant *S. E.* On 7 and 14 days post challenge hens were euthanized by cervical dislocation, cecae and ovaries aseptically removed, weighed and placed into sterile plastic bags. Prevalence of *S. E.* was determined by culture in tetrathionate (42°C) then XLT-4 (25 mg/ml Nalidixic acid). Enumeration of *S. E.* in ceca was by the MPN method of Berghaus and Thayer. Statistical analysis was by Kruskal-Wallis test and Dunn's procedure and MPNs were log transformed prior to status; $P < 0.05$ superscripts in common do not differ. **Results:** Ceca prevalence: Challenged untreated 7 day 97.9%^a, 14 day 53.2%^a; IMW⁵⁰ 7 day 93.8%^a, 14 day 47.9%^a. Ceca enumeration: untreated 7 day 2.70^a, 14 day 0.07^a; IMW⁵⁰ 7 day 2.23^b, 14 day 0.07^a. Ovary prevalence: untreated challenged 7 day 41.7%, 14 day 4.2%^a; IMW 50 7 day 33.3%^a, 14 day 2.1%. The *S. E.* challenge was effective in colonizing ceca and ovaries. The treatment with the YCW/MOS product IMW 50 did not reduce prevalence of *S. E.* in the ceca with this high challenge but did significantly reduce the level in

those positive ceca. The IMW 50 was effective in numerically lowering *S. E.* prevalence in ovaries at both 7 and 14 days post challenge.

Key Words: *S. E.*, Layers, Yeast, Cell, Wall

M45 A highly stable, effective, and safe form of fenbendazole (Safe-Guard® AquaSol) for the treatment of gastro-intestinal nematodes Blayne Mozisek* Merck Animal Health

Intestinal parasitic worms are a common problem in the poultry industry. These parasites have a significant impact, contributing to the transmission of disease, decreasing yield and, subsequently, increasing costs. Parasitism adds to the total price of production and results in significantly lower producer profits. Due to the systematic impact of intestinal worms, a water-miscible fenbendazole (Safe-Guard® AquaSol) has been developed. This new product is a highly stable, farm-friendly, water-administered suspension. The stability of AquaSol does not require frequent agitation and provides a high level of efficacy as demonstrated in repeated animal tests. Gastro-intestinal nematodes including *Ascaridia galli* (L5 and adult stages) and *Heterakis gallinarum* (L5 and adult stages) are susceptible. A review of stability characteristics over time and efficacy and performance improvements in an extensive US broiler trial will be discussed.

Key Words: Fenbendazole, Deworm, AquaSol

M46 Repeated isolation of virulent Newcastle disease viruses among poultry and captive non-poultry avian species in Pakistan from 2011 to 2016 Kiril Dimitrov^{*1}, Abdul Wajid², Shafqat Rehmani², Muhammad Wasim², Asma Basharat², Tasra Bibi², Saima Arif², Mustafa Ababneh³, Patti Miller¹, Claudio Afonso¹ ¹Southeast Poultry Research Laboratory, US National Poultry Research Center, US Dept. of Agriculture; ²University of Veterinary and Animal Sciences; ³Jordan University of Science and Technology

Newcastle disease viruses (NDV) with panzootic potential continue to circulate and cause problems in vaccinated Pakistani poultry. In addition, virulent NDV were repeatedly isolated (2012-2016) at multiple locations in Pakistan from non-poultry avian species from farms, parks, backyard, zoos and wildlife. The wide variety of involved bird species suggests a potential role in the maintenance of NDV. In this study, fifty two NDV isolated in Pakistan from poultry and non-poultry avian species were characterized and phylogenetically compared. All of the isolates were found to be members of sub-genotype VIIi, and had predicted amino acid motifs at the fusion protein cleavage site typical for virulent viruses (¹¹³RQKR↓F¹¹⁷), which were also consistent with the intracerebral pathogenicity indexes (1.75 to 1.96). In the constructed phylogenetic tree, viruses from different species (poultry and non-poultry) grouped together in branches. Within branches, NDV isolated from non-poultry species were found to be genetically very similar to those circulating in poultry (above 99.7 % nucleotide identity). In addition, two clearly distinct branches (1.4% nucleotide distance) of viruses from different species were identified. While the first branch included viruses isolated between 2011 and 2016 predominantly from pigeons and chickens, the second branch consisted of viruses mainly from peafowl and chickens from 2013 to 2015. Past studies have reported accidental spillovers from poultry that occurred over short period of time; however, here we demonstrated the repeated isolation over 5 years of very closely related virulent NDVs from poultry and non-poultry captive birds. This new data point to significant role of non-poultry captive species in the endemicity of NDV in Pakistan. The high similarity of sequences and the close distances between isolation sites point to the existence of direct epidemiological links. The higher genetic distance between some of the viruses and the location into separated clades suggest separate simultaneous evolution. These epidemiological connections between poultry and captive non-poultry species suggests the need of performing active surveillance in wild birds kept in captivity.

Key Words: Newcastle disease virus, APMV-1, Pakistan, Captive birds, endemicity

M47 Experimental evaluation of killed and live Newcastle disease virus vaccines heterologous to the virulent genotype XII challenge strain from the Peru/2008 outbreak Patti Miller*¹, Stivalis Cardenas Garcia², Kiril Dimitrov¹, Iryna Goraichuk¹, Tonya Taylor¹, Amulfo Toscano Contreras³, Victor Madrigal Sanchez³, Claudio Afonso¹ ¹USDA/ARS/U.S. National Poultry Research Center/SEPRL; ²UGA; ³Investigacion Aplicada, S.A. de C.V. (IASA)

While all Newcastle disease viruses (NDV) are contained within one serotype and different NDV provide cross-protection against others, antigenically matched strains have been shown to decrease viral shedding. Therefore, using recombinant technology, some companies have directed efforts in developing genotype specific Newcastle disease vaccines targeting the virulent NDV circulating in specific locations. Recombinant NDV vaccines matching genotypes V, VII and XIII have been developed. The goal of this experiment was to evaluate the immunity induced by genotype V, VII, and XIII NDV vaccines in both live and killed formulations and to determine their efficacy after challenge with a genotype XII virulent NDV. Genotype XII NDV have caused outbreaks in Peru and China during the last decade and no homologous vaccines have been developed for these viruses. Other virulent challenge viruses from genotypes V, VII and XIII, homologous to the genotypes of the vaccines, were also used as controls. Hemagglutination inhibition (HI) antibody titers before and after challenge, morbidity rates, mortality rates, number of birds shedding virulent challenge virus, and the relative amounts of shed challenge virus were obtained. All killed vaccines provided 100 % protection with no morbidity or mortality after challenge with the genotype XII Peru virus. The birds vaccinated with killed genotype V and XIII had similar pre- and post-challenge HI antibody titers when tested against the Peru challenge strain antigen. All vaccines provided at least a two log decrease in the amount of challenge virus shed. For the live vaccines, both genotypes V and XIII equally provided acceptable protection with both resulting in 10% morbidity and mortality after challenge. Both vaccines also had similar pre- and post-challenge HI antibody levels, similar numbers of birds shedding virus, and similar amounts of virulent NDV shed (around 2.5 logs less than the unvaccinated controls). To conclude, under these experimental conditions against the virulent Peru challenge virus all of the inactivated vaccines, and the live genotype XIII and V vaccine strains performed equally well in spite of being heterologous to the challenge virus.

Key Words: Newcastle disease virus, NDV, vaccine, homologous, genotype

M48 Use of Sequence-Independent-Single-Primer-Amplification (SISPA) for whole genome sequencing using Illumina MiSeq Platform for avian influenza virus, Newcastle disease virus, and infectious bronchitis virus. Klaudia Chrzastek*, Dong-hun Lee, Diane Smith, Poonam Sharma, David Suarez, Mary Pantin-Jackwood, Darrell Kapczynski *United States Department of Agriculture, Agricultural Research Service, U.S. National Poultry Research Center*

Over the past decade, Next Generation Sequencing (NGS) technologies, also called deep sequencing, have continued to evolve, increasing capacity and lower the cost necessary for large genome sequencing projects. The one of the advantage of NGS platforms is the possibility to sequence the samples without any prior knowledge of what is within the sample. NGS can also be a valuable tool to monitor the changes in viral genomes, or for virus discovery, including diagnostics. However, the samples used in such studies are often available in limited quantities. Here, we present a simplified, Sequence Independent Single Primer Amplification (SISPA) in combination with NGS which provided the viral genome sequences of avian influenza virus (AIV), Newcastle disease virus (NDV) and Infectious bronchitis virus (IBV), representing negative- and positive-sense single-stranded RNA viruses. The second goal was to assess feasibility of virus identification using SISPA – NGS and to get an estimate of sensitivity. The simplified SISPA protocol produces amplified product that when sequenced give high quality data that can be used for de novo assembly or reference mapping. This method allowed us successfully assembly sequences into full or near full length AIV, NDV, IBV viral genomes. The genome coverage ranged from 94.9% to 100% for all three viruses. Moreover, analysis of the sequence data demonstrated that from a single clinical sample, a mapping assembly representing 98.2 % of NDV and 99.7% of IBV genomes could be produced. The detection limit depended on viral load of samples. Based on our findings, a minimum of 10³ virus particles per RT-PCR reaction is needed to obtain the full or nearly full genome sequence. This application has potential for rapid sequencing, diagnosis and virus discovery and because of the nonspecific nature of the amplification should be adaptable to the other RNA and DNA viruses.

Key Words: SISPA, NGS, AIV, IBV, NDV

Environment Management I

M49 Detection of microsatellite loci linked to QTL for growth in warm-region chickens under natural prolonged heating conditions Doaa Higazy*^{UG}, Al-Amira El-Kashef, Essam El-Gendy *Faculty of Agriculture, Cairo University*

The objective of this research was to detect QTL contributing to growth performance of native Egyptian chickens (warm-region chickens) under natural prolonged heating conditions. Two genetic lines were used; line CE1 that has been selected 15 generations for high 6-wk BW and line CE2 that is randomly bred and serves as the genetic control of line CE1. The chicks of both lines have been intermingled and raised under natural prolonged heat stress conditions from hatch to 18 wks of age. The maximum temperature ranged from 32 to 44°C with an average of 39°C, and the minimum temperature ranged from 23°C to 31°C, with an average of 28°C. The averages of daily maximum and minimum temperature-humidity index (THI) were 28.8 and 18.6°C. Biweekly body weight (BW), body weight gain (BWG) and growth rate (GR) was obtained, and the genomic DNA was extracted from the birds under study. The DNA samples were screened by 7 pairs of microsatellite primers at chromosome-wise level. The heat stressed-growth data and genomic data were combined and statistically analyzed for genetic linkage.

Four of seven microsatellite loci have been detected on chromosomes 3, 4 and 5 in both lines. The number of polymorphic alleles per locus ranged from 12 to 45. The polymorphic information content in line CE1 was more than 2-folds of that in line CE2 (0.548 vs. 0.260). The detected microsatellite alleles revealed linkage with QTL for growth parameters under heat stress conditions. On chromosome 3, the alleles on locus LEI0166 showed linkage with QTL mostly influencing early BW; where QTL significantly ($P \leq 0.05$) contributed to 2-wk BW by 8.69- 9.96% of δ_p^2 and to 6-wk BW by 26.33% of δ_p^2 were found. On chromosome 4, the microsatellite locus LEI0073 included alleles that were linked to QTL significantly ($P \leq 0.01$ -0.05) contributing to 6-8 wk BWG and GR by 22.8-24.5% of δ_p^2 . The locus was also linked to QTL ($P \leq 0.05$) explaining 10.98-18.03% of δ_p^2 in 14-16 wk BWG. Also on chromosome 4, the microsatellite locus ADL0143 was linked to QTL contributing to the early and late growth, where QTL were reported with significant ($P \leq 0.01$ - 0.05) contribution by 2.06- 14.17% to δ_p^2 in 6-wk BW and by 31.83% to δ_p^2 in 6-8 wk BWG. On chromosome 5, there was an association between the microsatellite locus MCW0193 and QTL that revealed significant ($P \leq 0.05$) contribution to δ_p^2 in 6-wk BW by 7.02-11.83% and in 16-wk BW by 16.55-22.37%. Several microsatellite

alleles on chromosomes 3, 4 and 5 showed potentiality of use in MAS for early growth under heat stress conditions.

Key Words: Growth performance, natural heating conditions, microsatellite markers, native chickens, QTL

M50 Thermal Manipulation during pre and post hatch on Long bone development of Male broiler chickens exposed to Chronic heat stress Gholamreza Zaboli*^{GS1}, Shaban Rahimi¹, Farid Shariatmadari¹, Mohammad Amir Karimi Torshizi¹, Ali Baghbazadeh², Mohammad Kameli¹ ¹*Department of Poultry Science, Faculty of Agriculture, Tarbiat Modares University;* ²*Section of Physiology, Department of Basic Sciences, Faculty of Veterinary Medicine, University of Tehran*

Heat stress in poultry industries is considered as the main factor that causes economic losses, especially in hot and dry climate. To prevent negative effects suggested a new method known thermal manipulation that it could alleviate mortality and morbidity a long heat stress. Moreover, it has been showed that heat stress reduced density, long and width of the tibia, femur, and humerus. The influence of thermal manipulation on long bone development was not studied. The purpose of this investigation was to evaluate the influence of thermal manipulation (TM) during pre and post-hatch periods on the long bone development of male broiler chickens exposed to chronic heat stress during the finisher phase (34±2°C, 6h/day). Seven hundred fertile eggs of Ross 308 were assigned to the following groups: 1) control group consist of incubated and housed in standard conditions, 2) pre-hatch treatment (PRE), the eggs were exposed to 39.5°C and 65% RH for 12 h/d from embryonic d7 to 16 and after hatching the chicks were housed in standard condition; 3 and 4) post-hatch TM at d 3 (PO3) and post-hatch TM at d 5 (PO5), which had the same incubation conditions as control and exposed to 36-38 °C for 24 h at 3 and 5 days of age, respectively. The tibia, femur, and humerus were evaluated at d 42. Ten birds were used to measure parameters each treatment. After standard cleaning and drying, the bone density, length and width were measured. The result showed that thermal manipulation positively affected long bone development. Width and length of tibia and femur in treated birds were significantly improved by treatments, but the density of bone was not influenced. It can be concluded that thermal manipulation in pre and post hatch are able to induce tolerance against heat stress on male broiler chickens in finisher phase.

Key Words: Broiler, chronic Heat Stress, Long Bone Development, Thermal manipulation

M51 Environmental influences of Salmonella Heidelberg colonization in commercial broilers Elle Chadwick*^{GS}, James Krehling, Laci MacKay, Bradley Schrader, Kenneth Macklin *Auburn University*

Multiple intervention strategies to decrease *Salmonella* levels at poultry farms have been proposed, but few have analyzed the variation in inoculation routes to mimic environmental conditions that may alter *Salmonella* colonization. The objective of these studies was to assess various routes in which *Salmonella* entry is occurring in broilers with current poultry housing conditions to determine if such entryways will alter food safety concerns at the pre-harvest level. The exposure to *Salmonella* Heidelberg (SH) through multiple inoculation routes (intra-tracheal, oral, ocular, cloacal, or subcutaneous) and its ability to colonize different organs/tissues of broilers reared to market age was determined. Broilers were given 10⁴ CFU/mL of SH via one of the inoculation routes mentioned on day 0 then reared for 32-36 days. During the necropsy the following samples were collected: crop, ceca and cloacal swab (CS). The data was analyzed using the GLM Method ($P \leq 0.05$) and when appropriate Tukey HSD in SPSS. In comparing the average recovery of the samples from all inoculations, the ceca were highly significant (35%) compared to the crop (24%) and CS (23%). When comparing inoculation routes, the intra-tracheal was statistically greater in recovery of SH among all the samples collected (64%) compared to the oral (32%), ocular (19%), cloacal (11%) and subcutaneous (10%). When analyzing individual samples, the intra-tracheal inoculation had a significantly greater incidence of SH from the ceca (69%), CS

(68%) and crop (56%) in comparison to the other inoculation routes (oral: 50%, 21%, 26%; ocular: 30%, 9%, 17%; cloacal: 13%, 8%, 12%; and subcutaneous: 11.1%, 8.1%, 10%). These studies demonstrate that the ceca is an ideal organ to sample for SH recovery within a commercial poultry house in comparison to the crop and CS. To improve housing conditions within the poultry industry, air quality must be considered due to the intra-tracheal inoculation having the highest recovery of SH. This inoculation infers that the inhalation of *Salmonella* contaminated particles increases the colonization of this pathogen within a flock during grow-out.

Key Words: Salmonella, Heidelberg, pre-harvest

M52 The effects of physically modified switchgrass bedding on broiler production Amy Barkley*^{GS}, Paul Patterson, Jude Liu, R. Hulet *The Pennsylvania State University*

Although switchgrass is gaining popularity as a renewable alternative bedding material, it is becoming evident that the processing of this product directly influences its success as bedding. The objectives of this study were to process switchgrass to difference particle lengths and evaluate how it performed as bedding in addition to its effect on broiler performance and welfare in a replicated pen setting. The switchgrass was harvested in Central Pennsylvania in March 2016. Using a self-propelled forage chopper, three treatments were created with average particle lengths of 5.3mm (S1), 31.4mm (S2), and 62.8mm (S3). Softwood shavings served as a control (C). Eight replicate pens per treatment measuring 2.5m² were each bedded to a depth of 10cm. The pens were stocked with 26 or 27 randomly placed straight run Hubbard Redbro chicks and grown out to 8 weeks of age. Bedding samples were analyzed for moisture, pH, particle size distribution, density, and moisture retention/release. Litter was evaluated for pH, moisture, depth, and score. Bird performance parameters (feed intake, BW, FCR, and mortality) were measured and footpads and breasts were scored at weeks 4, 6, and 8 for lesions and cleanliness, respectively. A dynamic flux chamber and acoustic gas monitor were employed to measure ammonia flux from the litter surface at 8 wks. It was found that particle size distribution of C was most similar to S1 whereas S2 and S3 were very similar to each other. Significant differences (>0.01) existed for 12 of the bedding particle sizes from 0.125mm-12.5mm, excluding 4.75mm. Although bedding moisture was not different between treatments at bird placement, significance emerged at 6 and 8 weeks ($P < 0.05$), with S3 retaining the most moisture and S1 and C retaining the least. Litter scores only showed differences at 6 weeks ($P = 0.0299$), with S3 scores being the worst. Treatments significantly affected litter depth throughout the study, with C being the lowest overall. Bird performance parameters, footpad scores, and breast cleanliness scores were not affected by bedding treatment. Initial nutrient analysis of switchgrass and C beddings revealed differences in moisture, total N, ammonium N, organic N, and P₂O₅, though these differences only remained for ammonium N in the final nutrient analysis. These results indicate that harvesting switchgrass to particle lengths between 5.3mm and 62.8mm can influence its performance as poultry bedding, though it appears not to affect bird performance or welfare.

Key Words: switchgrass, broiler, particle, bedding, harvest

M53 Hen manure nutrients and production in the Chesapeake Bay Watershed Erica Rogers*^{GS}, Paul Patterson, R. Hulet, Amy Barkley *The Pennsylvania State University*

The Chesapeake Bay has one of the most studied watersheds in the world, covering almost 165,759 square kilometers. Pollution control is an ever-present concern within this watershed. To track pollution changes in this region, the Environmental Protection Agency introduced the Chesapeake Bay Total Maximum Daily Load (TMDL) in 2010. The TMDL allots 84.3 million kg of nitrogen, 5.67 million kg of phosphorus, and 2.93 billion kg of sediment to enter the watershed annually. The Chesapeake Bay model is currently using data from the 1980s to estimate the amount of nutrients poultry in Pennsylvania contribute to the TMDL. In the 1980s most management styles for laying hens were high-rise pit houses whereas today's

management styles are more diverse, including high-rise pit, belted, enriched colonies, cage free floor, and cage free aviary houses. The purpose of this study was to track nutrients produced by commercial laying hens under changing management styles for use in the Chesapeake Bay models that determine TMDL's. Historical data of manure nutrients, amounts, and flock records were collected from high-rise pit and belted layer houses from 2012-2015. Manure samples were analyzed by each individual producer's lab of choice over the course of this 4-year period. By using the flock records and manure nutrient data, we were able to calculate the amount of N, P2O5, and K2O produced per bird and per kg of body weight. All data were analyzed using a one-way or two-way ANOVA with the GLM procedure of SAS 9.4 and Tukey's range test for means comparison. Results indicated there were significant equipment differences resulting in greater manure P2O5 and K2O, both per bird and per kg of bird for pit-type houses vs. those with manure belts e.g. 0.310 and 0.201 kg P2O5/kg bird for pit and belted, respectively ($p=0.0002$). Likewise, the main effects for nitrogen per kg bird were also greater for the pit houses vs. belted (0.281 and 0.239 kg) and for the years 2014 vs. 2013. Furthermore, there was a significant year \times house type interaction ($p=0.0045$) indicating there were different yearly effects on N excretion within both pit and belted houses. Overall, these findings indicate that hen housing types and year can influence manure N, P2O5 and K2O. Therefore, updating Chesapeake Bay models to accurately reflect current housing and management practices would greatly improve TMDL's and nutrient management in the Bay.

Key Words: Nitrogen, Phosphorus, TMDL

M54 Time series forecast model selection & exchange rate index for wholesale chicken parts prices Chris Sims*^{GS}, H.L. Goodwin, Andrew McKenzie *University of Arkansas*

The United States (U.S.) poultry industry is the world's largest producer of poultry meat (Harvey, Melton, & Ramos, 2016). In 2015 per capita poultry consumption was 88 pounds, 2016 and 2017 are forecasted with continuous growth (National Chicken Council, 2016). Demand and supply changes, impact roughly 20% of U.S. poultry exports. With these variations, accurate forecasting of poultry prices is difficult.

This research effort creates both a superior forecasting model for wholesale poultry prices and a 'dollar index' focusing on exchange rates and respective export market capture of individual companies. This paper incorporates re-estimation of a model developed and published by McKenzie, Goodwin, and Carreira, "Alternative Model Selection Using Forecast Error Variance Decompositions in Wholesale Chicken Markets" (McKenzie, Goodwin, & Carreira, 2009). The re-estimation utilizes updated Uner Barry (UB) wholesale parts pricing through 2015 to perform in-period and out-of-period price forecasts utilizing Vector Autoregressive technique. Changes in market structure and new data allow for a more robust model to be created along with additional parts prices.

Also being utilized is the aforementioned dollar value index based on real-time export-country exchange rates compared to the U.S. dollar and Brazilian Real. Multiple forecasting models are analyzed with discussions of the advantages and disadvantages. The dollar index value allows targeting individual markets based on exchange rates and exports. The forecast and dollar index value models allow companies to better strategize their market capture. Preliminary data suggests that U.S. and Brazil have a competitive exchange rate with current trading partners. Strengthening exchange rates could increase export competition, adding volatility to poultry trade. This would also result in different market capture strategy as well. The UB pricing data suggests promise for a significantly robust forecasting model on wholesale chicken parts prices. Combined, these two would have a positive impact on U.S. exports; by giving insights on strengths and opportunities for poultry trade. Overall this research could have significant

impacts to the poultry industry with competitive advantage, cost savings, and market capture.

Key Words: Time Series Model, Forecasting, Poultry Prices, Forecast Error Variance Decompositions, Market Capture

M55 Wire-flooring induced lameness in broilers from hens fed a *Bacillus subtilis* Ashley Owen*^{GS}, Jeanna Wilson, Charles Hofacre *University of Georgia*

Broiler breeders are feed restricted to control body weight and improve reproduction, mobility and natural mating. It is thought that this stressful environment may encourage vertical transmission of bacteria to progeny. In the modern broiler, the incidence of bacterial chondronecrosis with osteomyelitis (BCO) is the most common cause of lameness. The objective of this study was to determine if feeding broiler breeder hens a direct fed microbial would reduce BCO in the progeny. In addition, determine if feeding the same direct-fed microbial to the progeny would have an impact on the incidence of BCO. The chicks in this study were from breeders fed a standard breeder feed (CT) or breeders fed *Bacillus subtilis* (BSS) supplemented feed. The CT chicks were fed an unsupplemented broiler diet control diet (CTCT) or *Bacillus subtilis* diet (CTBSS), while the chicks from the BSS fed hens were fed *Bacillus subtilis* (BSSBSS) or a control diet (BSSCT) (7 pens/treatment; 50 chicks/pen). Lameness was induced by placing a 60 degree angle wire-floor ramp between the feed and water at 28d. It should be noted that study incidences of femoral and tibia lesions are higher than commonly found without the added stress of the speed bumps. At 56d, 30 of the remaining broilers from each pen were individually gait scored (0-2 system), and 30 were necropsied to identify femoral or tibial lesions. Severity of lesions were scored on a scale of 1 to 8. From necropsy the severity of femoral head lesions was higher in the CTCT group than the BSSCT (3.6, 3.3 average score respectively). No differences in severity of tibia lesions were noted among the groups. The incidence of femoral and tibia lesions were similar in all of the groups as well. Hens fed *Bacillus subtilis* produced broilers that had a slower progression of femoral head disease.

Key Words: breeders, broilers, *Bacillus subtilis*, lameness, femoral head

M56 Evaluating the effect of corn and/or rye based diets on gut health, bone strength and body weight in modern broiler chickens Mikayla Baxter*^{GS}, Billy Hargis¹, Juan David Latorre¹, Steve Ricke¹, Si Hong Park¹, Sami Dridi¹, Liz Greene¹, Steve Bickler², Ruben Merino³, Memo Tellez¹ ¹*University of Arkansas*; ²*University of California, San Diego*; ³*Universidad Nacional Autónoma de México*

Diet composition has a major impact on digestibility, gut health and production in modern broilers. Feed ingredients containing a high amount of non-starch polysaccharides (NSP), such as wheat, bakery byproducts, high levels of DDGS, or rye grain, have been reported to decrease nutrient digestibility and growth performance, in addition to increasing digesta viscosity, number of coliforms in the intestinal tract, and gut permeability in broilers. The purpose of this study was to determine if broiler chickens could rehabilitate the intestinal epithelial barrier after consumption of a rye-based diet and determine if physiological damage could be repaired. From hatch to 10 d-of age birds were fed either corn or rye-based diets. At day ten, diets were switched to one of four treatments; corn to corn (C-C); corn to rye (C-R); rye to rye (R-R); or rye to corn (R-C). Chickens were cultured at 10d and 20d where livers were collected for bacterial translocation (BT), serum was collected for FITC-D measurement, cloacal swabs were taken for total IgA levels, duodenum and ileum samples were collected for morphometric analysis and tibia were collected for bone strength. At 10d, chicks on the corn diet resulted in significantly higher body weight (BW) and lower serum FITC-D, than chickens on the rye diet ($P<0.05$). At 20d, chickens on the C-C and R-C diets had higher BW, tibia diameter, bone breaking strength, villus height to crypt depth ratio in the ileum and smaller crypt depth in both the ileum and duodenum than the R-R and C-R groups. BW at 20d in C-C and R-C were similar ($P>0.05$), indicating that

switching from rye to corn resulted in compensatory gain. C-C and R-C had lower BT and cloacal IgA than the R-R and C-R, suggesting that a dietary switch allows the gut epithelium to recover. However all groups that received rye had higher levels of FITC-D when compared with C-C chickens suggesting that nutrition did not completely rehabilitate paracellular leakage within the time frame of this experiment. As well, the higher amount of BT in rye fed birds at 20d pose a food safety risk by increasing the risk for contamination if these broilers were harvested. Therefore, it is evident that high rye diets negatively impact the gut permeability and stunt growth, however switching diets allows chicks to rehabilitate their gut resulting in compensatory growth and improved bone quality. The effects of these diets on microbiome composition in different sections of the gastrointestinal tract as well as gene expression of tight junction proteins are currently being evaluated.

Key Words: Gut health, Nutritional rehabilitation, Broiler

M57 Infrared thermography (IRT) as a non-invasive indicator of leg lesions associated with bacterial chondronecrosis with osteomyelitis (BCO) in broilers Shawna Weimer*^{GS}, Andronikos Mauromoustakos, Robert Wideman, Dawn Koltz, Karen Christensen, Yvonne Vizzier-Thaxton *University of Arkansas*

Lameness is a prominent welfare issue in broilers. Bacterial chondronecrosis with osteomyelitis (BCO) is a major contributor to lameness. Currently, the method to diagnose the presence of BCO is *post-mortem* necropsy. Our long-term objective is to non-invasively assess BCO in broilers *pre-mortem* by measuring leg surface temperatures with infrared thermography (IRT) technology. Two experiments were conducted to evaluate the effect of light intensity (5, 10, and 20 lux) and flooring type (litter vs. wire) on the incidence of BCO. The objective was to assess the relationship of leg surface temperatures (°C) taken *pre-mortem* to the *post-mortem* severity of BCO lesions in the proximal femoral head (femoral head necrosis; FHN) and the proximal tibial head (tibial head necrosis; THN) of clinically lame broilers. Day old chicks were placed into six environmental pens with litter flooring. Light intensity treatments began at 1 wk of age. At wk 4 of age, half (N = 50) of the birds in each litter pen (N = 6) were moved to a wire flooring pen (N = 6) with the same light intensity as the source litter pen. Clinically lame birds were culled daily from 35 to 56 days of age in both experiments. An image of each leg was taken with a thermal image camera and anatomical leg areas were isolated within each image using the thermal imaging software. The birds were humanely euthanized and the proximal femoral and tibial heads were macroscopically scored for necrosis severity. Birds from both experiments were pooled for Pearson's pairwise correlation analysis and a p-value of $P < 0.05$ was considered significant. Only birds raised on the wire flooring developed BCO and cumulative BCO lameness increased with age. Light intensity had no effect on lameness incidence. The severity of FHN lesions did not increase with age ($P = 0.22$). However, the severity of THN lesions did increase with age ($P = 0.02$). As the cumulative combined severity of THN and FHN lesions increased, there was an increase in average temperatures of the hock ($P < 0.0001$), shank ($P = 0.02$), and foot ($P = 0.008$). These studies suggest IRT can be used as a non-invasive tool for detecting BCO lesions in live broilers.

Key Words: broiler, non-invasive, IRT, BCO, welfare

M58 Carcass and parts yield of broiler chickens incubated with a photoperiod and reared in different day lengths Janessa Henry*^{UG}, Kayla Graham, Xuijie Li, Janice MacIsaac, Bruce Rathgeber *Dalhousie University*

Consumption trends continue to favor the production of cutup parts compared whole carcass chicken. Breast meat and wings continue to be the most valuable parts. Photoperiod length has been used to influence growth rates of broiler chickens, with some studies showing near continuous photoperiods lead to higher breast meat yields. Earlier provision of light during incubation has been shown to produce chicks that achieve superior early growth rates, however it is not known how this may influence meat yield.

The current study analyzed the provision light during incubation and during the rearing period. Eight incubation units were used to replicate 2 setter treatments in combination with 4 hatcher treatments. From day 0-18 of incubation, eggs were set in complete darkness (D) or in 12 hours of light (L) per day using LED lights (4100K). Hatcher treatments consisted of 0L:24D, 12L:12D, 18L:6D, or 24L:0D in each of 2 hatchers. Two replicate trials produced 2304 unsexed chicks each that were placed in 1 of 4 rooms with 24 pens each to provide 3 pens per treatment combination per room. Two rooms had a photoperiod of 18L:6D from 0-33 days of age and the treatment was 23L:1D. At 33 days of age, 2 birds of each gender were selected from 2 pens per treatment per room, weighed and slaughtered (256 birds per trial). Carcasses were air chilled at 4°C overnight. Cold carcass weights and weights of wings, breast meat and bone-in legs were determined. There was a significant interaction with photoperiod in the setter, photoperiod in the rearing environment and gender for leg yield ($P < 0.05$). There was an increased yield for males (21.9%) compared to females (21.1%) when the eggs were set in the light and birds were given long days and when eggs were set in the dark and birds were given shortened days (male 21.8%; female 21.2%) otherwise there was no difference between genders. There were no interactions for breast meat yield or wing yield. Longer day lengths (22.4%) in the rearing facility increased ($P < 0.001$) breast meat yield compared to 18L:6D (22.2%). Rearing photoperiod has a measureable impact on carcass yield however, the photoperiods used in this study during incubation did not influence meat yield as a percentage of bird weight.

Key Words: Incubation photoperiod, Rearing photoperiod, Breast meat yield, Leg yield

M59 Air cell size profile and its relationship to eggshell temperature and water loss in broiler hatching eggs through day 12 of incubation Oluwaseun Durojaye*^{GS}, Katie Elliot, Edgar Peebles *Mississippi State University*

The air cell size profile of broiler hatching eggs (Ross 708) between 3 and 12 d of incubation (DOI) and its subsequent relationship to eggshell temperature (EST) and percentage egg water loss (PEWL) was determined. Seventy-two eggs were weighed and set on each of the 4 middle levels of a single-stage incubator. Seven eggs (28 eggs in total) on each level were selected at random at 4:00 PM on each DOI to measure air cell depth (ACD; cm), EST (infrared thermometry; °C), egg volume (EV; water displaced; mL), egg weight (EW; g) and air cell volume (ACV; water added; mL). Egg water loss of each egg was determined between 3 and 12 DOI. Mean ACD of the eggs were 0.9, 1.1, and 1.3 cm at 3 to 5, 6 to 10, and 11 to 12 DOI, respectively. Across 3 and 12 DOI, EST ($R^2 = 0.732$, C.V. = 2.63), ACD ($R^2 = 0.972$, C.V. = 2.32), ACV ($R^2 = 0.985$, C.V. = 5.66) and RACV ($R^2 = 0.98$, C.V. = 5.49) increased with DOI, whereas EW ($R^2 = 0.95$, C.V. = 0.75) decreased with DOI. Moreover, across 3 and 12 DOI, PEWL had significant ($P < 0.0001$) positive correlations with ACD ($r = 0.907$) and ACV ($r = 0.947$), and EW had significant ($P < 0.0001$) negative correlations with ACV ($r = -0.456$), RACV ($r = -0.538$), and ACD ($r = -0.443$). At 5 ($r = 0.399$, $P = 0.039$) and 6 ($r = 0.426$, $P = 0.027$) DOI, RACV was positively correlated with EST. In concurrence with increases in ACD and ACV with DOI, it was concluded that air cell size between 6 and 12 of DOI is adequate for pragmatic implantation of thermistors in the air cells of broiler hatching eggs for recording embryo temperature. Furthermore, EST may affect air cell size directly or indirectly through its effect on PEWL. Additional studies are needed to confirm these relationships.

Key Words: air cell, broiler, eggshell temperature, hatching egg, water loss

M60 Effect of in ovo LAB and Gram-negative bacterial inoculation on microbial profiles of broiler chicks Kim Wilson*^{GS1}, Whitney Briggs¹, Audrey Duff¹, Kendal Searer¹, Kyle Teague², Lucas Graham², Lisa Bielke¹
¹The Ohio State University; ²University of Arkansas

Improved GIT development of chicks may be influenced by exposure to bacteria during hatch. To promote early colonization of beneficial bacteria, *in ovo* administration is a potentially efficient means to influence pioneer colonizers of the GIT. Impact of different types of pioneer colonizers on gut health are not well-studied, especially direct comparison of Gram-negative and lactic acid producing (LAB) strains. Two initial studies of embryonic day (ED) 18 inoculation with *Citrobacter freundii* at 10² or 10³ CFU resulted in increased LAB (P<0.0001) recovery from GIT compared to the control in experiment 1. Inoculation with *Klebsiella oxytoca* did not have significantly increased LAB recovery at 72h post-hatch in experiment 2. We hypothesized that some species of apathogenic Gram-negative bacteria may promote beneficial changes in the microbial profiles of chicks. The objective of experiment 3 was to directly compare these strains, plus LAB on the microbial profile of chicks at day of hatch (DOH) and 72 h post-hatch. At ED18, embryos were inoculated with either saline (SAL), or approximately 10² CFU of *Citrobacter freundii* (CF), *Klebsiella oxytoca* (KO) or a LAB probiotic (PRO). On DOH, GIT were collected for microbial enumeration on tryptic soy agar (TSA) for aerobic bacteria, McConkey agar (MC), and MRS agar. Results showed significant (P<0.05) 4 Log10 or greater increase on TSA and MC in all bacterial inoculation groups compared to SAL. KO and LAB groups had increased (P<0.0001) MRS CFU compared to SAL and CF. At 72 h post-hatch, upper and lower ileum and ceca were separated and cultured similar to DOH. CF had higher cecal recovery on TSA and upper ileum on MC (P<0.05), compared to SAL. Additionally, KO showed higher lower ileum recovery on MRS (P<0.05) compared to LAB. Taken together, these studies suggest that *Citrobacter* and *Klebsiella* may have different influences on pioneer microbial profile of the GIT, and some Gram-negative bacteria may have positive effects on diversity and establishment of pioneer colonizers in the GIT. Additional samples will be evaluated for microbiome and proteome analysis to further study the influence of these bacteria on overall populations and GIT development.

Key Words: in ovo, pioneer colonizers, microbial diversity, probiotics

M61 Post-hatch performance of pullets provided light during incubation Nilakshi Abeyasinghe*^{GS1}, William Hannah¹, Janice MacIsaac¹, Karen Schwean-Lardner², Bruce Rathgeber¹ ¹Dalhousie University; ²University of Saskatchewan

Incubation conditions affect hatch performance and chick quality and can have a lasting influence post-hatch. The aim of this study was to determine the impact of light on early growth rate of layer chickens provided light during incubation. Two strains of laying hen eggs (Lohmann Lite and Lohmann Brown) were incubated (n=2400 in total) in 6 incubators. Two incubators were assigned to one of 3 lighting treatments. Traditional dark (D21) served as control (n=600; 300 of each strain). 600 eggs from each of 2 strains were incubated under predominantly red LED light (ONCE Innovation dim to red) for first 18 days of incubation with a photoperiod of 12L:12D. One half of these eggs were transferred to dark conditions on day 18 (R18) with 600 eggs remaining in red light (R21) for last 3 days of incubation. The remaining 600 eggs were incubated in white light (4100K) for 21 days (W21) with a 12L:12D photoperiod. Several post-hatch parameters were measured in pullets (n=512) reared in two different light regimes. Control birds were housed in 32 cages at 8 birds per cage and were given a photoperiod of 23L: 1D in first 3 days and 20L:4D from 4 to 14 days of age. Treatment birds were reared at the same density and number of cages with a photoperiod of 18h of light with one of these split into two 30 min phases provided intermittently during dark period in first 3 days. From day 4 to 14 light was reduced to 17h of continuous light with two 30 min phases. Body weights were measured at placement, followed by 6 h later and at 14 days of age. Placement body weights differed between hatchery light treatments (P<0.05). Chicks from the dark treatment (D21) were heaviest

(40.3±0.26g) and R18 chicks were lightest (38.7±0.26g) at placement. The other 2 groups were intermediate in size (W21 and R21, 39.6±0.26g). Over the course of 6 h the R21 birds gained the most (P<0.05) weight (1.49g) and the D21 birds gained the least (0.39g). The weight gain by 14 days of age was highest (P<0.05) for R18 and R21 (86.3 and 85.9g) while D21 had the lowest gain (79.2). There were no interactions with strain of bird and incubation treatments. Both types of laying hen benefited from the provision of red LED lights during incubation on early body weight gains.

Key Words: Lighting, Incubation photoperiod, Pullets

M62 Providing a photoperiod during incubation on broiler 6 hour post placement and final body weight Kayla Graham*^{GS}, Xujie Li, Janice MacIsaac, Bruce Rathgeber *Dalhousie University*

Early chick performance is important for broiler chick health and growth and is a good indicator of final body weight at the end of production. It was hypothesized that with the provision of light during incubation, chicks would get off to a better start and have an increased early growth rate. LED lights (4100K) were installed in the incubators and eight light programs were used. Two lighting programs were used from day 0-17 in the setting phase using a control of 0L:24D and a light treatment of 12L:12D. The eggs were then exposed to 0L:24D, 12L:12D, 18L:6D or 24L:0D for the last three days of incubation in the hatching phase in a factorial arrangement with setter treatments. 2,016 Ross 308 chicks were then placed in four rearing rooms in gender mixed pens. Two rooms had a photoperiod of 23L:1D and the other two rooms had a photoperiod of 18L:6D from start to 33 days of age. Body weights of the chicks were taken at placement and again 6 h post placement. The birds were reared until market age at 33 d when a final body weight was recorded. 6 h post placement body weight gains and 33 d of age body weight results were analyzed using the Proc Mixed Procedure of ANOVA. The results indicate that there was no difference between setting photoperiods but there was a difference in the hatching photoperiods for 6 h body weight gain. The lowest gains (P<0.05) at 6 h post placement were chicks hatched in 24L:0D set in 12L:12D (4.0g) or 0L:24D (3.6g) and chicks hatched from 0L:24D and set only in 12L:12 (4.2g). The remaining hatch photoperiods were not different from each other. At 33 days, there was no difference in body weight for any treatment combinations (2,240 kg). The results indicate that providing the chicks with a photoperiod of 24L:0D for the last three days of incubation has a negative impact on early growth performance at 6h post placement but no effect on final body weight.

Key Words: broiler, Lighting, Incubation photoperiod, Growth performance

M63 The impact of photoperiod spectrums during incubation on chick yolk free body weight William Hannah*^{GS}, Xujie Li, Kayla Graham, Bruce Rathgeber *Dalhousie University*

Removing novel stressors from the environment of newly hatched chicks has been found to be a key management strategy for increasing their health. Providing an embryonic photoperiod has been shown to be a successful management strategy. The objective of the experiment was to examine the effect of different light spectrums applied as a 12L:12D photoperiod on hatch performance. Performance included, chick hatch weights and yolk free body weight (YFBW) of male and female chicks on hatch day. Eggs from two strains of laying hens (Lohmann Lite and Lohmann Brown) were used to study the effect of photoperiod during incubation. The control photoperiod consisted of no light compared to a 12L:12D photoperiod produced with a red LED lights (ONCE Innovation – dim to red) or with white LED lights (4100K). Additionally, a fourth treatment included the photoperiod with red lights for 17 days followed by dark for the last four days of incubation. Six Chick Master® G09 incubators were used with two replicate incubators for each light treatment. 2400 eggs were set and 64 male and female chicks were randomly sampled to determine the effect of different light spectra on chick weight and YFBW. Data was analyzed using Proc Mixed procedure (SAS) and means were separated with Tukeys

means separation when effects were different ($P < 0.05$). For this group of 64 chicks, only the male provided a red photoperiod the entire incubation period used more ($P < 0.05$) of their yolk sac by hatch day. YFBW was 89.6% compared to 86.6% for dark and 87.5 for white. Chicks hatched in red with the last 4 days dark were intermediate (87.9%). An additional 256 male chicks were sampled to further investigate the effect of the light treatments on yolk free body weight. Regardless of light source the chicks hatched in the dark had a lower YFBW (87.6%) compared to the 3 light

treatments (Red 89.2%; Red/Dark 88.7%; White 88.9%). Light during incubation favors increased yolk sac consumption in male chicks which will prepare them better for the post-hatch environment. Further studies are warranted to further investigate the influence of light on metabolic activity of chicks during incubation.

Key Words: Lighting, Incubation photoperiod, Laying hens, Yolk free body weight

Environment Management II

M64 Growth performance and carcass comparison between commercial and alternative broiler strains. Joshua Deines*^{GS1}, Doug Yoho¹, Laura Chick¹, Richard Bramwell¹, Tom Whiting² ¹University of Arkansas; ²Whiting Farms Inc.

The poultry industry has a multitude of broiler strain (breed) options when selecting parent stock breeders. The rapidly expanding popularity of alternative production systems has increased the need for broiler strains that meet the needs of these producers and consumers. As such, the objective of this study was to compare a relatively new alternative strain to an existing commercial broiler by measuring growth performance parameters, carcass yield, and consumer sensory acceptance. This experiment was conducted at the University of Arkansas Research Poultry Farm. A Whiting Farms alternative strain and the commercial Cobb 500 strain were used, 288 chicks of each. All were hatched on the research farm. Chicks were randomly distributed by strain throughout 24 pens in the same house, 12 replicate pens per strain. Feed and water were provided *ad libitum* with birds housed at one ft² per bird, 24 birds per feeder, and 24 birds per water line, with all other specifications provided according to industry standards. Bird weights (by pen) were recorded at placement and weekly through the end of the grow-out period (six weeks for Cobb, nine for Whiting). Feed consumption was measured per pen on the same weekly schedule in order to calculate feed conversion. Mortality and cull weights were recorded. Significant differences ($P \leq 0.05$) were found in all growth performance data between the two strains with the exception of mortality. The following means were found for the Whiting strain: 43.0g chick weight, 1.491kg six week weight, 1.8531 feed conversion ratio through week six, 2.405kg nine week bird weight, and 2.2486 conversion ratio for the total grow-out. Carcass characteristics were also different between the two strains for all weights measured (WOG, breast, tenders, leg quarters, rack, wings, and yield). Differences between sexes were also assessed and both strains went through a consumer sensory panel study. It can be concluded that the Whiting broiler strain has lighter bird weights, higher conversion ratio, lighter carcasses and lower yield than the commercial strain. The variability among Whiting birds was also higher. Observations of behavioral differences were also noted and may play a significant role in their appeal as an alternative broiler strain.

Key Words: broiler, alternative, strain, performance, carcass

M65 Effect of beak shape of IRBT hens on welfare and productivity Cara Hughes*^{UG1}, Jenna Griffin², Karen Schwan-Lardner¹ ¹University of Saskatchewan; ²Egg Farmers of Alberta

The optimal shape of the beak of an IRBT hen that optimizes both welfare and productivity is not well agreed upon. In some cases, birds are scored as having abnormalities when the top and bottom beak of a treated bird are not flush, and other cases a small "step" on the bottom beak is considered normal. Other abnormalities can include a crack or bubble on the upper beak. The purpose of this study was to investigate the effects of beak shape following IRBT on the productivity and welfare of adult laying hens. The treatment groups studied included: top/bottom beak flush, or shovel beak extending either 0-1 mm, 1-2 mm, 2-3 mm, 3-4 mm, >4 mm, crack noted in upper beak (crk), or bubble noted on upper beak (bbl). Ten Lohmann LSL hens per treatment (80 total) were selected from a production flock based

on these beak characteristics at 56 weeks of age and placed in individual cages for a 4-week period, allowing 10 replicates per treatment. Data collected included body weight and changes in plumage at the start and end of the 4-week period. Feed intake was collected weekly and egg production daily. Egg weight and specific gravity were recorded for the last five days. Three cages per treatment were video recorded during the photophase for 12 intermittent days throughout trial, then observed via scan sampling at 15 min intervals. All data were analyzed with SAS Mixed Procedure as a one-way factorial analyses in a completely randomized design, with Tukey's mean separation to determine where differences, if any, existed. The percentage of time birds spent performing behaviors was (log+1) transformed prior to analyses. With regards to production data, no differences were noted in body weight gain, total hen day- or hen-housed production, overall plumage, feed intake, egg weight or specific gravity over the 4 wk period.

The percent of time spent preening was significantly different between groups but with no obvious pattern based on treatment (14.2, 11.8, 12.2, 7.0, 15.6, 9.4 and 16.6% of time for control, 0-1, 1-2, 2-3, 3-4, >4, bbl and crk consecutively). To conclude, difference in beak shape of adult laying hens was not detrimental to production, with only minor differences in bird behavior.

Key Words: IRBT, Welfare, Behavior, Hens, Beak

M66 Effects of incubation temperature profiles on carcass and cut up yields of four genetic lines at 57d of age Albaraa Sarsour*¹, Edgar Oviedo-Rondón¹, Beatriz Saldaña², Luis Bernal-Arango³, Mariana Mesquita⁴, Hernan Cordova¹, Ricardo Fasanaro⁵ ¹North Carolina State University; ²Universidad Politécnica de Madrid; ³Politécnico Colombiano Jaime Isaza Cadavid; ⁴Universidade Federal de Goiás; ⁵Universidade Estadual Paulista

Temperature during incubation could affect carcass and cut up yields, but responses may vary among genetic lines. This experiment was conducted to evaluate the effects of 2 incubation temperature profiles (INC) on carcass and cut up yields of 4 genetic lines of broilers raised sex-separate up to 57d of age. A total of 1,000 eggs from 4 genetic lines: Ross 344 x Ross 708, Cobb MX x Cobb 500, Hubbard M99 x Cobb 500, and Athens Random Breed Cross, ARBC (Control) were randomly distributed into four machines with 2 INC. In the first two machines, set points were modified to keep Standard eggshell temperatures (ET) close to 37.8°C during the whole period to simulate single stage incubation. In the other two incubators, machine set points were constant (37.4°C), and therefore ET were low (36.9°C) for the first 3d and later close to 37.8°C until the last 3d when hatcher was 36.9°C and ET raised up to 39°C, as observed in multistage machines. At hatch, 960 chicks (240/genetic line) were placed in 80 pens with used wood shavings. Chickens were fed starter (0-14d), grower (15-35d), and finisher (36-56d) diets. At 57d of age, 2 broilers per pen were processed. Total carcass, wings, leg quarters, and breast meat yield weights were recorded and relative weights (% BW) were calculated. Data were analyzed as a randomized complete block design in a 4 x 2 x 2 factorial arrangement of treatments with genetics, incubation, and sex as main factors with 5 replicates/treatment. Carcass and breast yield differed ($P < 0.05$) by sex. Only one three-way interaction was observed on leg yield, and two-way interaction effects ($P < 0.05$) of genetics by sex and incubation by sex

were detected for wing and *Pectoralis minor* yields. Genetic lines differed ($P<0.05$) on carcass and breast meat yield. The Ross 708 broilers had the heaviest carcass compared with all the other strains. Hubbard M99 x Cobb 500 had heavier ($P<0.05$) leg quarter yield compared with the Ross 708 and ARBC strains, and the Cobb MX x Cobb 500 was intermediate. Ross 708 had the biggest breast ($P<0.05$) compared with all the other strains. In conclusion, genetic lines differed on carcass and cut up yields and minor effects of incubation were detected on carcass traits.

Key Words: incubation temperature, genetic lines, carcass traits, broilers

M67 Performance of Commercial layers at different Cage Tier and housing zones Athar Mahmud*, Shahid Mehmood, Muhammad Irfan, Arshad Javid, Jibrin Hussain, Sohail Ahmad, Muhammad Usman, Mian Saleem *University of Veterinary and Animal Sciences, Lahore-Pakistan*

Recent trends in commercial layer farming is changing the production trends worldwide. The commercial layer farming in Pakistan is shifting from open or semi controlled floor farms to modern automatic controlled caged farms. To this end, a total of 588 birds were used for the experimentation and arranged according to completely randomized design, divided in three house zones (Near pads, middle and near fans) and four tier levels (Lower, Bottom, Middle, Upper) being replicated 6 times with 9 birds in each cage. These birds were placed in ECO-60 caged house (4x4) having 9 birds in each pen. These performance of birds were compared for differences in production performance, egg characteristics and immune profile. Statistically analysis revealed significant differences among different housing zones regarding body weight, production %, egg mass, FCR / dozen eggs and FCR/kg egg mass. Regarding environmental measurement temperature, relative humidity and heat index remained significant. In terms of different cage tier levels, significant effect was observed regarding temperature and heat index. The interaction between house zones and tier cage levels showed significant difference in terms of body weight, production %, FCR /dozen eggs and FCR/kg egg mass, temperature, relative humidity and heat index. However, no significant effect of house zones, tier cage levels and their interaction was observed regarding egg characteristics and immune response. In conclusion, different house zones had positive influence on productive performance, especially near the pad zone whereas temperature, relative humidity and thermal index varied among different house zones and tier cage level.

Key Words: Layers, House Zones, Cage Tier, Performance, Immune response

M68 The potential impact of replacing broilers with slower growing strains on industry resources and infrastructure Anthony Pescatore*, Tatijana Fisher, Jacqueline Jacob, Michael Ford *University of Kentucky*

Interest in the use of slow growing chickens in the broiler industry is increasing due to the statement of a major grocery chain indicating that it will exclusively be using slow growing chickens by 2024. The impact of this major marketing change to the logistics and resources needed to meet consumer demand for chicken is not yet fully understood. Data from Cornish Cross birds and a popular slow growing meat type bird, the Red Ranger, were used to analyze the potential impact of this change in genetic stock. In this analysis, the average daily gain for the Cornish Cross vs. the Red Ranger was 58 g/bird/day vs. 40 g/bird/day, with a feed to gain efficiency of 1.91g feed/g gain vs. 2.24. Carcass weight without giblets (WOG) relative to live weight was 73.8% vs. 67.8% with a breast meat yield of 31.2% of WOG weight vs. 20.3%.

Based on these data, to produce one million pounds of whole carcass using Red Rangers requires 9% more birds, 7% more poultry houses for the extra birds, and 50% more houses for the extra birds and scheduling. In addition, there will be a need for 28% more feed, 27% more trucks to deliver feed and 9% more trucks to transport birds to the processing plant. Water for processing would be 9% more and 36% more offal would be produced. If the end target is one million pounds of breast meat, then the

use of slow growing birds would require 68% more birds, with the need for 128% more housing for extra birds and scheduling. There would be a need for 97% more feed and associated vehicle traffic. Water usage to process the birds would increase by 68%. In addition, there would be a 73% increase in leg meat and 94% increase in wings to be marketed. In addition, a 95% increase in offal would be produced during processing. These data indicate that the use of slow growing chickens like the Red Ranger will not only directly impact the resources needed by the poultry industry but will ultimately have a negative impact on the environment.

Key Words: Red Ranger, Slow growing, Broilers

M69 Using biochar (Pro-C[®]) as litter amendment for heat-stressed broilers Michael Smith^{*1}, Ronique Beckford¹, Bryan Biss² *¹The University of Tennessee; ²Proton Power, Inc.*

This study was conducted to evaluate the effects of adding biochar generated from Eastern White Pine to poultry litter (pine shavings) on broiler production in two temperature conditions, thermoneutral (TN) and heat stress (HS). Seven hundred and twenty day-old mixed sex commercial broilers were weighed, wing tagged and placed in each environment. Twelve replicates of 10 chicks were randomly assigned to one of three litter treatments in each environment: Treatment 1 (CON) = wood shavings litter; 2 (Pro C 10) = as 1 plus 10 % biochar by volume; 3 (Pro C 20) = as 1 plus 20 % biochar by volume. Birds were fed a corn-soybean basal diet formulated to meet NRC requirements for broilers. Feed intake and body weights were recorded weekly. On day 41, litter ammonia was measured, litter samples were collected to evaluate wetness in each pen and feet were assessed for incidence of footpad dermatitis. At slaughter on day 42, breast meat was collected and drip loss evaluated 7 days post slaughter. Data were analyzed using mixed model ANOVA (SAS 9.4, Cary, NC). Over the 41 day period, feed intake, feed:gain and weight gain were similar across treatments. However, final weight and carcass weight were significantly ($p<0.0001$) lower for bird raised under heat stress conditions. Regardless of temperature condition dressing percentage was similar between birds in the control and 20% biochar groups. Drip loss at 7 days was significantly ($p<0.0001$) lower in the treatment groups compared to the control. The lowest litter moisture ($p=0.009$) and ammonia ($p=0.02$) levels occurred in TN birds. Litter ammonia in the 20% treatment pens tended ($p=0.08$) to be lower. Neither temperature nor treatment affected footpad dermatitis ($P=0.81$) however, birds on the highest level of biochar in the litter appeared to exhibit fewer occurrences of highest FPD score. Biochar (Pro-C[®]) as a litter amendment has the potential to positively impact heat-stressed broiler production.

Key Words: Broilers, Heat-stress, Biochar, Foot pad dermatitis

M70 The impact of antibiotic-free production on broiler health Matthew Salois^{*1}, Kevin Watkins¹, Kristi Baker¹, Joanna Karavolias² *¹Elanco; ²University of Florida*

Antibiotics, including ionophores, are generally acknowledged to support good health and welfare in the production of broilers. This study examines the impact of antibiotic-free, animal-only, and conventional broiler production on specific health conditions that are indicative of broiler welfare, including eye burns, footpad lesions, and airsacculitis. Production is defined as antibiotic-free (ABF) if no antibiotics or ionophores were used at any time. Animal-only production (ANO) is classified by the use of ionophores or non-medically important antibiotics (i.e. antibiotics not used in human medicine). Finally conventional (CNV) production is defined as the permitting the use of antibiotics.

Using 2014 data from the Elanco Health Tracking System[®] (HTSi) regression analysis is used to estimate the risk of raising broilers antibiotic-free on odds of occurrence for each disease states. A logistic regression is estimated for each condition and then odds ratios (OR) ratios and 95% confidence intervals (C.I.) are calculated. The OR represents the constant effect of ABF

status on the likelihood that a certain health condition is present on a bird (Table).

OR estimates (95% C.I.)

Eye Burns		Footpad Lesions		Airsacculitis	
ABF v. CNV	ABF v. ANO	ABF v. CNV	ABF v. ANO	ABF v. CNV	ABF v. ANO
3.57 (2.02, 6.31)	2.75 (1.58, 4.86)	1.45 (1.20, 1.76)	1.08 (0.90, 1.31)	1.55 (1.20, 2.01)	1.95 (1.50, 2.52)

For example, the OR of 3.57 suggests that ABF birds have a 257% increase in the odds of having an eye burn. In other words, for an ABF bird the odds of having an ammonia burn are more than three times the odds of not having an ammonia burn for a conventional bird. Results broadly show that ABF birds have a greater likelihood of the disease being present compared to conventional birds. Therefore, policies aimed at eliminating or banning the use of antibiotics in broiler production may come with potentially negative consequences with respect to animal health and should consider responsible antibiotic use.

Key Words: antibiotic-free, broiler, ionophore, health, welfare

M71 Avian basophilia and basophilosis as indications of stress Paul Cotter*, Kathleen Cotter *Cotter Laboratory*

When differentiated by affinity for Romanowsky dyes avian granulocytes sort into three classes; heterophils, basophils, and eosinophils. The fusiform (spindle) granules of heterophils and spherical eosinophil granules are red. The metachromatic basophil granules are deep purple spheres of varying size, often dense enough to obscure the nucleus. Heterophils are most numerous, basophils and eosinophils are scarce in normal blood films. Stress and disease may alter these proportions. The purpose is to describe blood films from hens, ducks, and turkeys with high basophil counts. In the first of a two-tier separation, basophils were classified as "resting" or "reactive". In a further separation, reactive basophils were sub-classified as dendriform, dysgranulosis, dysplastic, dwarf, lake, mesomyelocyte, metamyelocyte, net, oncosis, and toxic on differences from resting cells. The two tiers complete a basophil differential count (BDC) when 100 cells are sorted. As an example, 18 wk and 77 wk commercial hens had ~63 % and ~65% resting types. The remainder, at 18 wk, was 2.2% lake, 16 % dendriform, and 17 % dysplastic. At 77 wk the non-resting distribution was 10.3% lake, 10.5% dendriform, and 2.5% dysplastic. Dwarf forms found in chickens, ducks, and turkeys; were smaller than standard sized cells by ~ 50%. Projections from the cell body of dendriform basophils contained granules. These forms are reminiscent of Ehrlich's original interpretation of mast cells acting as feeder/donors to nearby cells. The term "basophilia" is applied when basophils compose ~5% of a standard differential count. If > 25% of basophils are non-resting atypical types, the blood is described as "basophilosis". As analogy it is proposed basophilia: basophilosis :: leukocytosis: leukemoid reaction. Basophilia/basophilosis commonly occur in the context of bacteremia/fungemia and like high heterophil/lymphocyte ratios (H/L) are indications of stress or disease.

Key Words: basophil, basophilia, basophilosis, stress, fungemia

M72 Effect of fan induced photoperiod on live performance and yield of male broiler chickens J.L. Purswell*, H.A. Olanrewaju *ARS - USDA*

Increasing broiler house size and ventilation capacity have resulted in increased light leakage into the house. Light ingress may alter the effective photoperiod for broiler chickens and create local increases in light intensity. This study examined live performance and processing yields in male broilers reared to 63 d of age exposed to either a constant light intensity or a variable light intensity to mimic light ingress through tunnel fans. A total of 960 male broiler chicks was obtained from a commercial hatchery and allocated to 16 groups of 60 chicks; initial body weight (BW) was equated

across groups. Groups were randomly distributed to each of 16 rooms in an environmentally controlled lighting research facility. Each room was equipped with fresh pine shavings, nipple drinkers, and tube feeders. Birds were provided a commercial-style four phase corn-soy diet. BW and feed consumption (FC) data were obtained at each feed phase change. Lighting was provided with broad spectrum 6W LED bulbs. Identical lighting programs were used for both treatments until 35 d when treatments were initiated. Treatments consisted of a constant light intensity at 2.5 lux for 18L:6D and a variable light intensity based on field measurements near tunnel fans in a commercial broiler house; the resulting variable lighting treatment was 18L:6D with a peak intensity of 35 lx. Each treatment was represented by eight replicate rooms. Data were analyzed using PROC MIXED in SAS in a completely randomized design with pen serving as the experimental unit. Mortality data were subjected to arcsin transformation prior to analysis. Treatment means were separated using Fisher's least significant difference, with significance considered at $P \leq 0.05$. BW, body weight gain, and mortality were not different between treatments. Feed conversion ratio and feed consumption were significantly increased for the variable light treatment, with a difference of 0.06 g feed:g gain ($P=0.01$) and 228 g/bird ($P=0.02$), respectively. The data illustrate the need to mitigate light ingress through ventilation system components to improve live performance in broilers. In addition, research trials employing constant photoperiods may not adequately mimic the commercial broiler house environment.

Key Words: ventilation design, housing management, lighting

M73 Effect of light intensity adjusted for species specific spectral sensitivity on live performance in broiler chickens J.L. Purswell*, H.A. Olanrewaju *ARS - USDA*

Providing adequate lighting for establishment and maintenance of circadian rhythms, eating and drinking, and reproductive behavior is critical for health and well-being. The spectral response of the chicken eye differs from that of humans and as such, lighting needs may also differ. This study examined live performance in broilers subjected to lighting systems which were designed for both human and poultry vision adjusted for each species' spectral response curve.

Two trials were conducted, each using a total of 352 straight-run broilers obtained from a commercial hatchery. Chicks were randomly allocated to eight rooms at 44 chicks per room. Rooms were equipped with tube feeders and nipple drinkers; feed and water were available ad libitum. Birds were provided a four phase corn-soy diet. Lighting was provided with either a red-supplemented LED bulb designed for poultry rated at 8W or a broad spectrum LED bulb rated at 6W. Intensity levels were adjusted according to human or poultry spectral response. A precision photometer was compared against a poultry specific spectroradiometer to determine appropriate offsets to achieve proper poultry-specific intensity levels. Treatments were arranged in a 2x2 factorial design with main effects of lighting source (RS or WL) and spectral response curve (CIE or CLUX). Each treatment combination was represented by two replicate pens per trial. Data were analyzed as a randomized complete block design with ANOVA using PROC MIXED. Means were separated using Fisher's LSD.

Mean body weight among all treatments was 3969 g and FCR was 1.76. No differences in any live performance variables were detected for any main effects or their interactions. The lack of differences observed in the current study illustrate the ability of broilers to adjust to, and flourish in, a variety of lighting environments. Furthermore, the differences in lighting output when adjusting for species' sensitivities can be quite subtle, especially at typical broiler house intensities.

Key Words: lighting, housing management, spectrum

Metabolism & Nutrition I

M74 Impact of increased dietary threonine on egg quality and component yield in older laying hens. John Padgett^{*UG}, Rachel Blount, Micky Clary, John Carey *Texas A&M University*

An experiment was undertaken to evaluate the influences of increased levels of dietary threonine on egg quality and component yield in older commercial laying hens. Beginning at 65 weeks of age, 162 laying hens were randomly assigned to three experimental treatments. Sixty hens in 20 replicate units served as the control (CON) group and received a standard laying hen diet with 2900 kcal/kg, 16% Crude protein, 0.48% total methionine, 0.71% total sulfur amino acids, 0.82% total lysine, 4.5% calcium, 0.67% total phosphorus and 0.62% total threonine. Fifty one hens in 17 replicate units received the control diet with 0.2% supplemental synthetic threonine (THR_L). The remaining 51 hen (17 replicate units) received the control diet with 0.4% supplemental synthetic threonine (THR_H). Hens were housed in individual cages in a tunnel ventilated laying facility. Replicate units consisted of three hens in consecutive cages sharing access to a common feed trough. Beginning at 69 weeks of age eggs from two consecutive day's production were evaluated every 28 days for egg weight, USDA size, shell thickness, shell breaking strength and specific gravity. Beginning at 67 weeks of age eggs one day's production were sampled weekly for egg component yield. Egg weight, albumen weight and yield, specific gravity and shell yield were not affected by the treatments. Shell thickness was significantly ($P < 0.016$) greater in eggs from hens fed THR-H compared to CON. Shell breaking strength was significantly greater ($P < 0.018$) in eggs from hens fed THR_L compared to CON. Shell weight was significantly higher ($P < 0.044$) in eggs from hens fed THR_H compared to those fed THR_L. Yolk weight was significantly higher ($P < 0.017$) in eggs from hens fed THR_H compared to both CON and THR_L. Yolk yield of eggs from hens fed THR_H was significantly higher ($P < 0.014$) than CON. This experiment demonstrates that supplemental threonine in diets of older laying hens can improve shell quality and egg composition in terms of yolk weight and yield. Improved shell quality will reduce losses due to breakage in collection, packaging and transport. Greater yolk weight and yield improves the functional quality and value of eggs marketed in liquid form.

Key Words: Laying hens, Threonine, Egg Quality, Egg Component Yield

M75 Evaluating the effect of yeast cell wall supplementation on ideal threonine to lysine ratios in broilers as measured by performance, intestinal mucin secretion, morphology, and goblet cell number Raghad Abdaljalael^{*GS1}, Thomas Gaydos², Morouj Al-Ajeeli¹, Hector Leyva-Jimenez¹, Yansoon AL-Jumaa¹, Christopher Bailey¹ *¹Texas A&M University; ²Phileo-Lesaffre Animal Care*

The objective of this study was to investigate whether or not a prebiotic a yeast cell wall previously shown to improve performance in challenge studies, effects threonine requirements by measuring performance, morphology, mucin secretion and goblet cell number per villi in the intestine. Two hundred forty 1-day-old Ross 308 broiler chickens were distributed in two Petersime battery brooder units (48 pens; 5 birds per pen). Different threonine to lysine ratios (0.65, 0.70, and 0.75) with 1.23 available lysine with and without yeast cell wall (YCW) at 250 ppm was feed for a 21-day trail. A basal diet with 22% protein and 2980 Kcal/Kg ME was used for the dietary treatments. The calculated lysine concentration was 1.35 while threonine was 0.88, 0.95, and 1.02 respectively. Birds and feed were weighted by pen and the weights recorded at day 1, 7, 14 and 21 of the experiment for general performance data. At day 21, samples from excreta and small intestine (jejunum and ilium) were collected. Crude mucin was analysed from excreta samples while villi height, crypt depth, villi width, muscular thickness and goblet cell number were measured in intestinal sections. The yeast cell wall did not show any significant effect with respect to the variables evaluated in this non-challenge study. Threonine to lysine ratio 0.75:1 showed numerically higher body weight throughout the study with significant main effect for jejunum villi height, villi width, crude mu-

cin and goblet cell number. Increasing the ratio between threonine and lysine led to an increase the mucin secretion probably due to the increase in the number of the goblet cells per villi.

Key Words: Threonine, Prebiotic, broilers, intestine, mucin

M76 Effects of various levels of synthetic arginine supplementation on growth response and fat deposition in broilers Fernanda Castro^{*GS1}, Paula Sedlacek¹, Jung-un Kim², Eunji Koo², Hojun Choi², Woo Kyun Kim¹ *¹University of Georgia; ²CJ CheilJedang Corporation*

Arginine is an essential amino acid for birds. Poultry are highly dependent on arginine dietary supply, as they are incapable of its synthesis *de novo* due to the lack and low activity of the key enzymes. Several studies in different species demonstrated that arginine can influence positively desirable performance traits, such as body weight, carcass yield and reduced fat deposition. For this reason, the objective of the study was evaluate the effects of crystalline arginine on performance traits and fat content in male broilers. A total of 690 one-day-old Ross 308 broiler chicks were allocated in floor pens, distributed in a completely randomized design, with five treatments, six repetitions and 23 birds per pen. The treatments were given as a percentage of the Ross 308 requirement, and defined as T1=70% of arginine (basal diet; 77% Arg:Lys ratio); T2=80% of arginine (85% Arg:Lys ratio); T3=90% of arginine (95% Arg:Lys ratio); T4=100% of arginine (Ross 308 requirement; 106% Arg:Lys ratio); T5=110% of arginine (116% Arg:Lys ratio). The diets were based on corn/soybean meal and divided for starter (1-10d), grower (11-24d) and finisher (25-42d) periods. Body weight gain (BWG), feed intake (FI) and feed conversion ratio (FCR) were measured at 10, 24 and 42 days of age, and at 42 days abdominal fat weight was measured from three birds per pen. The means were subjected to ANOVA and, when significant ($p \leq 0.05$), means were compared by Duncan test. For the overall period, T4 and T5 showed similar and the highest BWG and FI. T3 presented higher values for these traits when compared to T2, and T1 had the lowest BWG and FI ($p < 0.0001$). T3, T4, and T5 improved FCR compared to T1 and T2 ($p < 0.0001$), whereas there was no significant difference among T3, T4 and T5. The mortality percentage in T1 was significantly higher than the one in the other treatments ($p < 0.0001$). Fat pad weight corrected for body weight was higher for T1 when compared to T2, T3, T4 and T5 ($p = 0.0012$). In conclusion, the levels recommended by Ross 308 guideline (T4; 106% Arg:Lys ratio) are enough to ensure good performance results, and the use of 70% of the requirement (T1; 77% Arg:Lys ratio) resulted in decrease in performance traits as well as in increase in fat deposition.

Key Words: Arginine, Broilers, Performance, Fat deposition

M77 Effects of guanidinoacetic acid supplementation on carcass, cut up yields, and meat quality of broilers fed corn and sorghum-based diets Hernan Cordova^{*GS1}, Edgar Oviedo-Rondón¹, Albaraa Sarsour¹, Pedro Ferzola² *¹North Carolina State University; ²Universidade Federal do Rio Grande do Sul*

Carcass and cut up yields are affected by nutrition. This experiment was conducted to evaluate the effects of guanidinoacetic acid (GAA) supplementation as a precursor of creatine in broilers fed corn or sorghum based diets on carcass and cut up yields. The treatments consisted of corn or sorghum-based diets with or without the addition of GAA (600 g/ton) as CreAMINO[®]. A total of 800 male Ross 708 chicks were randomly placed in 40 floor pens. At 51 and 55d of age, 4 birds per pen were processed; carcass and cut up parts yield were obtained. Breast fillets were evaluated for drip and cook loss, shear force, and pH was measured 1, 4 and 24 h post-slaughter. Data were analyzed as a randomized complete block design in a 2 x 2 factorial arrangement of treatments with grain type and GAA supplementation as main effects with 10 replicates/treatment combination. At 51d, leg quarter yield increased ($P < 0.05$) by GAA supplementation.

No significant effects of GAA supplementation ($P > 0.05$) were detected in carcass, wings, and breast meat yield at 51d. However, carcass yield was reduced ($P < 0.05$) in broilers fed sorghum diets (78.08 vs. 78.44%). At 55d of age, an interaction effect ($P < 0.05$) was observed on breast meat yield. Broilers fed corn diets with GAA had more breast meat (39.15% vs. 38.19%) than the non-supplemented corn diet, and broilers fed sorghum diets were intermediate (38.37 and 38.68%). Wing yield decreased ($P < 0.05$) in broilers fed sorghum diets (9.28 vs. 9.52%). Wing and leg quarter weights increased ($P < 0.05$) by GAA supplementation. Drip loss, cook loss, and shear force were not affected ($P > 0.05$) by GAA supplementation in any processing day. At 55d, breast meat pH 4h post-slaughter decreased by GAA. Likewise, breast meat pH 24h post-slaughter decreased ($P < 0.05$) due to GAA supplementation at 51 (6.01 vs. 6.08) and 55 d (5.95 vs. 5.99). In conclusion, GAA supplementation increased leg quarter at 51 d of age independently of grain type, and breast meat yield only in broilers fed corn diets at 55 d. Sorghum diets decreased carcass yield at 51 d and wing yield at 55 d of age. GAA supplementation did not affect drip or cook loss properties or shear force, and decreased breast meat pH.

Key Words: Guanidinoacetic acid, carcass, cut up yields, meat quality, broilers

M78 Effects of feeding reduced crude protein diets to broilers on growth performance and carcass characteristics from 15 to 35 d of age Ruben Kriseldi*^{GS1}, Paul Tillman², Zhirong Jiang³, William Dozier¹ ¹Auburn University; ²Poultry Technical Nutrition Service LLC; ³Ajinomoto Heartland Inc.

An experiment was conducted to determine the effects of feeding reduced crude protein (CP) diets while providing adequate essential amino acid (AA) concentrations on growth performance and carcass characteristics of broilers from 15 to 35 d of age. Fifteen hundred Ross × Ross 708 male chicks were distributed into 60 floor pens (25 birds/pen; 0.09 m²/bird). From 1 to 14 d of age, birds were fed a common starter diet formulated to contain 1.25% digestible Lys and 3,053 kcal/kg apparent metabolizable energy using of corn and soybean meal as the primary ingredients. During the grower (from 15 to 25 d of age) and finisher (from 26 to 35 d of age) periods, broilers received 1 of 6 dietary treatments varying in CP content. Diet 1 (control) was formulated with DL-Met, L-Lys, and L-Thr (21.7 and 19.8% CP in the grower and finisher periods, respectively), while additional L-Val, Gly, L-Ile, L-Arg, and L-Trp were sequentially supplemented in the order of limitation respective of diets 2 through 6. These additions were intended to meet the essential AA requirements as CP percentage was reduced in diets 1 to 6 by 2.5 and 2.3% points in the grower and finisher periods, respectively. Digestible Lys concentrations in the grower and finisher diets were formulated to 1.10 and 1.00%, respectively, whereas digestible TSAA, Thr, Val, Ile, Arg, Trp, and total Gly + Ser were formulated to 77, 68, 77, 67, 105, 17, and 170% of digestible Lys, respectively. Broilers fed diets supplemented with DL-Met, L-Lys, L-Thr, L-Val, Gly, L-Ile, L-Arg, and L-Trp had similar ($P > 0.05$) body weight gain, feed intake, and feed conversion compared with those provided the control diet from 15 to 25 and 26 to 34 d of age. Likewise, the use of DL-Met through L-Trp to reduce dietary CP content did not decrease ($P > 0.05$) total breast meat yield at 35 d of age compared with those receiving the control diet. However, a reduction ($P < 0.05$) in thigh yield at 35 d of age was observed with broilers fed diets supplemented with L-Ile and L-Trp when compared with birds receiving the control diet. Results from this study indicated that sequential addition of AA in the order of limitation from DL-Met to L-Trp allowed reduction of dietary CP content beyond 2.0% points without depressing growth performance and total breast meat yield of broilers from 15 to 35 d of age.

Key Words: broiler, crude protein, amino acid, glycine

M79 Bioavailability of non-phytate phosphorus in diets formulated with various animal protein blends or meat and bone meal sources fed to Ross × Ross 708 male broilers from 8 to 21 d of age Klinton McCafferty*^{GS1}, Curran Gehring², William Dozier¹ ¹Auburn University; ²Tucker Milling LLC

An experiment was conducted to evaluate the bioavailability of non-phytate phosphorus (P) in diets formulated with various sources of animal protein blends (APB) or meat and bone meals (MBM) fed to Ross × Ross 708 male broilers from 8 to 21 d of age. Seven commercially available APB sources of mixed species origin and three MBM sources of either porcine, bovine, or mixed bovine and porcine origins were evaluated. Crude protein, ash, calcium, and P composition of the APB and MBM sources ranged from 41.7 to 61.8, 16.8 to 45.0, 5.9 to 19.9, and 3.1 to 9.4%, respectively. Four identical trials were conducted to achieve a total 8 replicates per treatment. In each trial, 680 chicks were randomly distributed into 68 battery cages (10 per cage; 0.046 m²/bird) and a common corn-soybean meal starter diet was fed from 1 to 7 d of age. From 8 to 21 d of age, 34 experimental diets were fed to 2 replicate cages per treatment. A corn-soybean meal negative control diet was formulated to contain 0.15% non-phytate P. Monosodium phosphate (MSP), 7 APB, and 3 MBM sources were added to the negative control diet to achieve non-phytate P levels of 0.25, 0.35, and 0.45%. Bioavailability of P was estimated using the slope-ratio technique by regressing tibia shear strength and ash weight on added P intake relative to MSP. Tibia shear strength, ash weight, and relative P bioavailability did not differ ($P \geq 0.05$) among broilers fed diets containing the MBM or APB sources. Relative P bioavailability of MBM and APB sources ranged from 98 to 128% and 92 to 137%, respectively, for tibia shear strength and ash weight. Broilers fed low ash MBM or APB sources had higher ($P \leq 0.05$) tibia ash weight than broilers fed high ash MBM or APB sources. However, comparisons of tibia shear strength and relative P bioavailability between broilers fed the low and high ash APB or MBM sources were not different ($P \geq 0.05$), thus, indicating little difference in bioavailability due to ash content. These results indicate that P from MBM and APB sources are readily available to broilers.

Key Words: broilers, phosphorus, bioavailability, MBM

M80 Effects of dietary protein source, digestible threonine to lysine ratio, and coccidiosis vaccination on the growth performance and processing characteristics of broiler chickens at 33 d of age Kate Meloche*^{GS1}, Paul Tillman², Zhirong Jiang³, William Dozier, III¹ ¹Auburn University; ²Poultry Technical Nutrition Services LLC; ³Ajinomoto Heartland, Inc.

Coccidiosis is the most economically damaging disease affecting commercial poultry in the United States. Although the complications of coccidiosis have been successfully managed through the use of coccidiostats and antibiotics, growing consumer pressure has begun to limit the application of these compounds in poultry production. Vaccinating against coccidia at hatch is an effective alternative to the use of traditional coccidiostats. However, vaccination inherently elicits a mild enteric challenge, which may alter the birds' need for amino acids critical to the production of mucin and the integrity of the intestinal mucosa, such as Thr. Furthermore, some producers have opted to remove ingredients of animal origin from formulation, limiting the array of ingredients available as dietary protein sources. An experiment was conducted to determine the impact of these increasingly popular nutrition and management strategies on the performance and processing characteristics of broilers at 33 d of age. Male broilers were allocated into 120 floor pens (26 birds/pen; 0.09 m²/bird) at placement with each pen assigned to 1 of 12 treatments representing a 2 × 2 × 3 factorial arrangement of vaccination status [vaccinated (C+) and non-vaccinated (C-)], protein source [animal (AP) and vegetable]; and digestible Thr to Lys ratio (dThr:dLys; dThr was formulated at 65, 68, and 72% of dLys concentration) with 10 replicate pens per treatment. Non-vaccinated birds received feed containing salinomycin as an anticoccidial. Prior to placement, C+ chicks were spray-vaccinated with live oocysts following manu-

facturer recommendations. At 33 d of age, 6 birds per pen were randomly selected for processing and subsequent measurement of carcass characteristics. Vaccinated birds had reduced BWG and poorer FCR at 14, 24, and 32 d ($P<0.001$). Birds receiving AP diets had increased BWG and improved FCR at 14 and 24 d of age ($P<0.001$). At each age, increasing dThr:dLys improved ($P=0.005$) FCR in C+ birds receiving AP, but did not affect ($P>0.05$) FCR in C- birds, regardless of diet. Vaccination resulted in reduced carcass and breast meat yield at 33 d of age ($P<0.001$). These results indicate that C+ birds may require increased dThr:dLys to support growth performance, particularly when receiving diets formulated with AP.

Key Words: broiler, coccidiosis, vaccine, threonine, animal protein

M81 Measuring whole body CO₂ production using an intragastrically and intravenously administered bolus dose of [1-13C] sodium bicarbonate as validated by indirect calorimetry Michael Schlumbohm^{*GS1}, Katie Hilton¹, Garrett Mullenix¹, Pramir Maharjan¹, Maria Mayorga¹, Judy England¹, Behnam Saremi², Craig Coon¹ ¹University of Arkansas; ²Evonik Nutrition and Care GmbH

In measuring substrate oxidation and energy expenditure, it is first important to know total CO₂ production. There are two methods for measuring CO₂ production; one is to use an infusion of [1-13C] sodium bicarbonate while the other is to use indirect calorimetry. A total of 160 male broilers, at 21 days of age, were infused with [1-13C] sodium bicarbonate in a 100μM/Kg dose. 80 birds were infused intragastrically (IG) and 80 birds were infused intravenously (IV). For birds infused through IV, the isotope solution was given in a 5ml dose. Birds infused through IG were given the solution in a 1ml dose. To determine the entire kinetic curve of the [1-13C] sodium bicarbonate birds were infused and blood samples were taken via the jugular vein at 2, 5, 10, 15, 30, 45, 60, and 120 minutes post-infusion. Whole blood [1-13C] enrichment was analyzed by GC-IRMS. Data were analyzed using JMP Pro 12 pharmacokinetic modeling. Additionally, 12 birds were placed in metabolic chambers to determine total CO₂ production via indirect calorimetry. This data was then compared to the two infusion methods of [1-13C] sodium bicarbonate to determine a correction factor for calculating the total volume of CO₂ (VCO₂). The following equation for finding VCO₂ was developed for both IG and IV infusion methods: $VCO_2 = (k \cdot Q) \cdot [1-13C] \text{ CF}$. Where k is the elimination rate (μmol/min) and Q is pool size (μmol) and [1-13C] CF is the correction factor. Both infusion methods represent an over estimation of VCO₂. VCO₂ as determined by indirect calorimetry, represents 99.69% of VCO₂ as calculated by IG infusion while representing 57.89% of VCO₂ as calculated by IV infusion. With IV infusion the elimination rate (0.0749μmol/min) is much faster than in IG infusion (0.0444μmol/min) which accounts for the higher over-estimation of VCO₂. By using these correction factors of 99.69% and 57.89% for IG and IV infusion respectively, total CO₂ production can be calculated using a bolus dose of [1-13C] sodium bicarbonate.

Key Words: [1-13C] sodium bicarbonate, CO₂ production, bolus dose, indirect calorimetry, substrate oxidation

M82 Comparison of two net energy calculations of two broiler strains fed varying levels of amino acids and varying levels of metabolizable energy Katie Hilton^{*GS1}, Garrett Mullenix¹, Michael Schlumbohm¹, Justina Caldas¹, Pramir Maharjan¹, Maria Mayorga¹, Judy England¹, Victor Naranjo², Antonio Kulinowski², Craig Coon¹ ¹University of Arkansas; ²Evonik Nutrition and Care GmbH

Two studies were conducted. The purpose of study one was to determine the effect of feeding diets with varying dietary amino acid levels to two modern broiler strains on net energy (NE) from d 22 to d 43. The purpose of experiment two was to determine the effect of feeding varying levels of dietary metabolizable energy (ME) on NE from d 22 to d 43. Chicks from two genetic lines were fed three experimental diets starting on day 22. Experiment one diets were iso-caloric and formulated to AMINOChick[®] 2.0 recommendations for dLys and were formulated at 80, 100 and 120% of the dLys. All other amino acids were formulated as a ratio to dLys. In

experiment two, diets were iso-nitrogenous and true metabolizable energy (TME_b) values of diets determined *in vivo* were 2819, 3137, and 3452 kcal/kg. Birds were moved to the respiratory chambers 1d before evaluation for a period of adaptation. Heat production (HP) $Kcal=3.872 \cdot VCO_2 (L/d) + 1.195 VCO_2 (L/d)$ (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 d 22 and d 42 by dual energy X-ray absorptiometry (DEXA) to determine net energy gain (NEg). Two NE equations were compared, $NE_1(kcal)=ME-HI$ versus $NE_2(kcal)=NEg + NEm$, where NEm (net energy maintenance)=HP – HI. NE percent (NE%) of gross energy was calculated by $\%NE=NE/GE$ in the diet. Data were analyzed using JMP Pro 13 (SAS, 2016). For both experiments there was no significant interaction between genetic line and diet for NE. Experiment one showed that as amino acids increased, lean mass increased ($p<0.0001$). As amino acids increased bivariate regression tended ($p=0.1848$) to indicate a difference between NE equations by 185 kcals. However, in experiment two, as ME increased, body fat increased ($p<0.0001$), but did not increase ($p=0.5993$) lean mass. As ME increases bivariate regression indicated a significant ($p=0.0316$) difference between NE equations by 131 kcals. These studies indicate that using an equation with both HP and body composition is more precise in describing NE.

Key Words: Net Energy, Heat Production, Body Composition, Metabolizable Energy, Amino Acids

M83 Varying dietary amino acids, metabolizable energy levels and seasonal effects on modern broiler growth performance and processing yields Garrett Mullenix^{*GS1}, Katie Hilton¹, Michael Schlumbohm¹, Justina Caldas¹, Judith England¹, Antonio Kulinowski², Victor Naranjo², Craig Coon¹ ¹University of Arkansas; ²Evonik

The objective was to establish how two modern broilers respond to dietary amino acid (AA) and energy levels at different environmental temperatures (seasons). Body weight (BW), average daily gain (ADG), feed conversion ratio (FCR) and processing yields were evaluated. Trials were alternated during seasons to identify if ambient temperature impacted performance. Four trials, each with 2025 male broilers of each strain (Cobb MX x Cobb 500 and Ross YP x Ross 308) were placed in 90 pens ($n=45$ birds/pen) and fed a common commercial starter and grower diet from 1-10d and 11-21d, respectively. Experimental finisher diets included 5 varying levels of either AA or energy and fed 22-42d in pellet form (9 replicates per strain/diet). The varying AA finisher diets were isoenergetic (3125 kcal/kg) and formulated to 80%, 90%, 100%, 110%, 120% of the ideal amino acid recommendation of AMINOChick[®] 2: 0.80%-, 0.90%-, 1.00%-, 1.10%- and 1.20% dLys, respectively. The finisher metabolizable test diets were iso-nitrogenous and formulated to different AMEn levels: 2800, 2925, 3050, 3175 and 3300 kcal/kg. In all trials, the 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. At 42d 90 birds per strain/diet were processed. There were no strain x diet interactions for any performance parameters in either trial, however there was significant energy diet x season interactions ($p=.0416$) at 42d. A strain x season effect ($p<0.0001$) was observed in the dietary energy trial; strain A performance was effected more by temperature than strain B. Increasing either dietary AA ($p<0.0001$) or metabolizable energy ($p=.001$) significantly affected 42d BW. Strain B was significantly heavier ($p=0.0113$) at 42d in the energy trials while the AA trial showed strain A significantly heavier ($p=.0012$) at 42d. These trials suggest that broiler strains' performance were affected more by increasing AA density than dietary energy and environmental temperatures affect strain performance.

Key Words: Amino Acid, Processing yield

M84 Effects of feed form during the starter period on productive and processing performance of broilers Andrea Rubio^{*GS1}, William Dozier¹, Endhrier Lezcano² ¹*Auburn University*; ²*Zamorano*

Feed form during the starter period has the potential to influence the subsequent performance of broilers. The objective of this study was to evaluate the effects of feed form during the starter period on live performance and processing yields of broilers. One thousand 1-d old male Ross x Ross 708 broiler chicks were randomly placed in 40 floor pens (25 birds per pen; 0.12 m²/bird). The birds were raised on used litter that was top-dressed with new wood-shavings at the start of the study. Broilers received 5 dietary treatments (8 replicate pens per treatment) that consisted of a combination of 3 dietary feed forms provided over the starter period (1 to 14 d): mash, crumbles, and/or 3.3 mm micro pellets. The 5 treatment combinations were as follows: 1) mash from 1 to 14 d, 2) crumbles from 1 to 14 d, 3) micro pellets 1 to 4 d and then crumbles to 14 d, 4) micro pellets 1 to 7 d and then crumbles to 14 d, and 5) micro pellets from 1 to 14 d. Common grower and finisher diets were offered in a 4.4 mm pelleted form from 15 to 35 d of age. Feed consumption and BW were determined at 4, 7, 14, 25, and 35 d of age. At 36 d, 10 birds per pen were processed for the determination of carcass characteristics. After processing, carcasses were chilled in slush ice for 4 hours before chilled carcass weights were determined. At 37 d, chilled carcasses were deboned to determine total breast meat yield (pectoralis major and minor muscles). Birds fed mash diets during the starter period had the lowest BW ($P < 0.01$) and feed consumption ($P < 0.01$) at 4, 7, 14, 25, and 35 d of age compared to the birds that received either crumbles and/or micro pellets. Moreover, birds fed mash diets during the starter period had the poorest FCR ($P < 0.01$) at 4, 7, 14, and 25 d of age compared to the birds that received either crumbles and/or micro pellets during the starter period. Birds fed micro pellets from 1 to 7 and 1 to 14 d had higher breast meat weight (519 vs. 488 g, $P < 0.01$) compared with the birds fed mash diets during the starter period. The results of this experiment indicated that feed form during starter period has an impact on bird subsequent performance.

Key Words: carcass, crumble, mash, micro pellets, pellets

M85 Diet formulation and feed processing effects on 18-d broiler performance Ariel Bergeron^{*GS}, John Boney, Brian Glover, Victoria Homan, Joseph Moritz *West Virginia University*

Feeding pelleted diets to broilers produces multiple advantages associated with improved physical form of feed. However, the effects of the pelleting process on nutrient digestibility are not as well understood. Nutrient digestibility may be dependent on diet formulation and degree of feed processing. The objective of the study was to assess performance of broilers fed diets that differed in formulation and exposure to thermal influences of feed processing. Dietary treatments consisted of a basal formulation that included corn, soybean meal, and distiller's dried grains with solubles, basal with meat and bone meal, or basal with bakery byproduct meal. Diet formulations were balanced to be similar in energy and digestible amino acids based on published values. Feed processing treatments consisted of unprocessed mash, ground pellets exposed to the pelleting thermal process once, or ground pellets exposed to the pelleting thermal process twice. The pelleting thermal process consisted of 82°C conditioning for 10 sec and extrusion through a 4.8 x 38.1 mm pellet die. Prior to feeding, diets did not differ in moisture content or particle size by more than 150 µm. Diets were fed to nine replicate raised wire cages of 10 straight-run Hubbard x Cobb broilers for 18 d. Performance data were analyzed using a 3 x 3 factorial arrangement in a randomized complete block design. Diet formulations containing meat and bone meal improved feed conversion ratio (FCR) ($P = 0.0046$). In addition, thermal processing in general improved FCR ($P = 0.0003$). Diet formulation and feed processing interacted to affect live weight gain (LWG) ($P = 0.0349$). Processing in general improved broiler LWG for meat and bone meal containing diets but not bakery byproduct meal or the basal diet ($P < 0.05$). The meat and bone meal may have contained greater digestible amino acids compared to the published values used for diet formulation. Thermal processing may have improved ingredient digestibility. The

combination of improved ingredient digestibility due to thermal processing and meat and bone meal inclusion likely enhanced broiler performance. These data suggest that thermal processing within the specific study parameters does not negatively affect digestibility of these particular ingredients.

Key Words: thermal processing, diet formulation, nutrient digestibility, performance

M86 Effects of environment, feed form, and caloric density on energy partitioned to performance and immune response Brian Glover^{*GS}, Jessalyn Hadfield, John Boney, Ariel Bergeron, Joseph Moritz *West Virginia University*

Performance benefits noticed from feeding broilers an improved pellet quality have been well documented. Energy savings from an improved crumble/pellet percentage via feed prehension could affect dietary caloric requirements, performance, yield, and health. The objective of the study was to assess the effect of variations of crumble/pellet percentages, dietary caloric density, and broilers' rearing environment on performance, carcass yield, and immune response. All diets were manufactured at the West Virginia University pilot feed mill. Treatments were organized in a split-plot consisting of a 2 x 2 factorial arrangement in a randomized block design. Whole plot treatments were considered one room (11 x 7.32m) of either clean shavings or built-up litter; divided into 16 treatment replications of either standard (30% crumble/pellet) or improved feed form (80% crumble/pellet), and 16 replications of either standard or increased caloric density (+110 kcal/kg) comprising the 2 x 2 factorial arrangement. On day 39 representative birds per pen were processed and yield data was calculated. Ileum samples were collected at the end of the finisher phase for RNA extraction. Immune response was determined through gene expression of TLR2, IFN γ , and IL-8 by RT-qPCR. Linear contrasts demonstrated that broilers provided improved feed form at standard energy increased feed intake, and live weight gain, ($P \leq 0.05$) while maintaining feed conversion ratio ($P \leq 0.05$) compared to broilers provided standard feed form at increased energy regardless of environment. Improved feed form increased breast yield for broilers reared on clean shavings ($P \leq 0.05$). An environment x feed form interaction ($P \leq 0.05$) showed up-regulation of TLR2 for birds fed standard feed form and reared on built-up litter and down-regulation of IL-8 for birds fed improved feed form and reared on built-up litter; TLR2 and IL-8 did not vary by feed form for birds reared on clean shavings. These data suggest that improved feed form may conserve maintenance energy requirements and benefit performance, yield, and immune response.

Key Words: crumble, immune response, pellet, broiler, feed form

M87 The effect of diets varying in commercial phytase product subjected to increasing steam conditioning temperature on broiler performance and tibia mineralization Victoria Homan^{*GS}, John Boney, Joseph Moritz *West Virginia University*

Phytases are commonly added to diet formulations prior to pelleting to support phosphorus requirements in broilers. Commercial phytase products vary in thermal stability, site of action, mode of action, and manufacturer suggested protocols for determining activity. The objective of this study was to evaluate three commercial 6-phytase products within a phosphorus deficient corn and soybean meal based diet subjected to increasing steam conditioning temperature on broiler performance and tibia mineralization. Commercial phytase products included a *Buttiauxella* phytase expressed in *Trichoderma reesei* (B Trich), an *E. coli* phytase expressed in *Pichia pastoris* (E Pichia), and an *E. coli* phytase expressed in *Trichoderma reesei* (E Trich). Conditioning temperatures included 82, 88, and 93°C for a duration of 10 seconds prior to extrusion through a 5 x 38 mm pellet die. Commercial phytase products were analyzed for activity using the AOAC 2000.12 method at two different laboratories. The lower obtained activity was utilized to include each product at 1,000 FTU/kg of the diet prior to pelleting. Post extrusion, diets were ground to eliminate any variations in feed form and stored in a dehumidified room to ensure diets were of a similar moisture level, i.e. 12 percent. Diets containing the three com-

mercial phytase products and a negative control diet without phytase were subjected to each conditioning treatment and fed to eight replicate raised wire cages of 10 Hubbard x Cobb straight-run broiler chicks for 20 d. Treatments were blocked by cage location within room. Broiler performance and tibia mineralization were analyzed using a 4 x 3 factorial arrangement within a randomized complete block design. The main effect product was significant for feed intake (FI), live weight gain (LWG) and feed conversion ratio (FCR). Broilers fed diets without phytase had the lowest FI and LWG ($P < 0.05$). Broilers fed E Trich had the highest FI and LWG ($P < 0.05$). Broilers fed B Trich and E Pichia had lower FCR compared to broilers fed diets without phytase and E Trich fed broilers were not distinguishable from other treatments ($P < 0.05$). The main effect conditioning temperature was significant for FI and LWG. Increased conditioning temperature sequentially decreased both FI and LWG ($P < 0.05$). Main effect interactions were not apparent ($P > 0.05$). Commercial products demonstrated differences in supporting the phosphorus requirement in broilers and increasing conditioning temperature was detrimental to broiler performance. Increased conditioning temperature may have decreased nutrient availability per se, denatured phytase products, or both factors contributed to performance detriment.

Key Words: phytase, thermostability, tibia mineralization

M88 Effect of corn particle size on nutrient utilization and growth performance of commercial broilers and pullets Lisa Kitto^{*GS}, Paul Patterson, R. Michael Hulet *Pennsylvania State University*

Dietary particle size for poultry diets has been debated for years, as it is related to pellet durability, fines, growth, feed conversion, and carcass characteristics for broiler chickens. In hens and pullets, less information is available regarding the impact of particle size, though research is equally important to maximize nutrient uptake, pullet growth, and hen performance. Two projects evaluated the impact of particle size. Both studies utilized corn ground to a mean particle size (PS) of 600, 900, 1200, or 1500 μ m, and all diets were formulated to contain the same level of nutrients across all treat-

ments. The broiler study compared diet digestibility, feed intake, growth and conversion, while the pullet study measured growth, feed conversion, and physiologic parameters before transition to the hen house.

Day old Cobb-500 male broilers (196) were placed into 17 battery cages with 10-16 birds per cage. Birds were fed a standard starter and grower diet to 29 d. At 14 days of age, birds were redistributed into 35 battery cages with 5 birds per cage for all corn particle size diets and 8 birds per cage for the protein-free (PF) diet. From days 29-30 birds transitioned to one of the five treatment diets (600 μ m, 900 μ m, 1200 μ m, 1500 μ m, or PF). The PF diet contained only dextrose monohydrate as the sole energy source. At 35 d birds were killed and intestine harvested for apparent digestibility determination.

Day old Hy-Line W-36 chicks (325) were placed 25 birds per cage and fed standard treatment diets with 600 μ m, 900 μ m, and 150 μ m corn. At 5 and 10 weeks of age, birds were weighed and feed intake and feed conversion were calculated.

All data for both studies were analyzed using a one-way ANOVA with the mixed procedure of SAS 9.4 and Tukey's range test for means comparison. There were significant broiler differences ($P < 0.05$) between treatments at 35 d for BW and 28-35 d BWG. Apparent digestibility of Met, Lys, Ile, Tyr, and crude fiber were significantly less for broilers fed 600 μ m and compared to the other PS. Jejuna digesta viscosity, measured in centipoise, was highest among birds fed the 600 and 900 μ m PS. Among the pullets there was a significant trend for the birds fed 600 μ m to be heavier and have greater BWG than birds fed 1500 μ m. There were no differences in feed intake, conversion, or mortality. In conclusion, particle size influences broiler and pullet growth performance and larger PS lend themselves to greater apparent digestibility.

Key Words: broilers, pullets, growth performance, particle size, nutrient utilization

Metabolism & Nutrition II

M89 Effect of oil source and peroxidation status on broiler performance and oxidative stress Stephanie Lindblom^{*GS1}, Elizabeth Bobeck¹, Brian Kerr² *¹Iowa State University; ²USDA-ARS*

Oil source has been shown to affect broiler performance and oxidative status. Lipid peroxidation may also affect animal performance and oxidative status through the generation and degradation of peroxidation compounds which differ according to oil source and temperature and length of heating. The objective of the study was to evaluate the effect of oil source and peroxidation status on broiler performance and measures of oxidative stress. Broilers (initial BW 85.1 \pm 7.8 g) were allotted to 40 battery cages in a completely randomized 4 x 2 factorial arrangement of treatments. Treatments consisted of oil source (palm oil, soybean oil, flaxseed oil, and fish oil) in combination with lipid quality (fresh or peroxidized oil). Peroxidation was achieved by thermally processing each oil at 90°C for 72 h with a constant air flow of 3 L/min. Oils were analyzed for peroxide value, anisidine value, hexanal, 2,4-decadienal, and total polymers as measures of oil peroxidation. Each treatment was replicated 5 times with 5 birds/cage (200 birds), with birds fed their respective diets for 20 d to measure performance criteria. On d 21, plasma was harvested from 2 birds from each cage for analysis of oxidative status, which included thiobarbituric acid reactive species (TBARS), protein carbonyls (PC), 8-hydroxy-2'-deoxyguanosine (8-OH-2dG), and glutathione peroxidase activity (GPx). An interaction between oil source and peroxidation status was noted for ADFI, ADG, and F:G ($P = 0.01$), where birds fed the peroxidized oil reduced ADFI, ADG, and F:G in all oil sources except for birds fed the fish oil. There were no interactions noted between oil source and peroxidation status for TBARS, PC, 8-OH-2dG, or GPx ($P > 0.10$). Oil source increased plasma TBARS and 8-OH-2dG ($P = 0.01$), and tended to increase plasma PC ($P = 0.09$),

but did not affect plasma GPx ($P > 0.44$). Although lipid peroxidation had no effect on plasma TBARS or PC ($P > 0.15$), plasma 8-OH-2dG and GPx were affected by lipid peroxidation ($P < 0.01$). In conclusion, oil source and peroxidation status differentially affected growth performance, oil source increased plasma TBARS, PC, and 8-OH-2dG, and lipid peroxidation increased plasma 8-OH-2dG and decreased plasma GPx.

Key Words: lipid peroxidation, oxidative stress, broilers, oil source

M90 Effect of fat oxidation on male broiler performance, yield, and muscle quality Cody Flores^{*GS1}, Hunter Walters¹, Danny Portillo¹, Rob Shirley², M. Briens³, Christine Alvarado¹, Jason Lee¹ *¹Department of Poultry Science, Texas A&M AgriLife Research; ²Adisseo USA; ³Adisseo France SAS (CERN)*

The current study evaluated the impact of oxidized fat on broiler growth performance, processing yield, and meat quality. Canola oil was the source of fat in the current study. Fat oxidation procedure included heating fat to 95°C for 60 hours, with air percolating thru at approximately 12 L/min in order to achieve a target peroxide value of 129 meq/kg fat. On day-of-hatch, 2752 Cobb 500 male broilers were placed in floor pens with 43 birds/replicate pen and 32 replicate pens/treatment. The two treatments fed throughout the duration of the trial were corn/SBM/DDGS/MBM-based with the inclusion of either oxidized or non-oxidized (NO) fat. The feeding program consisted of a starter (d 0-14: crumble), grower (d 15-28: pellet), and finisher (d 29-42: pellet) diets. Body weight (BW) and feed consumption (g/bird/d) measurements were taken at each feed changeover for determination of body weight gain and feed conversion ratio. Following an 8 hour feed withdrawal on d 42, 8 birds/replicate pen were selected for processing yield (+/- 300 g of the mean pen weight). Furthermore, tissues from

6 birds/replicate pen were then used for meat quality measurements, which consisted of muscle pH, drip loss, and color. Inclusion of oxidized fat significantly reduced feed consumption compared to NO fat during the grower phase, as well as cumulatively through d 28 (0.7% and 1.8%, respectively). On d 14 and 28, inclusion of oxidized fat significantly reduced average BW compared to NO fat (2.3% and 2.1%, respectively). No significant differences in FCR were observed throughout the trial. A correction factor of 27g of BW per kg of BW was applied to the cumulative d 41 FCR in an effort to standardize treatment means. A significant impact on cumulative d 41 BW-corrected FCR was observed when oxidized fat was fed, resulting in a higher FCR when compared to the inclusion of NO fat. No significant impacts were observed on carcass or parts yield; however, color of the breast file was unexpectedly impacted, as oxidation increased the redness (a^*) of the tissue. In conclusion, feed manufactured with an oxidized fat source can negatively impact broiler growth performance and alter breast tissue color.

Key Words: Meat quality, Oxidized fat, Broiler, Canola oil, Performance

M91 The effect on performance of turkey poults fed various levels of yellow grease in pre-starter rations Corey Johnson^{*GS}, Jeffre Firman *University of Missouri*

Nutritional intervention in the early growing poult can be a valuable strategy to staves the stress experienced during the transition from endogenous yolk sac lipid reserves to an exogenous feed source. The objective of the present study was to evaluate the performance effects on a high addition rate of yellow grease (YG) in pre-starter rations fed to tom turkeys. The 140-day long experiment was a 2×3 factorial arrangement, where poults were fed treatment diets consisting of a control (least cost addition of YG), 6% YG or 8% YG to 10 or 14 days of age. Each treatment consisted of 8 replicates containing 12 toms per pen in a randomized complete block design with location as the blocking factor. Diets were composed of a commercial type corn-soy-DDGS-meat meal base and were adjusted to maintain a consistent ME:CP and ME:AA ratios, as the three dietary treatments were not isocaloric. Birds were weighed and diets were changed at 10 or 14 days, and at 21 days; thereafter, these processes were repeated every 21 days until harvest. At completion, birds were processed and carcass composition was evaluated. The resulting performance data, which included livability, body weight, feed intake, feed to gain and adjusted feed to gain, yielded no significant treatment effects. Carcass composition showed a significant increase in fat pad weight in dietary treatments, where 8% YG was higher than both 6% YG and control ($P=0.01$). Fat pad weight also significantly increased in toms fed 8% YG for 14 days compared to those fed for 10 days ($P=0.028$). No significant treatment interactions were observed in fat pad weight. Livability in the present study was approximately 70% across all treatments. Although fat pad weight was greater in high fat diets, the level of mortality inhibits definite interpretation of the results and repetition of the study would be beneficial.

Key Words: Turkey, Yellow Grease

M92 Effect of different feed form and function on the performance of turkey poults to 3 weeks using Alphastart (AS) mini pellet and standard crumbled diets. Karlinton Flores^{*GS1}, Jesse Grimes¹, Steven Clark², Adam Fahrenholz¹ *¹North Carolina State University; ²Devenish nutrition*

The first feed can have an impact on poult health and performance. Feed form and nutrition can influence consumption, wastage, and early development of the intestine and immune systems. A study was conducted to observe and measure the performance and small intestine development of turkey poults with different diet forms (FRM) and/or function (FCT). Aviagen male poults (336) were randomly assigned to 48 battery cages with 7 bd/cage. Four treatments were evaluated: an NCSU control crumble diet, AS crumble (FCT), AS mini-pellet (FCT + FRM), and a 3-way medicated diet (3W). The treatments were fed from placement to 14 d. A control crumble starter (NCSU) was fed for all pens from 14 to 21 d. All crumble diets had a ratio of 70% crumbles and 30% fines. The parameters observed,

measured, and analyzed were mean body weight (BW), mean body weight gain (BWG), feed intake (FI) and feed conversion ratio (FCR) adjusted for mortalities. Histo-morphological observations and measurements were analyzed for 13 and 21 d. The JMP program of SAS was used to determine if the parameters between the treatments were significantly different ($P \leq 0.05$). Birds fed the AS mini-pellet exhibited improved BW and BWG at 7, 14, and 21d (184g, 465g, 870g \pm SEM 2, 6.6, 8 respectively for BW) (125g, 406g, 811g \pm SEM 1.6, 6.6, 8.6 respectively for BWG). A higher FI was observed for birds fed the AS mini-pellet at 14 and 21d (489g, 1087g \pm SEM 6.5, 15.7). FCR was not significantly different between treatments with an overall mean at 21d of 1.257 (g:g). No consistent differences were found for the histo-morphometric observations. In conclusion, a mini-pellet with both form + function factor fed to male poults resulted in an increase in body weight, body weight gain, and feed intake at 14 and 21 d. This effect persisted to 21 d of age despite poults being fed a control diet after 14 d. Further investigation is needed to better understand the relationship between feed form and function on turkey poult performance and small intestine development.

Key Words: starter, turkey poults, small intestine histology, feed form

M93 Effect of potassium and available phosphorus in broiler breeder diets on fecal and egg characteristics at the onset of lay. Dinabandhu Joardar^{*GS}, Coltin Caraway, John Brake *North Carolina State University*

Wet feces have been frequently observed at the onset of lay in broiler breeders. Hydrogen (H) ions produced during egg shell calcification that are not buffered by the phosphate system in the kidney are excreted in the form of water utilizing the bicarbonate buffer system. Excess dietary calcium (Ca) combines with available phosphorus (AvP) to reduce phosphate buffering capacity, which may be causally related to wet litter. Although potassium (K) is a primary intracellular cation, it has an overall dietary alkalogenic effect and was thought to affect wet litter. There were 64 Ross 708 broiler breeder pullets reared on diets containing 0.9% Ca and either 0.3% or 0.5% AvP. Half of the pullets on each rearing diet remained on their AvP while the other half were changed to the other AvP level as Ca was increased to 2.7% at 23 wk of age in a 2X2 arrangement. Layer diets were also amended with either 0% or 0.2% K as potassium carbonate to complete the 2X2X2 design. Fecal liquid portion (LP), fecal moisture (FM) and characteristics of the second and tenth egg laid were assessed. The LP and FM of each breeder hen were measured at 22 wk of age to establish a basal point and thereafter at 23, 24, 25, 26, 27, 28, and 30 wk of age. Addition of 0.2% K to the 0.3% AvP layer diet reduced ($P \leq 0.05$) LP at 25, 26, and 27 wk and FM at 23, 25, 26, and 28 wk as compared to the 0.5% AvP layer diet amended with 0.2% K. The non-amended 0.3% and 0.5% AvP layer diets were intermediate. Further, the LP and FM were generally reduced as the breeders achieved peak egg production. The 0.3% AvP grower diet increased ($P \leq 0.05$) the weights of the second egg and its albumen. It was concluded that while supplementing 0.2% K to the 0.5% AvP layer diet increased LP and FM the opposite was true with the 0.3% AvP layer diet. These findings could be beneficial in controlling excess litter moisture during onset of lay in broiler breeders.

Key Words: Broiler Breeders, fecal moisture, fecal liquid portion, potassium buffer

M94 Effects of dietary copper removal on Ross 708 male broiler growth performance K. Brown^{*GS1}, C. Eagleson¹, T. Parr², J. Lee¹ *¹Texas A&M University; ²Micronutrients USA - LLC*

A 48 day experiment was conducted to evaluate the effects of removing dietary copper (Cu) at specific time points during growout. The experimental design consisted of 5 treatment groups with 10 replicates per treatment and 35 chicks/replicate. Treatments included a control which contained no supplemental Cu, and then 4 treatment diets that contained dietary Cu at a concentration of 125 ppm added as copper chloride. The Cu in these 4 treatments was removed at either 28 d (trt 2 and 3), 41 d (trt 4), or left in for the entire 48 d (trt 5). Treatment 2 contained bacitracin methylene

disalicylate (BMD) for 28d while it was not included in any other treatments. On day of placement, all birds were vaccinated with a commercially available coccidiosis vaccine in a commercial spray cabinet and allowed to preen 1 hr prior to randomization and placement. Four dietary phases were fed throughout the duration of the trial: starter (d 0-14, crumble), grower (d 14-28, pellet), finisher (d 28-41, pellet), and withdrawal (d 41-48, pellet). Body weight (BW) and feed consumption (FC) measurements were taken at the conclusion of each dietary phase and were used to calculate body weight gain (BWG), FC, and mortality-corrected feed conversion ratio (FCR). The advantage of copper inclusion was immediately observed resulting in heavier ($P<0.001$) BW as soon as 14 d of age. Additionally, FC was increased ($P=0.005$) and FCR was improved ($P=0.002$) following the starter phase with Cu inclusion. Similar effects were observed on d 28, with Cu inclusion increasing ($P<0.001$) BW and reducing ($P=0.001$) FCR compared to the control diet. A further improvement in performance was not observed ($P=0.582$) due to the addition of BMD through 28 d of age. Body weight at d 41 and 48 was not impacted by treatment; however, treatments with Cu inclusion exhibited improved FCR compared to the control diet through the finisher phase ($P=0.030$) and continuous through d 48 ($P=0.031$). These data indicated Cu inclusion is beneficial to growth performance, and the inclusion of BMD in combination with Cu did not result in any further improvement.

Key Words: copper, broiler, performance

M95 Effects of manganese and zinc sources and increasing late supplementation on egg production and quality in corn-soy diets fed to White Leghorn hens Austin Jasek^{*GS1}, Kyle Smith¹, Terri Parr², Jason Lee¹ ¹Texas A&M; ²Micronutrients USA LLC

The objective of the current study was to evaluate the impact of manganese (Mn) and zinc (Zn) sources (oxides and chlorides) on production rate and egg quality in White Leghorn (W-36) hens and determine if a targeted increase in Mn and Zn level (wk 48-52) would improve production or egg quality. A total of 330 11-wk old pullets were randomly assigned to 5 dietary treatments consisting of 22 replicates of 3 hens / rep. The first two treatments, which served as the basal trace mineral diets, were an oxide control (OC) and a chloride control (CC) that were fed from 11- 62 wk of age, and which included Mn at 80 ppm and Zn at 60 ppm. Three additional treatments were generated by supplementing an additional 40 ppm of Zn and Mn either as an amino acid complex form to the OC (OC+OR) and CC (CC+OR) diets and the additional 40ppm added as additional chloride in the CC (CC+CC) diet during the period of 48 to 52 weeks of age. The feeding program included a pre-lay (wk11-18), production (wk19-47), pre-finisher (wk48-52), and finisher (wk53-62). Lay rate (%), egg weight, egg mass, feed consumption (FC), and egg feed conversion ratio (FCR) were determined every two weeks, and egg quality parameters were evaluated based on dietary changes. Lay rate, egg mass and FCR were improved ($p<0.05$) in the overall experiment for the CC-fed hens compared to the OC-fed hens. No significant differences were observed in egg quality between any of the treatments. The OC+OR-fed hens had a significantly ($p=0.011$) higher lay rate than any of the other treatments, however, similar results in lay rate were reported between the OC+OR and CC-fed hens. Egg weights were similar between OC and CC-fed hens, however, inclusion of either the organic minerals (OC+OR) or the additional chloride minerals (CC+CC) from wk 48 to 52 significantly ($p<0.001$) increased egg wt. The OC-fed birds had significantly ($p<0.001$) poorer egg FCR compared to any other treatment. Egg force (kg) improved during the phase of additional chloride supplementation for the hens fed the CC+CC diet though not to a level of significance ($p=0.12$). These data suggest that mineral source does influence laying hen performance and that a targeted increase in mineral level during the later stages of production is beneficial to egg production.

Key Words: Minerals, Chloride, FCR, Hen-day production

M96 Effects of combination of phytase and Multi-Carbohydase enzymes on growth performance and bone mineralization in broilers Jinquan Wang^{*GS1}, Rob Patterson², Woo Kyun Kim¹ ¹University of Georgia; ²Canadian Bio-Systems

Phytic acid and non-starch polysaccharides (NSP) are two primary anti-nutrient factors in poultry feed. An experiment was conducted to evaluate the effect of phytase and Multi-Carbohydase enzymes (Canadian Bio-Systems, Calgary, Canada) supplementation on growth performance and bone mineralization in broilers. A total of 640 Cobb 500 male broilers were randomly allocated as 20 birds per pen to eight experimental diets with four replicates from day 0 to 35. Treatments consisted of a positive control diet (PC) with 0.9% Ca and 0.44% of avP, 0.88% Ca and 0.42% avP, and 0.81% Ca and 0.38% avP for starter, grower and finisher diet, respectively. The negative control (NC) diet had 0.15% lower Ca and avP levels, and the same NC diet with or without Multi-Carbohydase enzymes supplementation (500 grams per ton) for three phytase levels (500, 1000, and 1500 FTU/kg). Feed intake, body weight, and feed conversion ratio were measured at day 7, 21 and 35. At day 35, 3 birds per pen were euthanized and body composition was measured by dual energy X-ray absorptiometry (DXA) and right femurs were collected for bone ash. Body weight gain was significantly improved ($P<0.05$) from day 0 to 21 with the supplementation of 1500 FTU/kg phytase, or 500, 1000, 1500 FTU/kg phytase plus Multi-Carbohydase enzymes. There was no difference of body weight gain, feed intake and feed conversion ratio during the 35 day period. The reduction of Ca and avP significantly reduced the body mineral density, bone ash percentage, and bone density at day 35. However, the combination of phytase and Multi-Carbohydase enzymes supplementation significantly improved the body mineral density ($P<0.05$) and bone ash percentage ($P<0.001$) to the PC level. There was no difference on body fat percentage and body mineral content.

Key Words: phytase, Multi-Carbohydase, broiler, mineralization, growth performance

M97 Effect of poult hatch weight on their subsequent growth response to dietary energy, phosphorus, calcium and Azomite®. Samantha Black^{*GS1}, Marissa Herchler¹, Vinicius Schramm², Rafael Crivellari¹, Ramon Malheiros¹, Peter Ferket¹ ¹North Carolina State University; ²Universidade Federal do Paraná

Poult quality and size at time of placement is a concern in the turkey industry because it affects animal welfare, production efficiency, and final product quality. Poults of substandard weight often have an undeveloped digestive capacity, a perturbed gastrointestinal ecosystem, and persistent enteric health problems. Consequently, they may be more sensitive to changes in diet nutrient density and bioavailability or enteric conditioning supplements than standard poults. Azomite® (Az, Azomite Mineral Products, Inc., Nephi, UT), a full spectrum trace mineral feed additive of volcanic origin is typically used as a pellet processing aid, but may also act as an enteric conditioner. In this randomized complete block split-plot design experiment, 864 turkey hen poults were randomly assigned to 24 pens, each with 25 standards and 11 smalls. The whole plot factors were six dietary treatments in a factorial arrangement with three levels of Az (0, 2.5, and 5.0 g/kg, Az0, Az2.5, Az5 respectively) and two dietary treatments differing by .145% aP, .125% Ca, and 100 kcal ME/kg (Hi and Lo). The sub-plot poult size factor was based on placement body weight (BW) (58 g standard vs 51 g small, $P<0.001$). BW and feed intake (FI) were recorded at 0, 3, 5, 8, and 10, 12 and 14 wks of age to calculate feed:gain, but identification of individual poults could only be tracked until 10 wks. Among hens fed the Hi diet, Az2.5 and Az5 supplementation increased BW, but for those fed the Lo diet, Az5 supplementation decreased BW. These interaction effects were lost after wk 10. Significant size effects were observed until wk 10, where the small birds had significantly lower 5 wk BW than the standard birds (5.34 kg vs. 5.56 kg, $p<0.001$). The small birds also had lower 14 wk BW (9.00 vs. 9.46 kg, $p<0.004$) and nominally lower breast muscle yield (23.8 vs. 24.6% BW, $p=0.07$) than the standard birds. There were no significant

treatment effects on feed:gain or mortality rate. Poult size and quality has a lasting effect on body weight gain and breast muscle yield and cannot be recovered by modifying dietary nutrient density or feed additives, such as Azomite®.

Key Words: Turkey Hens, Poult Size, Growth and Breast Muscle, Dietary Energy, P and Ca, Azomite®

M98 The effects of Hostazym® and Optiphos® super dosing in combination with Azomite® on growth performance in market turkey hens Marissa Herchler*^{GS1}, Samantha Black¹, Vinicius Schramm², Rafael Crivellari¹, Ramon Malheiros¹, Peter Ferket¹ ¹*North Carolina State University*; ²*Federal University of Parana*

Supplementation of xylanase and phytase are commonly used to minimize formula costs, formulation risks and animal performance variation, and improve nutrient utilization. A market turkey hen growth trial was conducted to evaluate the dietary supplementation of Azomite® (Az; Azomite Mineral Products, Inc., Nephi, UT), a full-spectrum mineral dietary supplement of volcanic origin, the xylanase Hostazyme® (Xyl; Huvepharma, Inc., Sophia, Bulgaria), and the phytase Optiphos® (Phy; Huvepharma, Inc., Sophia, Bulgaria). Nicholas Select turkey hen poults were randomly assigned among 48 litter floor pens containing 36 poults each according to a randomized complete block design. The 12 dietary treatments consisted of a 3 X 4 factorial arrangement of 3 dietary levels of Az (0, 2, 5, or 5 g/kg) and 4 enzyme diets: a positive control (PC; 0 EPU Xyl/kg, 0 FTU Phy/kg), a

negative control (NC; 0 EPU Xyl/kg, 0 FTU Phy/kg), a NC with standard enzyme levels (NC250; 1500 EPU Xyl/kg, 250 FTU Phy/kg), and a NC with Xyl and elevated Phy levels (NC1500; 1500 EPU Xyl/kg, 1500 FTU Phy/kg). The PC and NC diets differed by 0.145%aP, 0.125%Ca, and 100 kcal ME/kg. Body weights (BW) and feed intake (FI) were measured to calculate the feed conversion ratio (FCR) during the brooding phase (0 – 5 wk) and overall production phase (0 - 14 wk). Breast muscle yield (BMV) as a percent of total body weight was measured on a random sample of 4 hens per pen at wk 14. A significant Az X Diet effect was only observed on 5 wk BW, where dietary inclusion of Az improved the BW of birds fed the PC diet ($p < .05$). Throughout the growth trial, the NC diets resulted increased BW than PC, especially when supplemented with enzymes ($p < .05$). In comparison to PC, NC and NC250 increased 5 wk BW, which was further increased by NC1500 (1.561 vs 1.642 and 1.662 vs 1.700, $p < .001$). NC1500 also had significantly improved 0-5 wk FCR than the other treatments (1.635 vs 1.662, 1.685, and 1.1693, $p < .01$), but not for 0-14 wk FCR. In comparison to PC, 14 wk BMV was increased by the NC diets, which was increased further by NC250 and NC1500, respectively (23.83 vs 24.58 and 24.79 vs 25.102% of BW, $p < .05$). No treatment effects were observed on mortality rate. Dietary supplementation of Xyl and Phy improved growth performance of turkey hens during the brooder phase and through to market age, and will improve breast meat yield, especially when at highest dietary level of Phy supplementation.

Key Words: turkey hens, growth performance, xylanase, phytase level, Azomite (R)

Metabolism & Nutrition III

M99 The effect of Original XPC on egg production, component yield and composition in laying hens Rachel Blount*^{GS1}, Juan Suarez¹, Jungwoo Park¹, Don McIntyre², Hilary Pavlidis², John Carey¹ ¹*Texas A&M University*; ²*Diamond V*

An experiment was designed to evaluate the effects of the functional metabolites of Diamond V Original XPC™ on egg production, quality, component yield, and composition in commercial laying hens. Birds in this experiment were fed a standard layer control diet (CON) or a diet containing Original XPC at either 0.625 kg/MT (FM-L) or 1.25 kg/MT (FM-H). Overall, no significant treatment effect ($P > 0.95$) was observed for egg production during the entirety of the study (20-53 weeks of age). Hens from the FM-H group had significantly higher feed consumption compared to the CON group, feed consumption of the FM-L group was not significantly different from the other treatments. Hens from the FM-L and FM-H groups had significantly improved feed conversion ($P < 0.0009$) compared to the CON group. FM-L hens had lower hen-day egg mass ($P < 0.0013$) compared to those of CON or FM-H. Compared to CON and FM-H, FM-L hens had significantly ($P < 0.0183$) greater percentage of jumbo-sized eggs. Egg characteristics were evaluated weekly 30-53 weeks of age. Yolk weight from FM-H hens was significantly ($P < 0.0001$) heavier at 16.3g compared to CON and FM-L hens at 16.0g and 16.1g, respectively. Percent yolk yield from FM-H hens was also significantly ($P < 0.0001$) increased to 26.3% compared to 25.9% and 26.1% for the CON and FM-L hens, respectively. Compared to CON, eggs from FM-H hens exhibited a significant ($P < 0.0001$) increase in yolk solids of 0.10% and a decrease in yolk nitrogen of 0.09% with FM-L hens being intermediate in yolk yield. Each treatment was significantly different ($P < 0.0004$) from the others for percent albumen yield (64.4%, 64.0% and 63.8% for CON, FM-L and FM-H, respectively). Albumen nitrogen in the FM-H group was 14.08%, which was significantly ($P < 0.0004$) greater than the CON and FM-L groups at 14.01% and 14.02%, respectively. Egg weight, albumen weight, shell weight, shell yield and albumen solids were not significantly impacted by the treatments. This research demonstrates that feeding Original XPC had

a positive impact on egg production parameters as well as egg component yield and composition.

Key Words: Original XPC, egg components, egg yield, egg solids, egg production

M100 Effect of lignosulfonate on pellet durability under marginal pelleting conditions Jeffrey Pope*^{GS1}, Adam Fahrenholz¹, Thomas Winowski² ¹*North Carolina State University*; ²*LignoTech*

Three trials were conducted to investigate the effect of a lignosulfonate (LS) pellet binder on pellet durability under marginal pelleting conditions. Factors understood to affect pellet durability include, but are not limited to, conditioning temperature, mixer-added fat (MAF) inclusion, grain grind size, and crude protein (CP) level. The aforementioned factors are inevitably implemented to spare heat sensitive ingredients, supply adequate nutritional energy and protein, and stimulate gizzard function. The first trial investigated the interaction between conditioning temperature and LS. Diets were pelleted over a range of temperatures from 70 to 82 °C with or without LS supplementation at 0.5% on top of the basal formulation. It was determined that LS improved pellet durability more at cooler conditioning temperatures than at warmer conditioning temperatures. The second trial was a 2 x 2 x 2 factorial design utilizing 1.5 and 3.0% MAF, 0 and 13.5% coarse corn (CC), and 0 and 0.5% LS to determine if LS interacted to improve pellet durability more when increased MAF and CC inclusion were necessary parts of a formulation. It was determined that LS improved pellet durability to a greater extent when MAF inclusion was greater, but inclusion of CC did not affect pellet durability. The third trial investigated the effect of LS supplementation at 0.5% in diets ranging in CP from 16 to 24%. It was determined that pellet durability decreased as CP increased. The addition of LS did not result in an interaction, but rather improved pellet durability similarly across all ranges of CP. In conclusion, LS could be used as ingredient to improve pellet durability when marginal pelleting conditions, such as greater inclusions of MAF and cooler pelleting temperatures, were inevitable but maintenance of pellet durability was desired.

Key Words: lignosulfonate, pellet binder, pellet durability, conditioning temperature, mixer-added fat

M101 The effect of refined functional carbohydrates (RFCs) from enzymatically hydrolyzed yeast on the transmission of *Salmonella* spp. between broilers and proliferation in broiler housing. Grayson Walker*^{GS1}, Sangita Jalukar², John Brake¹ ¹North Carolina State University; ²Arm and Hammer Animal Nutrition

Enzymatic hydrolysis of yeast produces RFCs that have activities against gram negative bacteria. Specifically, Aviator SCP (Arm and Hammer Animal Nutrition, Princeton, NJ) possesses sugars that interfere with *Salmonella* attachment to the intestinal lumen. Hatching eggs were collected from four treatment groups of broiler breeder females that had been fed RFCs or control diets, with RFCs included at 0+0, 0+50, 50+0, or 50+50 g/MT during growing (0-21 wk) and laying (+22-48 wk), respectively. 576 male and female broiler progeny chicks were assigned to sex separate, new-litter pens by parent treatment and fed a 0 or 50 g/MT RFCs diet in a 4 x 2 factorial design within sex. Treatments were randomly assigned to 6 replicate pens of 12 broilers per interaction for both sexes. BW and feed intake were determined at 14, 28, and 42 d. Litter was sampled by pen using sterile socks at 35 d and tested for *Salmonella* spp. using enzyme linked fluorescence assay methods. *Salmonella* spp. was isolated in 7 of 48 control-fed broiler pens but was not isolated in RFCs-fed pens. Thereafter, the 48 males and 48 females selected based on litter *Salmonella* presence and RFCs treatment had their cecae aseptically excised and tested for *Salmonella* spp. presence. Of the 48 control-fed broilers from litter-positive pens, 16 were confirmed positive for cecal *Salmonella* spp. No broilers from litter-negative pens fed RFCs were positive ($P<0.05$). Female broilers that had been fed RFCs exhibited greater BW at 28 d ($P<0.05$) and 42 d ($P<0.10$). Female broilers that were progeny of 50+50 and 0+0 parent treatment groups exhibited improved overall feed conversion ($P<0.05$). These data demonstrated that RFCs had a beneficial effect on the presence of *Salmonella* in the litter and ceca of broilers when fed continuously while not having detrimental live performance impacts.

Key Words: *Salmonella*, refined functional carbohydrates, broiler

M102 Coarse corn improves feed efficiency in both coccidiosis-vaccinated and salinomycin-fed broilers Coltin Caraway*^{GS}, John Brake ^{North Carolina State University}

This study evaluated two coccidiosis control methods (CM) beginning at placement: Vaccine (VAC) and Salinomycin (SAL) versus a non-treated control (CON). Beginning at 11 d, two corn particle size (PS) treatments were applied: coarse corn (CC) or fine corn across the three CM treatments to complete a 3 x 2 factorial arrangement. CC had been shown to improve live performance in broilers fed salinomycin. However, many coccidiostats could come under scrutiny in antibiotic-free production, thus it was important to understand how CC affected coccidiosis-vaccinated broilers. Treatments were randomly assigned to 36 pens resulting in 6 replicate pens per treatment combination with 16 birds per pen at placement. Data was analyzed using JMP 12.2 with means separated by Student's T-test. At 10, 20, 28, 35, 41, and 48 d of age, feed intake (FI) and body weight (BW) were measured and used to calculate AdjFCR. At 10 d, no differences due to CM were observed in live performance. At 20 d, CON (952 g, 1.32 g:g) and SAL (946 g, 1.31 g:g) were heavier and demonstrated improved ($P<0.01$) AdjFCR compared to VAC (921 g, 1.36 g:g). At 35 d, SAL (2575 g) exhibited increased ($P<0.01$) BW when compared to both VAC (2527 g) and CON (2504 g). From 21-35 d, all three CM treatments exhibited significantly ($P<0.01$) different AdjFCR with SAL (1.56 g:g) < VAC (1.62 g:g) < CON (1.66 g:g). However, from 35-48 d, no differences were observed as a result of CM. No differences were observed as a result of PS from 10-20 d or 21-35 d, nor were any interactions observed. However, from 35-48 d, the CC (1.90 g:g) improved AdjFCR compared to fine corn (1.95 g:g; $P<0.01$). At 48 d, no differences were observed in cumulative FI or BW as a result of CM or PS but cumulative AdjFCR was affected by PS [CC (1.64 g:g) < FC (1.65 g:g); $P<0.05$] and by CM [SAL (1.65 g:g) < VAC (1.66 g:g) & CON (1.66 g:g); $P<0.01$]. The results of this study demonstrated

that CC benefited coccidiosis-vaccinated broilers similarly to broilers fed a coccidiostat.

Key Words: particle size, broilers, vaccine, antibiotic free, coccidiostat

M103 Computed tomographic precision rate-of-passage assay without a fasting period in broilers: more precise foundation for targeting the releasing time of encapsulated products Jundi Liu*^{GS1}, Scott Secrest², Justin Fowler¹ ¹Department of Poultry Science, University of Georgia; ²Department of Veterinary Biosciences and Diagnostic Imaging, University of Georgia

The objective of this study was to develop a precision-fed rate-of-passage assay through computed tomography methods in broilers. Twenty-two Cobb-Cobb male broilers were obtained on the day of hatch and fed a standard corn-soybean meal starter diet until d 21. All birds were then orally gavaged 3 g of feed mixed with 2 ml of iodinated contrast. Two birds were selected for collection of the gastrointestinal tract (gizzard, duodenum, jejunum, ileum, ceca, and colon) at 0:15, 0:30, 0:45, 1:00, 1:30, 2:00, 2:30, 3:00, 4:00, 5:00, 6:00 h post-gavage. A computed tomographic exam of the intestinal tract was acquired to determine the location and percentage of each intestinal segment which contained the admixed contrast and feed. Results indicated that feed entered the gizzard extremely fast after the gavage (less than 0:15 h). The marked feed left the gizzard between the 0:15 and 0:30 h time points, and was shown in both the duodenum and jejunum after 0:30 h. After 1:30 to 2:00 h, feed reached the ileum and was found in ceca after 4:00 h. The enteric cavity was virtually cleared of the iodinated contrast between the 4:00 to 6:00 h time points, except for a few stagnated spots in the gizzard and ceca. The results indicate that the rate-of-passage can be easily determined in young broilers by using iodinated contrast as a marker without fasting the birds. It is recommended that the birds be gavaged with 3 g feed mixed with 2 ml iohexol using a tube-feeder when conducting such assay. The digestive time for feed passing through the anterior digestive tract (from mouth to ileum) is less than 2:30 h and arriving at the ceca at 3:00 to 4:00 h. Most of the feed is digested 4:00 to 5:00 h after feeding. This assay would provide further accurate digestive time results of the bird in a non-fasted state, and support research conducted with encapsulated products that are evaluating releasing times using the *in vitro* technology.

Key Words: precision feeding, iodinated contrast, rate-of-passage, broiler

M104 Effects of lysophospholipid product (Lipidol Ultra™) on growth performance and carcass characteristics in broilers Chongxiao Chen*^{GS1}, Byoungyun Jung², Woo Kyun Kim¹ ¹University of Georgia; ²EasyBio Inc.

A study was conducted to evaluate the effects of supplementing different levels of lysophospholipid product (Lipidol Ultra™) to normal or reduced energy diets on growth performance and carcass characteristics in broilers. A total of 960 1-day-old cobb 500 male birds were randomly placed to 8 treatments with 6 replicates each with 20 birds. The experiment employed a 2 x 4 factorial arrangement. Factors were energy level (normal or 100kcal/kg ME reduced) and Lipidol Ultra™ level (0, 0.025%, 0.050% or 0.075%) of diets. Three diet phases were fed throughout the trial: starter (d 0-7), grower (d 8-21), and finisher (d 22-42). Body weight (BW), feed intake (FI), and feed conversion ratio (FCR) were calculated at the conclusion of each phase. At d 42, four birds per replicate were selected to measure the carcass characteristics. The birds fed with normal energy diets (NE) group had higher BW and BWG in all phases; higher FI in grower and overall trial period; and better FCR in the starter and finisher periods compared with the birds fed reduced energy diets (RE) group ($P<0.05$). Lipidol Ultra™ main effects were observed with a lower FI at 0.05% dosage during the finisher period and throughout the study ($P<0.05$) and then resulted in an improved trend of cumulative FCR compared with the others ($P<0.1$). The interactions showed adding 0.075% Lipidol Ultra™ to NE improved BW, BWG and FI in finisher and the overall period compared with the one without Lipidol Ultra™ ($P<0.05$). In RE, improved growth performance

was with 0.025% dosage ($P < 0.05$). For the meat characteristics, NE had higher live body, hot carcass, cold carcass, major, minor, wing, and leg weight ($P < 0.05$) but a lower minor percentage ($P < 0.1$). The main effect of 0.075% dosage increased dressing percentage compared with the rest ($P < 0.05$). The interactions were detected with adding 0.05% and 0.075% Lipidol Ultra™ in NE diets increased major percentage compared with the one without Lipidol Ultra™ ($P < 0.05$). In conclusion, adding 0.025% Lipidol Ultra™ to low energy diets, and 0.075% to normal diets had a positive effect on growth performance and the latter could improve meat characteristics as well. Moreover, supplementation of 0.05% Lipidol Ultra™ would help birds balance the BWG and FI to reach a better FCR.

Key Words: lysophospholipid, growth performance, carcass characteristics

M105 Evaluation of Direct Fed Microorganism and enzyme blend co-administration on the gastrointestinal microbiota of broilers fed US commercial type diets, with or without antibiotic growth promoters. Tyler Askelson^{*GS1}, Cody Flores¹, Sadie Dunn-Horrocks¹, Yueming Dersjant-Li², Kirsty Gibbs², Ajay Awati², Jason Lee¹, Tri Duong¹
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Direct-Fed Microorganisms (DFM) and exogenous enzymes have been demonstrated to improve growth performance in poultry and are potentially important alternatives to antibiotic growth promoters (AGP). We investigated the administration of a feed additive composed of a DFM culture containing spores of three *Bacillus amyloliquefaciens* strains and an enzyme blend containing endo-xylanase, α -amylase, and serine-protease (XAP) in diets with or without antibiotics at sub-therapeutic levels in broiler chickens over a 42 day growth period. Treatment groups were arranged as a 3 (AGP) \times 2 (feed additive) factorial experiment and were fed experimental rations formulated to contain combinations of an AGP (control, bacitracin methylene disalicylate, or virginiamycin) with or without the feed additive. Evaluation of growth performance determined feed conversion of broiler chickens administered the feed additive was comparable to those fed a diet containing AGPs. Characterization of the gastrointestinal microbiota using culture-dependent methods determined administration of the feed additive increased counts of total Lactic Acid Bacteria (LAB) ($P = 0.028$) relative to a negative control and reduced *Clostridium perfringens* to levels similar to antibiotic administration. Correlation analysis revealed significant associations between bacterial counts and feed efficiency. Moderate negative associations were observed between total LAB counts on Day 21 and Day 42 with Day 0–21 ($r = -0.287$, $P = 0.035$) and Day 22–42 ($r = -0.278$, $P = 0.042$) feed conversion ratio (FCR), respectively; while moderate positive associations were observed between *C. perfringens* counts on Day 21 with Day 22–42 ($r = 0.339$, $P = 0.003$) and cumulative ($r = 0.405$, $P = 0.002$) FCR. Our results suggest co-administration of DFM and exogenous enzymes may potentially be an important component of antibiotic free poultry production programs and that LAB and *C. perfringens* may be important targets in the development of alternatives to AGPs in poultry production.

Key Words: DFM, Enzymes, AGP, gastrointestinal microbiota, broiler

M106 Effects of lactic acid bacteria and organic acids on the concentration of an antibiotic resistant strain of Salmonella Heidelberg, in vitro Dana Dittoe^{*GS}, Chris McDaniel, Aaron Kiess *Mississippi State University*

Lactic acid producing bacteria and organic acids are being investigated in poultry diets as alternatives to antibiotic feed additives to control pathogen prevalence in the gastrointestinal tract. In this study, the objective was to determine the effect of these two feed additive products on the growth of an antibiotic resistant strain of *Salmonella* Heidelberg (S). The two products consisted of a probiotic supplement, containing *L. acidophilus*, *L. rhamnosus*, *B. thermophilum*, and *E. faecium* (P) and an organic acid product, consisting of encapsulated butyric acid (B). Thus, the treatments consisted

of the 2 products (P, B) and the combination of S and products (S+P, S+B). A 12 h stock of S was diluted 10⁻⁶ fold to provide 10⁶, 10⁵, and 10⁴ cfu/ml. 1 g of product was weighed and reconstituted in 9 ml of broth. For combinations, 1 ml of S stock culture (10⁶, 10⁵, and 10⁴) was added to broth containing 1 g of product. After treatments were made, 100 μ l was serially diluted at 0, 2, 4, 6, and 8 h of incubation and spread plated onto Tryptic Soy Agar (TSA) containing nalidixic acid and incubated under aerobic conditions at 37°C for 24 h. Log transformed counts were analyzed using a randomized complete block design with split plot over incubation time. Means were separated using Fishers protected LSD when $P \leq 0.05$. A *Salmonella* concentration by time by treatment interaction was present for S growth ($P < 0.0001$). At all times and *Salmonella* concentrations, S growth was significantly less in both treatments compared to the control. S growth in both the control and S+P was increased over time, however S+B did not show the same trend in growth. S growth in S+B plateaued after 4 h and maintained that level of growth throughout the remainder of the study. Also, products were more effective as *Salmonella* concentrations decreased, with products being most effective at 10⁴ cfu/ml of S (8h at 10⁴ cfu/ml *Salmonella* concentration: Control = 7.59, S+P = 6.29, and S+B = 4.03 logs cfu/ml ($P < 0.0001$)). In conclusion, both products are capable of reducing an antibiotic resistant strain of *Salmonella*, with butyric acid having the greatest reduction capabilities. However, further research needs to be conducted to evaluate the effect of both products in poultry diets.

Key Words: antibiotic alternative, probiotic, organic acid, poultry, *Salmonella*

M107 Effects of VANNIX™ C on the performance of broilers raised on dirty litter. James Lewis^{*GS1}, Rachel Tonda², Jon Rubach², Mitch Poss², Michael Persia¹ ¹Virginia Tech; ²Kemin Industries, Inc.

A 42 day experiment was completed to evaluate the effects of pen hygiene and feed additive (VANNIX™ C, a proprietary blend of tannic acid extract and *Bacillus coagulans*) on the performance of broilers. In total, 1,104 Heritage broiler chicks were randomly assigned to four treatments including clean litter (CL), dirty litter from birds grown to 28 days that had received a coccidial vaccine (DL), the dirty litter with feed additive (VANNIX™ C added at 0.5 lb/ton; FA) and dirty litter with an anticoccidial Zoamix® (zoalene added at 113.5 g/ton; AC). Treatments were administered to 12 replicates of 23 broilers in a randomized block design. Body weights and feed consumption were measured weekly. At 14 d, litter was sampled for oocyst shedding and 3 birds/pen were euthanized for intestinal lesion scoring. All data were analyzed using ANOVA and if significant differences were noted ($P \leq 0.05$), means were separated using Fishers LSD test. Over the first 35 d, the birds on CL resulted in higher body weight gain (BWG) than those on DL without dietary treatment ($P \leq 0.05$). From 1 to 42 d, the birds on CL had greater BWG than those on the AC, while DL treated birds were intermediate, but not significantly different than either ($P > 0.05$). The FA treated birds showed increased BWG in comparison to DL birds over the first 35 d ($P \leq 0.05$), but this significance was lost for the 1 to 42 d period. The BWG of FA birds was significantly reduced in comparison to CL treated birds for the first 14 d period, but was not significantly different from CL birds after 14 d until the conclusion of the experiment at 42 day of age. Unexpectedly, AC birds resulted in BWG that was less than DL birds ($P \leq 0.05$). The FA birds resulted in the lowest FCRm from 1 to 28. From 1 to 35 d FCRm was reduced in FA birds compared to DL birds ($P \leq 0.05$), however as with BWG this significance was lost from 1 to 42 d. Lesion scoring was unable to confirm necrotic enteritis, but oocyst shedding tended to be reduced with CL and/or FA and AC, and taken with the performance does suggest a mild microbial challenge. Overall, throughout the majority of the experiment, exposure to DL reduced performance in comparison to CL birds, but treatment with VANNIX™ C restored performance to that of birds raised on CL.

Key Words: tannic acid, *Bacillus coagulans*, performance, lesion score, oocyst

M108 Evaluation of Safmannan on full term broiler performance with coccidiosis vaccinated broilers on used litter Morouj Al-Ajeeli*^{GS1}, Thomas Gaydos², Raghad Abdaljalael¹, Hector Leyva-Jimenez², Jimmie Corley², Christopher Bailey¹ ¹Texas A&M University; ²Phileo Lesaffre Animal Care

The poultry industry's move toward antibiotic free poultry production has increased the demand for antibiotic alternatives. This study was conducted to evaluate the effect of a proprietary yeast cell wall (YCW) product on performance of broilers reared on used litter. A total of 1200 Commercial broilers chicks were randomly distributed among 60 floor pens (20 birds/pen) with 12 pens per treatment. A basal diet with no coccidia medication and supplemented with a commercially available phytase enzyme was formulated and divided into five treatments; basal control diet (T1), T1+salinomycin (T2), T1+bacitracin MD (T3), T1+YCW 250 ppm (T4), T1+YCW 500 ppm (T5). Birds in all treatments except T2 received Coccivac®-B52 (Merck Animal Health) on the day of hatch. Treatments were distributed in a randomized block design. Body weight (BW) and feed consumption were recorded on day 14, 28, 42, and 49 of the study. On day 14, birds fed salinomycin had significantly higher BW and weight gain than the control, and birds fed YCW (T4&T5) or bacitracin were statistically similar to the salinomycin treatment. On day 28, birds fed salinomycin had significantly higher BW (1465 g) than control birds (1404 g), and birds fed YCW in T4 (1438 g) and T5 (1420 g) treatments were statistically similar performance to the salinomycin (T2). The phase and cumulative feed to gain ratios were significantly better at day 28 than the control treatment for birds fed salinomycin, bacitracin MD, and YCW 250. By day 42, there were no significant differences with respect to body weight and cumulative feed conversions were not significantly different from the control for any treatment. By day 49, the bacitracin treatment had the lowest performance index which was significantly lower than the control treatment. In summary, both YCW treatment levels are effective in reducing the negative impact associated with the cycling of coccidiosis.

Key Words: broilers, coccidia, yeast cell wall, salinomycin, bacitracin

M109 In vitro evaluation of seven commercially available *Bacillus* spp based probiotic supplements and one *Saccharomyces cerevisiae* based prebiotic supplement and their effects on an antibiotic resistant strain of *Salmonella* Heidelberg Claudia Castaneda*^{GS1}, Omar Gutierrez², Christopher McDaniel¹, Aaron Kiess¹ ¹Mississippi State University; ²Huvepharma

Because of the concerns about bacterial resistance to antibiotics, alternatives such as probiotics and prebiotics have been developed to reduce pathogens in poultry. Therefore, the objective of this study was to evaluate 7 *Bacillus* spp probiotic products and 1 *Saccharomyces cerevisiae* prebiotic product for their ability to reduce different concentrations of an antibiotic resistant strain of *Salmonella* Heidelberg (S) *in vitro*. Treatments included: an antibiotic resistant strain of S (control) at 10⁶, 10⁵, 10⁴, and 10³ cfu/ml; 7 probiotic products (P1 - P7); and 1 prebiotic product (P8). Products were combined with each level of S to create (S+P1 - S+P8). For S, a 12 h stock was diluted 10-fold to create the desired concentrations. For products, 1 g was diluted in 9 mL of nutrient broth and incubated for 24 h to obtain 10⁶ cfu of probiotic or prebiotic/ml. For combination treatments, 1 ml of S at the desired concentration was added to nutrient broth containing 10⁶ cfu of probiotic or prebiotic/ml. Afterwards, 100 µl of each treatment was serially diluted at 0, 2, 4, 6, and 8 h of incubation, spread plated on their appropriate agar, and incubated at 37°C for 24 h (probiotics) and 48 h (prebiotic) under aerobic conditions. Counts were log transformed and analyzed using a factorial arrangement of treatments (4 levels of S x 8 products) within a split plot design over incubation time. A time by treatment interaction (P<0.0001) revealed that when products were added to 10⁶ cfu S/ml there were no significant reductions of S over time. However, when products were added to 10⁵ cfu S/ml only P8 reduced S immediately but S recovered at later time periods. When products were added to 10⁴ cfu S/ml, at 0 h S was completely reduced by P3, P6, and P7; by 2 h, P3 and P6 maintained this

reduction; and by 4 h all products except P5 and P7 reduced S by 1 log. When products were added to 10³ cfu S/ml, at 0 h all products except P4 reduced S completely; by 2 h P6 and P8 reduced S completely while P4, P5 and P7 reduced S by 1 log; and by 4 h S recovered for all products except P6 which did not allow S to recover until 6 h. In conclusion, although all products contain *Bacillus* they can have different serovars, which could affect how certain products worked against S in this study.

Key Words: Antibiotic alternative, Salmonella, Probiotic, Prebiotic, Poultry

M110 Effects of probiotics and zinc supplement on gut development and microflora of male broilers with *Eimeria* challenge Xi Wang*^{GS1}, Timothy Johnson², Wei Zhai¹ ¹Mississippi State University; ²University of Minnesota

Effects of dietary antimicrobials and alternatives (*Bacillus subtilis* and zinc) on digestive tract and intestinal microflora of commercial broilers with *Eimeria* challenge were determined. A total of 504 one-day old male Ross × Ross 708 broilers were randomly distributed into 36 floor pens (with 14 chicks/pen). Broilers were fed 1 of 6 diets from D0 to 41 (with 6 replication pens/diet): a control diet (corn and soybean-meal basal diet), a probiotic diet (basal diet + 10¹¹ CFU of *Bacillus subtilis*/ton of feed), a zinc diet (basal diet + 100ppm zinc), a probiotic and zinc combined diet (basal diet supplemented with both probiotics and zinc), an anticoccidial diet (basal diet + 54g of narasin/ton of feed), and an antimicrobial diet (basal diet + 54g of narasin and 50g of bacitracin/ton of feed). At D21, each chick was gavaged with a × 10 dose of commercial vaccine containing live *Eimeria* oocysts. At D40, digestive tract and cecal contents were sampled from 1 bird/pen. Cecal microflora diversity and composition were detected by DNA sequencing. ANOVA analysis was applied to determine dietary effects on each measurement. No difference on intestinal length, weights of bird, intestine, pancreas, spleen, and bursa, or Alpha diversity (Shannon, observed-OUT, Chao1 of microflora DNA sequence) was observed among treatments. Feeding antimicrobial diets resulted in the highest number of bacterial species in ceca and feeding probiotics diets resulted in the least number of bacterial species (P = 0.004). Zinc supplementation decreased *Blautia* and *Clostridium* proportions in cecal microflora as compared to other diets (P = 0.050 and 0.032). Antimicrobial diets lowered *Lactobacillus* proportion as compared to control diets (P = 0.008). Anticoccidial diets increased *Bifidobacteria* proportion as compared to probiotic and zinc combined diets (P = 0.021). In a companion study, both probiotics and antimicrobial diets decreased D29-40 feed conversion ratio as compared to control diets (P = 0.007). In conclusion, both dietary probiotic and antimicrobial supplementations improved the feed efficiency of broilers; however they have opposing effects on cecal microflora diversity and composition. In addition, extra zinc supplementation may inhibit the growth of *Clostridium* pathogens in broiler ceca.

Key Words: broiler, probiotics, microflora diversity, digestive organs, zinc

M111 Effects of replacing antibiotics and anticoccidials with probiotics in broiler diets on growth performance Kacey O'Donnell*^{GS}, Xi Wang, Kelley Wamsly, Aaron Kiess, E. Peebles, Wei Zhai *Mississippi State University*

The study was conducted to determine an optimal time to withdraw antimicrobials (antibiotics and anticoccidials) and replace them with probiotics in broiler diets without adverse effects on growth performance. A total of 1,536 male Ross × Ross 708 broilers were divided into 12 treatments with 8 replications each. Birds were fed in 6 phases: 0-14, 14-21, 21-28, 28-35, 35-46, and 46-56 days with 1 of 3 feeds including basal, antimicrobial, and probiotic diets during each feeding phase, so that antimicrobials were withdrawn at different phases. In place of antimicrobials, half of the diets were supplemented with probiotics. On day 14, all the birds were challenged by oral gavage of 10 × dose of commercial coccidial vaccine including live *Eimeria* (*E.*) *acervulina*, *E. maxima*, *E. maxima* MFP, *E. mivati*, and *E.*

tenella. One-way ANOVA was used to analyze the data using Proc GLM of SAS 9.4. Dietary treatments did not affect BW on day 14 before the coccidial challenge ($P = 0.680$). Within a week of *Eimeria* challenge, the removal of antimicrobials from the diets decreased body weight (BW) on day 21 ($P < 0.0001$). Two weeks after *Eimeria* challenge, the removal of dietary antimicrobials on day 21 decreased BW on days 28, 35, and 47 ($P = 0.0005$, < 0.0001 , and 0.002 , respectively). However, supplementation of probiotics to the basal diet brought the BW back close to that of antimicrobial groups ($P = 0.400$, 0.071 , and 0.456 , respectively). This continued until day 55 when birds who started receiving basal or probiotics diet on day 21 exhibited similar BW as compared to the antimicrobial groups ($P = 0.403$ and 0.499). Birds that had antimicrobials taken out on day 28 showed a significantly lower BW on days 35, 47 and 55 ($P = 0.0023$, 0.0040 , and 0.0030 , respectively). Birds supplemented with probiotics starting on day 28 exhibited similar BW as those fed antimicrobial on days 35, 47, and 55 ($P = 0.083$, 0.216 , and 0.676 , respectively). Withdrawal of antimicrobials or supplementation of probiotics on day 35 did not affect BW on day 47 ($P = 0.796$ and 0.912) or 55 ($P = 0.712$ and 0.331). Supplementation of probiotics in the last feeding phase (days 47 to 55) did not affect BW on day 55 ($P = 0.312$). In conclusion, the results suggest that supplementing probiotics may alleviate the adverse effects of coccidiosis on growth performance of broilers fed diets with antimicrobial taken out on day 21 or 28.

Key Words: broiler, coccidiosis, antibiotic, anticoccidial, probiotic

M112 Effects of probiotics on performance of broilers fed corn or sorghum-based diets Albaraa Sarsour*^{GS1}, Edgar Oviedo-Rondón¹, Hernan Cordova¹, Beatriz Saldaña², Luis Bernal-Arango³, Mariana Mesquita⁴, Ricardo Fasanaro⁵, Rose Whelan⁶, Kiran Doranalli⁶ ¹North Carolina State University; ²Universidad Politécnica de Madrid; ³Politécnico Colombiano Jaime Isaza Cadavid; ⁴Universidade Federal de Goiás; ⁵Universidade Estadual Paulista; ⁶Evonik Nutrition & Care GmbH

Probiotics could be used as alternatives to antibiotic growth promoters. An experiment was conducted to evaluate the effects of feeding a *Bacillus subtilis* probiotic compared to BMD-50 in broiler diets based on either corn or sorghum. Six treatments were evaluated resulting from a 2 x 3 factorial arrangement of treatments with two basal diets based on either corn or sorghum and including one of three additives (No additive, 50g/MT BMD-50, or 5x10⁵ cfu/MT *B. subtilis* DSM 32315) as main factors. A total of 2,016 Ross 708 day-old male chicks were placed in 72 pens (28 chicks/pen) on used litter. Chickens were fed starter, grower and finisher diets between 1-14, 15-35, and 36-40 d of age, respectively. Group BW and feed intake were recorded. FCR and BW gain were calculated at the end of each phase. At 42 d, 2 broilers/pen were selected to obtain the weights of carcass and cut up parts. Data was analyzed as a randomized complete block design with grain type and additive as main effects and 12 replicates/treatment. At 7, 14, and 21 d of age, a two-way interaction effect ($P < 0.05$) was observed for BW and BW gain. Chickens fed the non-additive and BMD corn-based diets were heavier than broilers fed sorghum-based basal and *B. subtilis* DSM 32315 diets up to 14 d of age. BW was affected by grain ($P < 0.001$) and additive ($P < 0.01$) at 40 d of age. Chickens fed BMD were heavier than the control and *B. subtilis* DSM 32315 had intermediate results. At

21 d of age, a two-way interaction effect ($P < 0.01$) was observed for feed intake. Chickens fed the control or BMD corn-based diets consumed more feed than the control or BMD sorghum-based diets. Additives affected ($P < 0.05$) FCR at 7, 14, and 21 d of age. At 14 and 21 d both feed additives improved FCR, but this effect was not significant ($P > 0.05$) at 40 d of age. Flock uniformity was worse ($P < 0.05$) in the sorghum basal diet, but broilers fed diets with additives had coefficient of variation % similar to that observed in corn diets. No interaction or main effects ($P > 0.05$) of grain source or feed additives were observed for mortality, carcass yield or cut up part yield. In conclusion, this probiotic could be used as an alternative for BMD in corn and sorghum-based diets.

Key Words: probiotics, broilers, performance, growth promotants

M113 Effects of sodium butyrate, essential oils, and medium chain fatty acids to control *Clostridium perfringens* induced Necrotic Enteritis Cristiano Bortoluzzi*^{GS1}, Juan Mallo², Monica Puyalto², Maria Villamide³, Charles Hofacre⁴, Todd Applegate¹ ¹University of Georgia; ²Norel; ³Universidad Politécnica de Madrid; ⁴Southern Poultry Research

Limited use of antibiotics for growth promotion may increase the incidence of necrotic enteritis (NE) in broilers. Thus, gut health feed additives have an increasing importance in the prevention and control of NE. The objective of this study was to determine the effectiveness of sodium butyrate protected with sodium salts of palm fatty acids (N'RGY; SB), sodium butyrate and essential oils (carvacrol and zingiberene) protected with sodium salts of palm fatty acids (NATESSE; SB+EO), and sodium butyrate protected with sodium salts of medium chain fatty acids (DICOSAN; SB+MCFA) to reduce the negative effects of a toxigenic *Clostridium perfringens* in broiler chickens. One-day-old broiler chickens were assigned to 6 treatments with 8 replicates of 58 birds each. The treatments were: 1 - Negative control - NC (basal diet and no challenge), 2 - NC + challenge, 3 - Bacitracin Methylene Disalicylate (BMD, with 0.05% of inclusion)+challenge, 4 - SB+challenge, 5 - SB+EO+challenge, 6 - SB+MCFA+challenge. The three additives were included at 0.1%. On d 1, all birds were vaccinated against coccidiosis by coarse spray. On d 13, the birds from treatments 2 to 6 were inoculated with 25,000 oocysts of *Eimeria maxima* by oral gavage. On d 18 and 19, the same birds were administered a fresh broth culture of *Clostridium perfringens* via drinking water. Performance data was obtained at 13, 21, 34 and 41 d of age. Scoring for NE was performed at 21 d, and excreta oocysts were counted at 21 and 28 d. At 21 d, the unsupplemented challenged birds gained 5% less than the unchallenged control, whereas challenged birds supplemented with BMD, SB or SB+MCFA did not. The supplementation of SB+EO improved the FCR ($P < 0.05$) from 1 to 41 d of age when compared to the challenged and unsupplemented group (1.507 vs. 1.620). Oocyst shedding at 21 d increased due to the challenge ($P < 0.05$); however, no additive was able to prevent the lesions caused by NE ($P < 0.001$). The use of SB+EO was effective in ameliorating the performance of NE challenged birds by 41 d of age, and was the only treatment with lesion score similar to the negative control; no feed additives were able to reduce the severity of infection as measured by lesion score and oocyst shedding.

Key Words: Gut health, Coccidiosis, Feed additives

Metabolism & Nutrition IV

M114 Effects of Mannan Oligosaccharide on lean tissue, fat tissue, and bone mineral composition in broiler ducks Micky Clary*^{UG}, Jungwoo Park, John Carey Texas A&M University

The effects of a mannan-oligosaccharide (MOS) feed additive on lean tissue, fat tissue, and bone mineral composition were evaluated in 25 day old Pekin ducks using dual-energy x-ray absorptiometry (DEXA). The experiment consisted of five treatments; Control, 250 g/ton of MOS (T1), 500 g/ton of MOS (T2), 1 kg/ton of MOS (T3), and 2 kg/ton of MOS (T4). Birds were housed in battery units with nine replicates per treatment. One bird

from each unit was randomly selected for DEXA analysis (45 birds total). Light and temperature were controlled and maintained equal for all replicates. There were no challenges or therapies applied to the ducks during the experiment. Feed conversion data were also gathered. At 25d, the 45 birds were humanely euthanized via carbon dioxide asphyxiation. Immediately after, they were transported to the Applied Exercise Science Laboratory at Texas A&M University. The DEXA scanner was used to scan the ducks from the ventral side. The results of the feed conversion data show that there was no significant difference between the Control and treatments. All

data concerning lean and fat tissue in pounds, fat tissue percentage, as well as bone mineral density and bone mineral content were analyzed and recorded from the birds. In terms of lean tissue, the experiment showed that there were no significant differences in lean tissue deposition in pounds between the control and any of the treatment groups. The results of the experiment concerning fat tissue deposition in pounds showed that T1 had significantly more fat tissue than T2. The results of the experiment in terms of percentage of fat showed that T1 had a significantly greater percentage of fat deposition. The effects of the experiment on bone mineral density showed that there were no significant differences in bone mineral density among the treatments. The bone mineral composition of T3 was significantly greater than that of the Control, and was numerically the highest of all the treatments. Due to the fact that bone mineral composition is a measurement of the amount of hydroxyapatite salt in bone these results indicate that there may be a correlation between the changing of gut morphology due to the MOS. Therefore MOS may increase nutrient absorption.

Key Words: mannan-oligosaccharide, DEXA, Pekin ducks, hydroxyapatite

M115 Proving the concept that commercial in ovo delivery of a prebiotic and probiotics can positively impact broiler performance Chrysta Beck^{*UG1}, Pedro Mota², Kelley Wamsley¹, Christopher McDaniel¹, Aaron Kiess¹ ¹Mississippi State University; ²University of Sao Paulo

It is expected that the world populace will exceed 9 billion by the year 2050 and the question being asked is how poultry will contribute to feeding the populace, especially without antibiotics. Prebiotics and probiotics appear to be acceptable alternatives to antibiotic supplementation, however, the method by which prebiotics and probiotics are administered may have potential for improvement. Therefore, the objective of this study was to investigate *in ovo* injection as a method for administering probiotic bacteria and a prebiotic to fertile eggs and determine if this method impacts hatchability, live performance, or gut microflora. Four studies were conducted using *L. acidophilus*, *B. animalis*, *B. subtilis* or a yeast fermentation prebiotic derived from *Saccharomyces cerevisiae*. For each experiment, 7 treatments (no punch; dry punch; diluent punch; and either 10^3 cfu, 10^4 cfu, 10^5 cfu, or 10^6 cfu probiotic or increasing concentrations of the prebiotic/50 µl of diluent) were evaluated using 5 replicates per treatment. Initially, 1200 fertile eggs were obtained from a commercial hatchery. Eggs were incubated under standard incubation conditions. On D 10, eggs were candled, and infertile, early dead, cracked, and contaminated eggs were removed. On D 18, all eggs were injected with their appropriate treatment, transferred to hatching baskets and placed into the hatcher. On D 21, hatch residue analysis was conducted on all unhatched eggs. Chicks were counted, weighed, and 16 chicks from each replicate were placed in battery cages to obtain live performance and microbial data. Live performance and microbial samples were collected on D 0, 3, 7, and 14. Results indicated that *B. subtilis* decreased hatchability ($P < 0.0001$), *B. animalis* increased chick weight ($P < 0.05$), and the prebiotic improved live weight gain ($P < 0.05$) compared to the no punch control. The microbial results established that *L. acidophilus* increased over time in the jejunum ($P = 0.006$) but maintained a high concentration (10^8 cfu/ml) in the ceca ($P = 0.98$). *B. animalis* and the yeast used to produce the prebiotic decreased over time in both the jejunum and ceca ($P < 0.0001$). In summary it suggested to not inject *B. subtilis* into fertile eggs, performance by certain probiotics and prebiotics can improve chick and live weights, and injecting probiotics into fertile eggs can influence the gut microflora.

Key Words: in ovo Injection, Fertile Eggs, Prebiotic, Probiotic, Broiler

M116 Effect of antibiotics, Diamond V Original XPCTM and Lactobacillus plantarum on broiler performance Samane Rasulzade^{*1}, Shaban Rahimi¹, Kambiz Akbari² ¹Tarbiat Modares University; ²Molecular Genetics, National Institute of Genetic Engineering and Biotechnology (NIGEB), Tehran, Iran

A comparative study was carried out to evaluate the effect of antibiotic, Diamond V Original XPCTM and *Lactobacillus plantarum* on broiler performance. A total of 480 one-d-old chicks of mixed sex were assigned in four treatments with eight replications (15 birds in each pen) as completely randomized design. The diet treatments were included: 1) control (basal diet), 2) basal diet plus antibiotic (oxytetracycline 20 %), 3) basal diet plus Diamond V Original XPCTM, 4) basal diet plus *Lactobacillus plantarum*(LP). One mL of LP (2×10^7 cfu/mL at OD= 0.1) was used for LP treatment. The basal diets were formulated according to National Research Council (NRC). Experiment carried out for 42 days and the data were analyzed by ANOVA using the GLM procedure of SAS. Duncan's multiple range tests was used to determine the statistical significance among the means. There was no statistically significant difference between the treatment groups in: body weight, body weight gain, feed intake and feed conversion ratio ($P \leq 0.05$). It was assumed that Diamond V Original XPCTM and LP can improve microbiota of broiler gastrointestinal tract, which thereby have an important role in enhancement of intestinal function and production performance. Data analysis of this experiment did not show a significant effect on production performance of broilers. Further studies are needed to investigate the effect of the above mentioned treatments on gut health and growth performance of broiler chickens.

Key Words: Original XPC, Lactobacillus plantarum, broiler chicken

M117 Effect of Different Levels of Yeast Based Mannan Oligosaccharide (ActigenTM) on Blood Biochemistry and Immune Response of Broilers Muhammad Waqas^{*}, Athar Mahmud, Shahid Mehmood, Saima Naveed *University of Veterinary and Animal Sciences, Lahore-Pakistan*

This study evaluated effect of different levels of yeast based Mannan Oligosaccharide (MOS) on blood biochemistry and immune response of broilers. To this end, 360 day old chicks were divided into 4 treatment groups having six replicates of 15 birds each according to completely randomized design. Treatment consisted of four MOS levels 0.2g/kg, 0.4g/kg, 0.6g/kg and a control group. Blood biochemistry (cholesterol and glucose) and immune response (titers against ND and IB) were evaluated. There was significant influence of MOS supplementation on blood biochemistry and immune response. Dietary inclusion of MOS @ 0.6g/kg reduced glucose and cholesterol level and developed the protective titer against ND and IB. It was concluded that addition of MOS @ 0.6 g/kg in broiler feed improves blood biochemical profile and immune response.

Key Words: MOS, Broiler, Blood biochemistry, Immune response

M118 Effect of different rearing system on carcass characteristics in sexed broilers supplemented with different levels of Mannan Oligosaccharides (MOS) Muhammad Talha Altaf^{*}, Athar Mahmud, Shahid Mehmood, Saima Naveed *University of Veterinary and Animal Sciences, Lahore-Pakistan*

The objective of this study to aim at comparing carcass quality of sexed broilers housed under four rearing systems (floor, cage) supplemented with four different levels of MOS (400 g/ton, 600 g/ton, 800 g/ton & control). For this purpose, 720 day old commercial broilers (Hubbard Classic) were procured and half of them were reared in cages and other half on floor for 42 days of age. Each treatment was replicated three times on floor and cage having 10 birds each. The data were collected on the time of slaughter of abdominal fat, breast yield, leg quarter yield, drum stick, gizzard empty weight, and carcass weight. The data were analyzed through Analysis of Variance (ANOVA) technique in Completely Randomized Design (CRD) under factorial arrangements. Means were compared using Duncan's Multiple Range Test (DMR) with the help of SAS 9.1. Statistical analysis of

data revealed significantly high percentage of breast yield, leg quarter yield, gizzard empty weight, carcass weight and drum stick was observed in cage reared birds in female as well as less abdominal fat was observed in floor reared birds. It can be concluded from the present study that birds reared on cage rearing system supplemented of 600 g/ton of MOS perform better.

Key Words: Rearing System, Carcass Characteristics, MOS levels, Sexed boilers

M119 Effect of essential: total nitrogen dietary ratios using a mixture with alanine, glycine and glutamic acid on performance and blood parameters for broilers Rosana Maia*, Horacio Rostagno, Luiz Albino Federal University of Viçosa

Non-essential amino acids can become limiting in very low protein diets for poultry and swine. One way to avoid this limitation is determine nitrogen ratios through the definition of balance between essential (eN) and total nitrogen (tN). The objective of this study was to evaluate the effect of different dietary eN:tN ratios using a levels of mixture with alanine (Ala), glycine (Gly) and glutamic acid (Glu) on the performance and blood parameters of broiler chickens from 8 to 21 days old. It was used 300 males broiler chickens, Cobb 500, distributed in a completely randomized design with 6 treatments, 10 replicates and 5 birds per experimental unit. Treatments consisted of six Ne:Nt ratios T1 = Control treatment with 222.5g/kg CP (47% eN:tN); T2 = 190g/kg CP (56% eN:tN); T3 = 190g/kg CP + 1.201% of Mixture (53% eN:tN); T4 = 190g/kg CP + 2.516% of Mixture (50% eN:tN); T5 = 190g/kg CP + 3.999% of Mixture (47% eN:tN); T6 = 190g/kg CP + 5.683% of Mixture (44% eN:tN). To calculate the essential nitrogen it was considered the nitrogen content of each essential amino acid present in the diet. It was evaluated the pH of diets, final body weight (FBW), weight gain (WG), feed intake (FI), feed conversion (F:G), serum uric acid, globulin, albumin, and total protein. The performance and blood parameters were analysed using SAS (Statistical Analysis System), F test ($\alpha = 0.05$) and subsequently compared by Dunnett test ($\alpha < 0.05$) and regression models (linear, quadratic, LRP and LRP+Q). The pH of diets range among 6.09 and 6.90, it did not represent a big difference that affect broiler performance. The treatment with 56% eN:tN showed worse results for FBW, BW, F:G when compared to control treatment. Serum uric acid was higher in treatments with 44% and 47% eN:tN when compared to control treatment. A linear effect were found for FBW, WG, F:G, and serum uric acid. LRP analysis indicated that until 50% eN:tN broilers can maintain the performance with dietary protein reductions. In conclusion it is important to keep the eN:tN ratio no more than 50% in low protein diets.

Key Words: broiler, performance, non-essential nitrogen, amino acids

M120 Ileal digestibility coefficient of some high-protein feedstuffs for broilers Bruno Carvalho*, Helvio Ferreira Júnior, Raully Silva, Bruna Kreuz, Melissa Hannas, Luiz Fernando Albino, Horacio Rostagno Universidade Federal de Viçosa

The use of high-protein feedstuffs (>60%), although they have no major presence in commercial diets, have a great application in controlled experimental trials, especially to use in purified diets. However, knowing each amino acid digestibility of these ingredients is essential for the formulation of nutritionally adequate diets. Thus, the aim of this experiment was to determine the Total Amino Acid Content (TAAC), Ileal Digestibility Coefficient (IDC) and Digestible Amino Acid Content (DAAC) of 5 high-protein feedstuff for broilers. The experiment was conducted at the Universidade Federal de Viçosa using 240 male broiler Cobb500 with 22d of age, randomly distributed in 48 metal cages (6 treatments with 8 replicates, with 5 animals each). The animals in each cage receive one of 6 different diets: a protein-free diet (PFD) for evaluation of endogenous losses, and 5 diets composed of PFD including 15% of the tested feedstuff, constituting 6 experimental treatments, which 8 repetitions with 5 birds. The feedstuffs tested were casein, albumin, corn gluten, conventional and micronized soy protein concentrate (SPC). All diets contained 1% insoluble acid ash to determine the indigestible factor of feds.

After an adaptation period of 4 days, the birds were killed by cervical dislocation, opened in abdominal cavity, removing all the intestinal contents to 40 cm of the terminal ileum portion, up to 5 cm before the ileocecal junction. The ileal contents of each bird were assembled for the formation of the sample. The samples of feds and ileal digesta were lyophilized and conducted laboratory tests to verify the amino acids content, dry matter, acid insoluble ash and crude protein. The protein and amino acids results were corrected for endogenous losses.

The crude protein content of casein, albumin, corn gluten, conventional and micronized SPC were 89%, 82%, 63%, 64% and 63%, respectively. Casein is highlighted by digestible lysine (5.00%), digestible leucine (6.46%) and digestible phenylalanine (3.78%) content, with an average IDC of 84%. Albumin, with a greater amount of digestible leucine (5.85%) and digestible phenylalanine (4.26%), shows an average IDC of 83%. Corn gluten, with a high level of digestible leucine (8.60%), had 93% of average IDC. SPCs had high amount of arginine (3.99% and 4.58%) and average IDC of 94% for the micronized and 92% for the conventional. All ingredients present high amino acids digestibility and can be used as protein source for poultry.

Key Words: High Protein Feedstuff, Amino acids Digestibility, Ileal digestibility coefficient, Broilers

M121 Effects of supplementation of guanidinoacetic acid in corn and sorghum diets on broiler live performance until 50 days of age. Hernan Cordova*¹, Edgar Oviedo-Rondón¹, Albaraa Sarsour¹, Pedro Ferzola² ¹North Carolina State University; ²Universidade Federal do Rio Grande do Sul

A precursor of creatine has been reported to improve broiler live performance up to 42 d of age in diets containing either corn or sorghum. This experiment was conducted to evaluate the effects of guanidinoacetic acid (GAA) supplementation in broilers fed corn or sorghum based diets on broiler performance. The treatments consisted of corn or sorghum-based diets with or without the addition of GAA (600 g/ton) as CreAMINO®. A total of 800 male Ross 708 chicks were randomly placed in 40 floor pens with 10 replicates per treatment combination. At hatch, 14, 35, and 50d of age, BW and feed intake were recorded. BW gain and FCR adjusted by mortality weight were calculated at the end of each phase and flock uniformity (CV%) at 50d of age. Data were analyzed as a randomized complete block design in a 2 x 2 factorial arrangement with grain type and GAA supplementation as main effects. At 14 d only, an interaction ($P < 0.05$) effect was detected on feed intake and FCR. Feed intake was lower in sorghum-based than corn-based diets without GAA supplementation, but similar to diets with GAA. Chickens fed corn diets with GAA had better FCR than chickens in other treatments. BW was affected ($P < 0.05$) by GAA supplementation at 14, 35, and 50 d of age. Broilers fed the supplemented diets were heavier ($P < 0.05$) than the treatments fed diets with no GAA (4,167 vs. 4,061 g at 50d). The BW and BW gain were also affected by grain type at 14, 35 ($P < 0.001$) and 50 d ($P < 0.05$). Broilers fed corn diets were heavier than the ones in treatments fed sorghum diets. At 35 and 50 d of age, diets containing GAA improved ($P < 0.01$) FCR (1.682 vs. 1.724 g:g at 50d) independently of grain type. No effect ($P > 0.05$) of GAA supplementation was detected on feed intake, however, sorghum diets had lower ($P < 0.01$) feed intake at 35d. At 50 d, no significant effect of GAA supplementation was observed on BW gain and feed intake. In contrast, chickens fed sorghum diets gained less weight ($P < 0.05$) than those fed corn diets. Flock uniformity improved ($P = 0.071$) by GAA supplementation (7.23 vs. 8.44%). In conclusion, GAA supplementation improved broiler live performance of broilers fed corn or sorghum diets up to 50 d of age.

Key Words: Guanidinoacetic acid, broiler performance, flock uniformity

M122 Response of broilers to varying dietary levels of lysine, methionine, threonine, isoleucine and valine in pre-starter age Zafar Hayat^{*1}, Shehzad Ahmed¹, Muhammad Arif¹, Abd Rehman¹, Zafar Ullah¹, Muhammad Akhtar² ¹University of Sargodha; ²CVSD Remount Depot Sargodha

An experiment was conducted to figure out effects of varying dietary levels of lysine (Lys), methionine (Met), threonine (Thr), isoleucine (Ile) and valine (Val) on growth performance, carcass characteristics and serum metabolites of broilers in pre-starter phase (0-7 days) under Completely Randomized Design. A total of 420 broiler chicks (Cobb500) were randomly distributed to 42 equal replicates. Six diets as control (C; according to the Cobb dietary requirement), negative control (NC: 3% less Lys, Met, Thr, Ile and Val than C diet) and T5, T10, T15 and T20% diets having 5, 10, 15 and 20% supplemented synthetic Lys, Met, Thr, Ile and Val were formulated on digestible AA basis. Each diet was fed to seven randomly assigned replicates. After feeding experimental diets for first 7 days, same starter and finisher diets (according to the Cobb requirements) were fed along with NC diet up to 21 and 35 days to all birds, respectively. Improved FI ($p < 0.05$) with C diet was observed during pre-starter period but it was same ($p > 0.05$) by higher levels of AA. The FI increased with C diet as compared to NC diet in grower and finisher phases. Body weight gain and FCR were not affected ($p > 0.05$) with dietary treatments during pre-starter phase; however it was better ($p < 0.05$) with all diets except NC. Dietary treatments did not influence mortality percentage ($p > 0.05$) in any phase of life. Enhanced carcass and breast weight ($p < 0.05$) was noticed at higher levels of dietary AA. Serum uric acid concentration was significantly affected ($p < 0.05$) by supplemental AA and it was increased with increasing levels of AA whereas similar ($p > 0.05$) serum total protein value was at higher AA level.

Key Words: Amino acid, broilers, growth performance, carcass characteristics, serum metabolites

M123 Influence of reducing dietary protein concentration in the starter phase via two formulation methods on subsequent performance and processing characteristics of male Cobb 500 broilers Samuel Rochell^{*} University of Arkansas

The factors which limit the maximum reduction in dietary CP of broiler feeds that can be achieved by amino acid (AA) supplementation without negatively impacting performance or processing yields are not fully understood. An experiment was conducted to evaluate growth performance and processing characteristics of broilers fed starter diets in which CP content was reduced via 2 formulation methods. A control starter diet was formulated to contain 22.50% CP and meet requirements for essential AA and all other nutrients. Six additional diets were formulated to contain 21.25, 20.00 or 18.75% CP either by reducing the inclusion of SBM to result in a variable ratio of corn to SBM (VCSBM), or by reducing corn and SBM in concert at a fixed ratio (FCSBM). In FCSBM diets, corn starch was used as an energy source to compensate for reduced corn inclusion. Amino acids were supplemented to maintain equal levels of digestible Lys, TSAA, Thr, Val, Ile, Arg, Trp and total Gly + Ser across all diets. Experimental diets were fed to 576 male, Cobb × Cobb 500 broilers from 0 to 14 d post-hatch. There were 6 replicate floor pens of 12 birds (1.11 m² per bird) for the control group, whereas 7 replicate pens were used for other treatment groups. Birds were fed common grower and finisher diets from 15 to 28 d and 29 to 41 d, respectively. Body weight gain (BWG), feed intake (FI), and feed conversion ratio (FCR) were determined for each phase, and 6 birds per pen were processed at 42 d. Decreasing dietary CP content linearly reduced ($P < 0.05$) BWG and FI of birds fed FCSBM diets from 0 to 14 d, with no influence on FCR ($P > 0.05$). Dietary CP content did not affect ($P > 0.05$) FI, BWG, or FCR of birds fed VCSBM diets. From 0 to 41 d, dietary CP reductions linearly reduced ($P < 0.05$) FI and BWG, but not FCR, for FCSBM-fed birds. Feed intake linearly decreased ($P < 0.05$) with dietary CP for VCSBM birds in the same period, but BWG and FCR were not affected ($P > 0.05$). Carcass and breast meat yield and abdominal fat pad weights of birds at 42 d were not influenced ($P > 0.05$) by starter diet CP level for either formulation method. These data indicated that potential changes in dietary AA profile caused by an increased corn to SBM ratio have minimal influence on the response of broilers to low CP diets.

Key Words: broiler, starter, crude protein, amino acid

Metabolism & Nutrition V

T124 Discovery and advanced in vitro profiling of the unique probiotic strain *Bacillus subtilis* DSM 32315. Stefan Pelzer^{*1}, Jessica Schneider¹, Stella Molck¹, Maike Kipker¹, Daniel Petri¹, Claudia Borgmeier², Guido Meurer² ¹Evonik Nutrition & Care GmbH; ²BRAIN AG

There is a growing awareness that dysbiosis or alteration of the gut microbiome in poultry may be implicated in gastro-intestinal disorders and loss of performance. Probiotics are increasingly used in commercial poultry production to advantageously alter gastrointestinal microbiota, thereby improving gut health and performance of birds. The current study will highlight the discovery and *in vitro* profiling of a unique *Bacillus subtilis* strain exhibiting properties that indicate it may be a consistently effective probiotic in poultry.

A multi-parameter selection process was utilized to screen more than 500 environmentally sampled *Bacillus* strains for probiotic properties. This screening approach resulted in the characterization of a unique probiotic strain, *B. subtilis* DSM 32315. The newly identified strain was shown to form heat resistant spores and display features, which are important for survival in the intestinal tract. Compared to wildtype and competitor *Bacillus* strains investigated, *B. subtilis* DSM 32315 performed superiorly in simulated gastric passage assays, as well as growth assays in the presence of bile and organic acids. By applying SMRT (Single Molecule Real Time) sequencing and genome annotation strategies, a core genome based phylogenetic tree was constructed for *Bacillus subtilis* strains, in which *B. sub-*

tilis DSM 32315 was shown to inhabit a unique branch. In *silico* analyses of the 4.2 Mbp genome revealed the potential of *B. subtilis* DSM 32315 to produce at least 8 different secondary metabolites. Furthermore, *in vitro* cultivation studies demonstrated the ability of *B. subtilis* DSM 32315 supernatant to inhibit growth of field isolates of *C. perfringens*, the causative agent of Necrotic Enteritis.

This study demonstrates the benefit of applying an advanced *in vitro* selection process to identify unique probiotic strains. Based on various criteria established during the screening process, *B. subtilis* DSM32315 was identified as a strain exhibiting phenotypic characteristics indicating exceptional potential as a probiotic for poultry.

Key Words: Probiotic, Gut Health, Bacillus, Poultry, Mode of Action

T125 Feeding *Bacillus subtilis* DSM 32315 consistently improves performance of broilers reared in various feeding conditions. Kiran Doranalli^{*1}, Rose Whelan¹, Daniel Petri¹, Saksit Srinongkote², Savaram Rama Rao³ ¹Evonik Nutrition & Care GmbH; ²Animal Research and Consultant Co. Ltd.; ³Sri Ramadhotha Poultry Research Farm

In commercial poultry farming, birds are continuously exposed to stressful conditions which can increase their susceptibility to gastrointestinal disease resulting in reduced performance, immune suppression and increased mortality. Probiotics can improve gut health to achieve optimal bird perfor-

mance. Three studies were conducted to test the efficacy of the probiotic strain *Bacillus subtilis* DSM 32315 under various feeding conditions. Two trials were conducted in India (1- 42 d) with Vencobb 400 male broilers and one in Thailand (1-42 d) with Ross 308 male birds. All trials were conducted in floor pens with used litter.

In the India trials, dietary treatments included a basal diet (control), an AGP diet with bacitracin methylene disalicylate (BMD), a diet with a competitor probiotic and a diet with *B. subtilis* DSM 32315. Meat and bone meal was added to all diets at 5%. The same protocol was followed in both Indian trials. Birds fed *B. subtilis* DSM 32315 had numerically higher body weight (BW) than the competitor or control. However, the FCR was significantly ($p < 0.05$) lower in birds fed *B. Subtilis* DSM 32315 compared to the group fed control or competitor probiotic based diet.

The second trial was conducted to verify the repeatability of the first experiment with the same protocol. At 21 d of age *B. subtilis* DSM 32315 significantly ($p < 0.05$) improved both BW and FCR compared to the control, while these performance effects were statistically similar to BMD. The final BW and FCR during 1-42 d of age were numerically improved in broilers fed *B. subtilis* DSM 32315 compared to the control.

The Thailand study included a basal diet (control), an AGP diet (zinc bacitracin, ZnB), a diet with a competitor probiotic and a diet with *B. subtilis* DSM 32315. Distiller's grains with solubles was added to all diets at 5%. The FCR was significantly ($p < 0.05$) lower in birds fed *B. subtilis* DSM 32315 compared to the control. In addition, the 42 d BW was numerically higher in birds fed *B. subtilis* DSM 32315 followed by ZnB, the competitor and control diet.

Based on this study, it is concluded that dietary supplementation of *B. subtilis* DSM 32315 can consistently improve broiler performance when potential gut health challenges exist, under various feeding conditions.

Key Words: Probiotic, Bacillus, Strain, Gut Health, Performance

T126 Impact of *Bacillus subtilis* DSM 32315 on pathology and performance of broiler chickens in a subclinical Necrotic Enteritis challenge. Rose Whelan^{*1}, Kiran Doranalli¹, Kirsi Vienola², Teemu Rintilä², Juha Apajalahti² ¹*Evonik Nutrition & Care GmbH*; ²*Alimetrix Ltd.*

Necrotic enteritis (NE) is a serious intestinal disease challenge in poultry caused by a pathogenic strain of *Clostridium perfringens*. Toxins produced by *C. perfringens* damage the gut mucosa affecting the digestion and absorption of nutrients, most often leading to subclinical level of infection which impacts the bird's performance and increases mortality. *Bacillus subtilis* DSM 32315 is a unique strain has the potential to produce eight secondary metabolites and has been shown to inhibit the growth of various pathogenic strains of *C. perfringens*. It was hypothesized that inclusion of *B. subtilis* DSM 32315 to broiler diets could inhibit the development of *C. perfringens* induced NE, therefore improving performance of birds and reducing footpad lesions. A NE challenge study was conducted, using male, day-old broiler chicks reared in floor pens. Birds were randomly assigned to 14 birds/pen, 11 pens/treatment and 3 treatments which included a basal diet control (Control), a positive control (Narasin), and a probiotic group containing the *B. subtilis* DSM 32315 strain. The NE challenge was induced in each bird by oral inoculation of *Eimeria maxima* oocysts at 12 days of age as a predisposing factor for the inoculation of the birds with a pathogenic field strain of *C. perfringens* at 16 days of age.

Mortality was significantly ($p < 0.001$) reduced by both the *B. subtilis* probiotic (3.9%) and Narasin (1.3%) compared to the Control (10.4%). Feeding *B. subtilis* DSM 32315 significantly ($p < 0.001$) reduced the feed conversion ratio as compared to the control diet. Additionally, *B. subtilis* DSM 32315 fed group had numerically higher body weight. Furthermore, feeding probiotic and Narasin reduced the footpad lesion scores compared to the control with significant ($p < 0.001$) treatment effects. Molecular analysis of microbial populations in the ileum and cecum of birds at several

time points showed that feeding *B. subtilis* DSM 32315 consistently and significantly ($p < 0.05$) increased populations of *Bacillus* and decreased populations of *C. perfringens*. Positive alterations to the microbial populations in the gut of broilers may at least be a partial mechanism by which inclusion of *B. subtilis* DSM 32315 in the feed can reduce the risk NE and improve performance of flocks.

Key Words: Probiotic, Strain, Bacillus, Necrotic Enteritis, Clostridium

T127 *Bacillus subtilis* 29784 improves growth performances and gut microbiota parameters of broilers Amir Ghane^{*1}, V. Jacquier², A. Nelson³, L. Rhayat², P.A. Gereart², K. Brinch⁴, E. Devillard² ¹*Adisseo*; ²*Adisseo France, SAS, Centre of Expertise and Research in Nutrition*; ³*Novozymes Biological Inc.*; ⁴*Novozymes Animal Health & Nutrition*

The Problem: In broilers, as well as in all animal species and in humans, it is becoming increasingly clear that the intestinal microbiota and host response mediate key physiological processes and, by doing so, are key to optimizing bird performances. Probiotics can promote growth, protect host from intestinal infection, and stimulate immune responses in farm animals, via direct effect on the host or indirect effect on commensal microbiota (Pan et al., 2014). Notably, the strain *Bacillus subtilis* 29784 has been shown to improve broiler performance in different rearing conditions (Devillard et al., 2016). In the present study, the strain was tested for its effects on animal performance but also for investigating its mode of action through changes in commensal microbiota, as well as changes in the intestinal morphology.

How we investigated or researched the problem: A 42 day experiment was conducted to evaluate the effect of *B. subtilis* 29784 on growth performance of Cobb 500 male broilers fed corn-soybean meal based diets. The birds were fed one of the following treatments: 1) Control or 2) Control + *B. subtilis* 29784 (1.0E+08 CFU/kg of feed). Performance parameters (body weight gain, feed intake, and feed conversion ratio) and mortality were measured. At the end of the experiment, digestive contents and tissues from ileum and cecum were collected for metagenomics, histology, and electron microscopy.

Results: *B. subtilis* 29784 was able to improve BWG (+5.7%, $p=0.001$) and FCR (-5.4%, $p<0.0001$). Comparison of gut communities showed 7 significant genus-level differences between the 2 groups as measured by relative abundance. Among the most important differences, *Ruminococcus* ($p=0.0375$) and *Lachnoclostridium* ($p=0.0291$) were increased in the cecal contents of treated birds vs. controls. These groups of bacteria are known for their beneficial effect on the host by producing metabolites of interest such as butyrate. Microvilli were also significantly longer in both the ileum (+18%, $p<0.001$) and cecum (+17%, $p<0.001$) of *B. subtilis* 29784-fed birds compared to controls, suggesting an increase in surface of absorption.

Implications / Conclusions: The inclusion of *B. subtilis* 29784 in diet brought benefits to broilers, both in terms of performances and gut microbiota parameters. This strengthens the hypothesis of a positive change of the microbial ecosystem and of the intestinal morphology with the addition of probiotics.

Key Words: bacillus subtilis, probiotic, microbiota, broilers

T128 Effect of a three strain blend of *Bacillus subtilis* on ileal and caecal microbiota dynamics of broilers challenged with *Salmonella* Heidelberg isolated in the south of Brazil Ricardo Gonzalez-Esquerre^{*1}, Ricardo Mitsuo Hayashi², Raquel Bighetti Araujo¹, Marcelo Falzarella Carazzolle³, Eduardo Leonardecz⁴, Anderson Ferreira da Cunha⁴, Paulo Monzani⁴, Juliana Costa de Azevedo², César Gonçalves de Lima⁵, Elizabeth Santin² ¹*Novus International Inc.*; ²*Universidade Federal do Paraná*; ³*UNICAMP*; ⁴*Universidade Federal de São Carlos*; ⁵*Universidade de São Paulo*

The potential of feeding a blend of three strains of *Bacillus subtilis* (Sporulin® - SPR) on gut microbiota changes was evaluated in broilers challenged with a strain of *Salmonella* Heidelberg (SH) isolated in Brazil. Intestinal samples were collected at 21d of age from birds randomly submitted to 4

treatments and 4 replicates of 12 chicks each: T1) Negative control (NC), T2) SH- challenged birds (SHC), T3) SHC fed 250g of SPR/ton, T4) SHC fed 500g of SPR/ton. At 3d of age, half birds from groups T2, T3 and T4, were orally challenged with 10^7 CFU/chick of SH. Ileum and cecum contents from 12 birds ([U1] for T2, T3 and T4) were frozen in liquid nitrogen and stored at -80°C . Genomic DNA was purified and pooled to form 4 replicates per treatment. In order to characterize the most abundant bacterial communities, V3 and V4 region of 16S rRNA gene were amplified and sequenced using Illumina MiSeq platform. Bacteria with abundance higher than 1%, *Salmonella* sp., *Bacillus* sp. and ecological indexes were analyzed by ANOVA and Tukey test at $P \leq 0.05$. As expected, microbiota analysis presented a high coefficient of variation illustrating the difficulties in establishing statistical differences when studying changes in bacterial populations, and the need for greater replication. From the 16S rDNA library, an unidentified member (U.m.) from RF39 order in cecum, U.m. of *Enterococcus* genus and U.m. of Streptophyta order in ileum showed significant changes ($P < 0.05$) among treatments. *Salmonella* was absent from the ileum but present at the cecum. Feeding 250 or 500g/ton of SPR significantly reduced the frequency of *Salmonella* in cecum while feeding SPR at 500g/ton increased *Bacillus* spp in ileum. Results on ecological indexes showed that SPR 500g/ton group presented a more diverse microbiota (Shannon-Wiener index) ($p < 0.05$) compared to NC and SHC, while SPR 250g/ton improved richness (Jackknife index) compared to NC. Evenness test (Hill) revealed that SPR 500g/ton tended ($P = 0.08$) to promote higher microbiota heterogeneity than SHC group. SPR at both dosages showed equivalent cecum *Salmonella* sp. abundance in relation to NC and a significant reduction ($P < 0.01$) regarding SHC group. Ileum *Bacillus* sp. abundance increased ($P < 0.01$) compared to SHC when SPR was added at 250 or 500g/ton. In summary, SPR was effective in reducing *Salmonella* in cecum at 250 or 500g/ton, and promotes positive alterations in gut microbiota resulting in a more stable ecosystem which is by itself correlated with better gut health.

Key Words: *Bacillus subtilis*, *Salmonella*, Broilers, Gut health, Gut microbiota

T129 Evaluation of *Clostridium perfringens* challenged broilers fed *Bacillus licheniformis* (GalliPro® Tect), *Bacillus licheniformis* plus *Bacillus subtilis* (GalliPro® MS) and three other commercial DFM in a 6-week floor pen study Frank Jin¹, Herb Kling¹, Michael Sims², Alfred Blanch³ ¹Chr. Hansen, Inc.; ²Virginia Diversified Research, Corp.; ³Chr. Hansen A/S

The *Bacillus licheniformis* (GalliPro® Tect, BL_1) and *Bacillus licheniformis* plus *Bacillus subtilis* (GalliPro® MS, BLBS) have been shown to reduce necrotic enteritis (NE) caused by overgrowth of *Clostridium perfringens* (CP), and improve growth and feed efficiency. An experiment was conducted to evaluate five commercial *Bacillus licheniformis*, *Bacillus subtilis* or combined *Bacillus licheniformis* and *Bacillus subtilis* DFM products on intestinal health status and growth performance of the broilers under the CP challenged condition. On day 17 all birds were individually caught and gavaged with inoculum containing 1.0×10^9 CFU/ml of CP. The experimental diets were Corn, SBM and DDGS based with 3044, 3086 & 3142 Kcal ME/kg; 17.76 – 19.49% CP and 0.9 – 1.1% Dig Lys. A total of 2160 straight-run Cobb 500 broilers were randomly allocated to 1 of 6 treatments. The 6 treatments were: Control without DFM; BL_1 (1.60×10^6 CFU/g); BLBS (1.28×10^6 CFU/g); BS_1 (1.00×10^4 CFU/g); BS_2 (3.00×10^5 CFU/g); BL_2 (1.60×10^6 CFU/g) for 46 days with 12 reps/treatment and 30 birds/pen. Under NE challenged condition, the mortality was lower ($P \leq 0.100$) for birds treated with BL_1 (2.98%), BLBS (6.55%) and BS_2 (6.55%). BL_1 had no effect on mortality (21.43%) and BL_2 being intermediate (13.39%). All treatments resulted in lower ($P \leq 0.100$) NE lesion score (1.139 - 1.472) vs. Control (1.972). Both BL_1 and BLBS had heavier ($P \leq 0.100$) body weights (4.67 and 4.74 lb) vs. Control (4.21 lb), BS_1 (4.40 lb), BS_2 (4.50 lb) and BL_2 (4.44 lb) at 42 days. BL_1 and BLBS resulted in better ($P \leq 0.100$) FCR_{adj} (1.861 and 1.830) vs. Control (2.309), and numerically better than BS_1 (1.957), BS_2 (1.880) and BL_2 (1.913) at 42 days. This study indicated that the level of improvement by

DMF on broiler health and performance varies among different strains of *Bacillus licheniformis* and *Bacillus subtilis*.

Key Words: GalliPro®, *B. licheniformis*, *B. subtilis*, Broilers, *Clostridium perfringens*

T130 Assessment of the effect of a *Bacillus licheniformis* DFM and a *Lactobacillus animalis* DFM, alone or together, on the performance of broiler chickens under *Eimeria* and *Clostridium perfringens* challenge conditions Alfred Blanch¹, Frank Jin², Herb Kling², Mickael Rouault¹, Steve Lerner², James McNaughton³, Michael Roberts³ ¹Christian Hansen A/S; ²Chr. Hansen, Inc.; ³AH Pharma

A study was conducted to assess the effect of dietary supplementation of GalliPro® Tect and PoultriMax® alone or in combination, on live performance and health status of broiler chickens in the presence of a challenge with *Eimeria* spp. and *Clostridium perfringens*. A total of 2,496 Ross 708 chickens were randomly distributed among four experimental treatments (12 replicates per treatment, 52 birds per replicate): T1, control group without DFM in the diet; T2, GalliPro Tect (1.6×10^6 *B. licheniformis* CFU/g feed); T3, PoultriMax (0.9×10^6 *Lactobacillus animalis* CFU/g feed) and T4, GalliPro Tect and PoultriMax (1.6×10^6 *B. licheniformis* CFU/g feed and 0.9×10^6 *Lactobacillus animalis* CFU/g feed). Built up litter bedding from three previous grow-outs was used in order to obtain a mild sub-clinical challenge model. Additional bacteria challenge on the litter included *C. perfringens* (10^8 per bird the day before chicken placement) and *E. acervulina* (10^4 per bird) and *E. maxima* (10^3 per bird) on the 7th and 10th day of age, respectively. Coccidiosis vaccine was applied at hatchery, just prior to deliver to the research facility. A starter diet from 1-21 days of age, grower diet from 22-35 days of age and finisher diet from 36-42 days of age were fed *ad libitum*. At 10, 21 and 42 days of age, live performance variables (body weight, feed conversion, and mortality) were evaluated. Lesion scores were determined at 21 and 42 days of life. In general, daily feeding of GalliPro Tect (T2), PoultriMax (T3), or a combination of both DFMs (T4) improved ($p < 0.05$) live performance at 10, 21 and 42 days of age as compared to the control group. Likewise, lesion scores, intestinal bacterial counts and mortality were also improved. In conclusion, both DFMs, and particularly the combination of them, were efficient in promoting performance and intestinal health of broilers under mildly challenging conditions.

Key Words: DFM, *Eimeria*, *Clostridium*, Performance, LSC

T131 In vitro assessment of immunomodulatory properties of *Bacillus*-based probiotics Amir Ghane¹, L. Rhayat², M. Maresca³, V. Jacquier², P.A. Geraert², E. Devillard² ¹Adisseo USA; ²Adisseo France SAS, Centre of Expertise and Research in Nutrition; ³Aix Marseille University, CNRS

The Problem: As the first line of defense, the intestinal immune system is a key part helping to maintain gut health and thus, plays an important role in animal performance. Disturbances of the immune homeostasis, due to stresses and life events, can lead to an inflammatory response. The immunomodulatory properties of probiotics, even well-recognized, are devoted to specific strains. The objective of this study was to investigate the anti-inflammatory properties of the new *Bacillus subtilis* probiotic strain 29784 in comparison with two other commercially available *B. subtilis* strains, (Bs A and Bs B).

How we investigated or researched the problem: Human intestinal epithelial cells (Caco-2 cells) were used to evaluate the ability of these three *B. subtilis* strains to prevent inflammation in stimulated and non-stimulated conditions. Vegetative cells of each *B. subtilis* strains, or a positive control, epigallocatechin gallate (EGCG) known for its anti-inflammatory properties, were applied to 14 day differentiated Caco-2 cells monolayer established in a Transwell system. Caco-2 cells were then exposed, or not, to the inflammatory mediator IL-1 β . Trans Epithelial Resistance (TER) and IL-8 production were then monitored as indicators of intestinal permeability and inflammation, respectively.

Results: As expected, TER was not affected by IL-1 β and was increased by EGCG. Interestingly, the 3 *B. subtilis* strains had different impact on TER. Whereas Bs A decreased TER, Bs B had no effect and *B. subtilis* 29784 increased it. IL-1 β induced inflammation as shown by an increase in IL-8 production. All strains tested were able to significantly reduce IL-8 level. In these conditions, however, *B. subtilis* 29784 was the only strain able to fully reduce the inflammatory response, as shown by the equal level of IL-8 secreted by the IL-1-stimulated cells treated with *B. subtilis* 29784, as well as EGCG, and the non-stimulated cells.

Conclusions: Our results clearly show that 1) different *B. subtilis* strains can have different levels of efficacy in modulation of inflammatory response modulation and intestinal permeability and 2) *B. subtilis* 29784 is a good candidate as a probiotic since it both enhances intestinal barrier and reduces intestinal inflammatory status.

Key Words: bacillus subtilis, probiotic, inflammation

T132 Effects of dietary bee venom on growth performance, meat quality, immune response and gut health in broiler chicks Kyung Lee*¹, DaHye Kim¹, SangMi Han², YongSuk Lee³, YounGeun Jo³, MoungCheul Keum¹, Sang Lee¹, ByoungKi An¹ ¹*konkuk university*; ²*Rural Development Administration*; ³*Eagle Vet Tech Co., Ltd*

The effects of dietary bee venom (BV) on growth performance, relative organ weights, immune response, intestinal morphology and cecal short-chain fatty acid concentrations were evaluated in broiler chicks. A total of 700 feather-sexed male broiler chicks were divided into four treatments with seven replicates (25 birds per replicate) and reared for 35 days. A corn-soybean meal base diet was used as the control diet (CON) and the experimental diets were formulated by adding BV into the basal diet to reach 10, 50, and 100 μ g BV per kg of diet. All data were analyzed using the GLM procedures of SAS and orthogonal contrasts were utilized to evaluate the graded BV level. Statistical significance was pre-set at the level of $p < 0.05$. Dietary BV did not affect feed intake at all ages. However, feed conversion ratio and weight gain were improved linearly at 1-21 days and at 1-35 days as the BV level in diet increased. Relative breast meat yields were increased linearly ($p < 0.05$) at 21 days with the increasing BV levels in diets. Increasing dietary BV levels linearly lowered ($p < 0.05$) relative spleen and bursa weights in chicks. Serum nitric oxide levels were quadratically ($p < 0.05$) increased at 35 days. However, dietary BV did not affect ileal sIgA concentration, intestinal morphology and cecal short-chain fatty acids. Taken together, dietary BV increased growth performance, breast meat yields in broiler chicks. Further studies are ongoing whether dietary BV could enhance gut health or prevent chickens challenged with enteric pathogens including *Eimeria* spp.

Key Words: bee venom, broiler chicken, growth performance, immune response, intestinal morphology

T133 Protease, essential oil, and organic acid improve growth performance and gut health of broilers subject to *Eimeria* challenge Fenglan Yan*, Juxing Chen, Vivek Kuttappan, Mercedes Vazquez Anon *Novus International Inc.*

Government regulation, along with consumer pressure, is driving US poultry production toward Antibiotic Growth Promoter (AGP) free production in a rapid pace. Nutrition program including feed additives will need to be an integral part of any AGP free production. A floor pen study was conducted with 1320 day-old male broilers to evaluate the efficacy of protease, essential oil, and organic acid in alleviating the negative impact of mild *Eimeria* challenge on growth performance and gut health in comparison to Bacitracin Methylene Disalicylate (BMD®). The study consisted of 5 dietary treatments – Negative Control (NC), NC+organic acid (ACIDOMATRIX™ GH), NC+essential oil (NEXT ENHANCE® 150), NC+protease (CIBENZA® DP100), and NC+BMD, each with 12 replicate pens of 22 birds. Nutritionally complete typical US corn soybean meal based broiler diets were formulated for starter (0-14 d), grower (14-29 d), and finisher

(29-42 d) phases. All diets were pelleted, and starter diet was crumbled after pelleting. All birds were orally gavaged with a coccidiosis vaccine at 5X the recommended dose on d 15. Body weight, feed intake, FCR, and mortality were determined at d 14, 21, 29, and 42. On d 30, three birds per pen were euthanized to measure concentrations of serum endotoxin, IL 1 β , IL 6, IL 10, α 1 acid glycoprotein, and yellowness. Data were subject to one way ANOVA; means were separated by Fisher's protected LSD test. A P-Value ≤ 0.05 was considered statistically different. Increase in BW was observed for organic acid (21 d), protease and essential oil (29 d), and BMD (21 and 29 d). Essential oil and BMD reduced 0-29 d mortality. Protease and essential oil decreased serum endotoxin and IL 10 concentrations, and increased serum yellowness. Similarly, BMD also reduced serum endotoxin and IL 10 levels; however it had no effect on serum yellowness. Organic acid only reduced serum IL 10 concentration. In summary, in broilers under mild *Eimeria* challenge, protease, essential oil, and organic acid improved growth performance and gut health, especially protease and essential oil effects were comparable to BMD. Therefore, these feed additives could be effective nutritional tools to manage gut health challenge and improve growth performance of broilers in AGP free production.

Key Words: protease, essential oil, organic acid, broiler, antibiotic

T134 Efficacy of an oregano-based phytogetic on bird performance during coccidial challenge David Harrington*¹, Aikaterini Konstanti¹, Greg Mathis², Brett Lumpkins², Leon Broom¹ ¹*Anpario plc*; ²*Southern Poultry Research, Inc*

Phytogenics such as oregano have been shown to be beneficial in antibiotic free production programmes. A study was undertaken to investigate the effect of a commercial oregano essential oil (OEO) product (Anpario plc, UK) presented via feed or drinking water on the development of coccidial immunity.

A total of 1,320 Cobb 500 birds were hatchery spray-vaccinated at day-old with an anticoccidial vaccine and allocated to 3 treatments (55 birds/pen; 8 replicates/treatment): ROB (Robendine 33g/t; OSP) OEO in-feed, 300g/t; OSL) OEO in-water, 150ml/1000 l. Treatments were administered continuously from Day 0. Birds were floor-reared on reused litter until Day 42. Litter samples were collected weekly for oocyst enumeration (OPG). At 21 days, 5 birds/pen were moved to cages (40 birds/treatment, 8 replicates) and challenged orally with a mixed *Eimeria* infection. Coccidia-free birds were used as a Positive Control (CON) (5 birds/cage, 8 replicates). Birds were fed an untreated ration for the challenge phase. On Day 27 birds were euthanased, weight recorded and coccidial lesion scored (LS). Performance data were analysed by ANOVA; LS and OPG using Kruskal Wallis.

Bodyweight gain (BWG) at Day 42 was non-significantly higher in OSL (2.151 kg) and OSP (2.228 kg) than ROB (2.138 kg). FCR was numerically lower in ROB versus OSP and OSL, 1.65, 1.66 and 1.67, respectively. OPG counts differed significantly between treatments on Days 7, 14 and 21. A peak in OPG was observed on Day 14 in the OSP group (higher than OSL and ROB) and on Day 21 in the OSL group (higher than OSP and ROB). OPG counts in ROB continued to increase from Day 0 to Day 35. Mortality did not differ significantly between groups.

LS were significantly lower in ROB (1.5), OSP (1.1) and OSL (1.3) compared to CON (2.8). BWG from Day 21-27 was significantly higher in ROB, OSP and OSL compared to CON, 0.157, 0.215, 0.214 and 0.082 kg, respectively. LS and BWG did not differ significantly between ROB, OSP and OSL.

This study demonstrated that a commercial oregano-based product did not disrupt the development of coccidial immunity, either via feed or water. OSP or OSL improved weight gain during the floor pen and challenge phase and ameliorated intestinal damage during coccidial challenge compared to either CON or ROB.

Key Words: Oregano, Coccidiosis, Essential oil, Phytogetic, Immunity

T135 Amelioration of performance losses from necrotic enteritis by bacitracin, avilamycin, and Avi-Lution® in broiler chickens. Lucas Krueger^{*1}, David Spangler¹, Michael Sims² ¹Agri-King, Inc.; ²Virginia Diversified Research Corporation

Avi-Lution® (AvL) is a defined, patented synbiotic formula containing *Saccharomyces cerevisiae*, *Enterococcus faecium*, and *Bacillus* spp. that has been formulated on the principle of competitive exclusion. Two studies (42 d) were conducted to test the effects of Avi-Lution® on performance of broiler chickens challenged with necrotic enteritis. In study 1 ($n = 1,250$), broilers supplemented with Avi-Lution® were infected with *Clostridium perfringens* and compared with un-infected controls, infected controls, and broilers that were challenged and supplemented with bacitracin. In study 2 ($n = 2,700$), broilers were similarly challenged with *C. perfringens* and supplemented with avilamycin from d 10-31, Avi-Lution® for the study duration, or a next-generation Avi-Lution® formula (AvL2) containing proprietary bacterial strains.

Antibiotic treatments in both studies improved the growth and feed efficiency of broilers when compared with infected, untreated controls. In study 1, supplemental AvL at 1.0 g/kg produced similar or improved growth and feed efficiency compared with bacitracin. Avi-Lution® and bacitracin similarly suppressed a cecal bacterial subset, defined by 16S ribosomal gene sequencing, that was found to be positively associated with *C. perfringens* infection and with the molar proportion of cecal butyric acid. In study 2, avilamycin significantly improved broiler body weights and feed conversion by d 21 before peak challenge symptoms were observed. Through d 42, however, AvL, avilamycin, and AvL2 treatments similarly improved mortality-adjusted feed efficiency, whereas AvL2 significantly improved broiler body weights. These results demonstrate that Avi-Lution® ameliorated performance losses of necrotic enteritis in broilers.

Key Words: necrotic enteritis, bacitracin, avilamycin, broiler, *Clostridium perfringens*

T136 Effect of synbiotic supplementation on intestinal integrity of broilers Chasity Pender^{*1}, Ganapathi Murugesan¹, Dawn Koltes² ¹Biomim America Inc.; ²University of Arkansas

As researchers and industry leaders search for an alternative to the use of sub-therapeutic antibiotics to help alleviate concerns of antibiotic resistance and satisfy consumer and regulatory demands, probiotics have received increased attention for their ability to improve enteric health in poultry. The objective of this experiment was to evaluate the effects of synbiotic supplementation on broiler intestinal integrity. A total of 300, day-old Cobb 500 broiler chicks were randomly assigned to one of two treatment groups, each consisting of 3 replicate pens (50 birds/pen). Treatment groups consisted of a non-treated control and a treated group supplemented with a synbiotic (PoultryStar®; 500 g/ton). On days 7, 14, 21, and 35, eight birds per treatment were euthanized and ileal samples were collected. Intestinal integrity parameters included transepithelial electrical resistance (TEER) before and after lipopolysaccharide (LPS) inclusion and apical to basolateral flux of fluorescein isothiocyanate-LPS (FITC-LPS) as an indicator of paracellular permeability. Data were analyzed using the Proc Glimmix of SAS (SAS Institute Inc.) and significance is set at $P \leq 0.05$. Intestinal integrity increased over the course of the study and had a significant treatment by time interaction. At day 35, birds provided treated feed exhibited significantly higher TEER than birds on non-treated feed. While endotoxin permeability was not found to be significant, exposure to FITC-LPS significantly increased TEER in the treated group as compared to the control group at day 21. Interestingly, this was when birds subject to the synbiotic treatment tended to have lower initial TEER than the control birds, suggesting the synbiotic supplementation may increase the resilience of the intestinal tract in the face of a potential pathogen. Overall, these results suggest that synbiotic supplementation may be an effective means of improving intestinal integrity and allow the intestinal tract to adapt to pathogenic stressors, thus helping to prevent bacterial translocation and enteric diseases.

Key Words: gut integrity, permeability, probiotic, barrier function, broilers

SCAD II

T137 Analysis of five clinical cases of runting-stunting syndrome in broiler chickens caused by avian astrovirus and avian Reovirus Martha Pulido -Landinez^{*}, Alejandro Banda *Mississippi State University*

Five clinical cases of broilers of 5 to 12 days of age were analyzed. The history as reported by submitter was runting birds and high mortality. Clinical evaluation showed moderate depression, poor body condition, lack of uniformity in size among each group of birds, lameness, poor feathering, dehydration, and whitish diarrhea. At necropsy the most remarkable lesion was pale, dilated thin-walled intestines with watery contents and undigested food (4/5). The pancreas showed whitish discoloration (1/5). In 3/5 groups mild aerosacculitis and pericarditis were observed. Samples for bacteriology, histopathology, and virus isolation were collected. Histopathologic findings for 1/5 cases showed abnormality of intestinal villi and pancreatitis. This case was positive for avian reovirus. 4/5 cases showed no remarkable micro changes in intestine and pancreas. Collected samples of these four groups of birds were positive to Avian Astrovirus. All isolated virus were confirmed by PCR. Apparently, avian astrovirus is capable of causing runting stunting syndrome without compromising the villi integrity.

Key Words: Avian Astrovirus, Avian reovirus, intestinal integrity

T138 A comparison of mid-lay serology and IBV Arkansas protection in flocks receiving different commercial Salmonella enteritidis (SE) bacterins Kalen Cookson^{*1}, Andrew Barker¹, Savannah Featherson¹, John Brown¹, Dan Wilson² ¹Zoetis; ²Rose Acre Farms

SE vaccines help minimize the risk of food borne illness in the layer industry. The purpose of this study was to compare Arkansas (Ark) infectious

bronchitis virus (IBV) protection of two SE bacterins—one containing Ark antigen and the other containing only Mass antigen. **Study Design:** Hy-Line W-36 pullets received a single live Ark vaccination at 2 weeks of age. At 13 weeks of age, pullets in adjacent rows received either SE-ND-IB Vaccine A (0.3ml; no Ark) or SE-ND-IB Vaccine B (0.25ml; contains Ark). Three weeks later the birds were moved to a layer farm where they remained in adjacent rows. At 45 weeks of age, 40 birds from each group were moved to isolators in Durham, NC, along with 30 2-week old SPF leghorns. A week later, 24 birds from each vaccine treatment and 20 SPF controls were challenged with 4.5 log₁₀ Ark IBV. 16 birds from each vaccine treatment and 10 SPF controls remained un-challenged; vaccinates were bled for serology comparison. Five days later, all birds were examined for clinical signs and airsac lesions; tracheas were submitted for histopathology; choana and trachea swabs were tested for IBV PCR. **Results:** There were no significant clinical signs or airsac lesions in any challenged groups. 63% of challenge controls had 3-score tracheal lesions (necrosis) compared to none of the commercial birds. There were also no differences in tracheal lesions (most had modest infiltrates and epithelial hyperplasia) between challenged and non-challenged commercial birds. Challenge controls were strongly positive on Ark PCR of both choana and trachea samples, indicating a good “take”. Challenge of Vaccine A birds yielded 79% and 83% protection of choana and trachea (PCR negative) compared to 67% and 96% protection, respectively, in Vaccine B birds. There were no significant differences in IBV (including Ark HI), NDV and SE serology. **Discussion:** A mid-lay Ark challenge of commercial layers did not cause an increase in tracheal lesions and resulted in low Ark recovery levels, indicating solid immunity in both vaccine treatments. This study demonstrates

that an SE bacterin containing Ark is not necessary to achieve solid Ark IBV immunity—probably because of live Ark priming and the boosting influence of field challenge on the layer premise at housing time.

Key Words: IBV, Arkansas, SE, bacterin, protection

T139 Replication of chicken embryonic kidney cell culture-adapted Ark DPI infectious bronchitis virus vaccine strain in chickens Saiada Farjana*^{GS}, Ramon Zegpi, Haroldo Toro, Vicky Santen *Auburn University*

ArkDPI-like infectious bronchitis virus (IBV) is frequently isolated from respiratory disease cases in intensive broiler-producing areas of the U.S. despite vaccination with live-attenuated ArkDPI vaccines. Commercial ArkDPI vaccines contain subpopulations that are rapidly selected in vaccinated chickens and are a likely source of many of the ArkDPI-like viruses isolated. We previously eliminated these vaccine subpopulations selected in chickens by adaptation of a commercial ArkDPI-derived vaccine to chicken embryonic kidney (CEK) cell culture, and demonstrated protection against virulent Ark-type IBV challenge following vaccination with our CEK-adapted Ark DPI vaccine strain. However we also observed three amino acid changes in the spike protein of the CEK-adapted ArkDPI vaccine strain compared to the major population of the vaccine from which it was derived, and found that these changes eliminated detectable binding of recombinant spike protein to chicken tissues *in vitro*. Both the lack of detectable binding of recombinant spike protein to chicken tissues and lack of the subpopulations that are selected in chickens predict that the CEK-adapted vaccine strain replicates to lower levels in chickens than the commercial vaccine strain from which it was derived. To characterize replication of our CEK-adapted ArkDPI vaccine strain in chickens and compare it to replication of the commercial ArkDPI vaccine strain, we ocularly inoculated three groups of fifteen SPF leghorn chickens with 10^4 or 10^5 EID₅₀ CEK-adapted ArkDPI, or 10^4 EID₅₀ commercial ArkDPI vaccine. Replication of the vaccine viruses in individual chickens of each group was monitored by Taqman qRT-PCR to determine the relative levels of viral RNA in tears 3, 5 and 8 days post-vaccination (DPV) and choanal and tracheal swabs 5 and 8 DPV. Data was analyzed by ANOVA and Tukey's post test. As expected, vaccine viral RNA was consistently statistically significantly lower in all three sample types in chickens inoculated with CEK-adapted vaccine compared to the commercial vaccine when the same dose (10^4 EID₅₀) was used and in tracheal swabs even when ten times the dose was used. In spite of its lower ability to replicate in chickens, the CEK-adapted vaccine strain provides effective protection.

Key Words: Infectious bronchitis virus, ArkDPI, Vaccine, qRT-PCR, Attenuation

T140 Kidney cell-adapted Infectious Bronchitis ArkDPI vaccine is stable and protective Ramon Alejandro Zegpi Lagos*^{GS}, Cassandra Breedlove, Vicky van Santen, Haroldo Toro *Auburn University*

We previously demonstrated that adaptation of an embryo-attenuated infectious bronchitis virus (IBV) Arkansas (Ark) Delmarva Poultry Industry (DPI)-derived vaccine to chicken embryo kidney (CEKp7) cells shifted the virus population towards homogeneity in spike (S) and non-structural protein (NSP) genes. Moreover, typical Ark vaccine subpopulations emerging in chickens vaccinated with commercial Ark vaccines were not detected in chickens vaccinated with CEKp7. In the current study, both conventional and next generation sequencing results show that the changes observed during CEK adaptation remained after five back-passages in ECE indicating that kidney-cell adaptation drastically increased the stability of this vaccine virus population. In a first protection study one-day-old chickens were vaccinated with $10^{4.0}$ or $10^{5.0}$ EID₅₀/chicken of the 2nd ECE back-passage of CEKp7 (CEKp7e2) and demonstrated to be protected against Ark virulent ($10^{6.0}$ EID₅₀) challenge. In a 2nd protection trial, CEKp7e2 was compared against protection conferred by an attenuated commercial ArkDPI-derived vaccine, different from which the CEK-adapted virus originated. All vaccinated chicken groups showed a significant reduction of respiratory signs and viral load after Ark virulent challenge compared to unvaccinated-chal-

lenged controls. In CEKp7e2 vaccinated chickens, viral subpopulations different from the challenge virus were detected in a marginal number (6-7%) of chickens after challenge. In contrast, IBV S1 sequences differing from the predominant population in the challenge virus were detected after challenge in a large number (77%) of chickens vaccinated with the commercial Ark attenuated vaccine. The CEK-adapted IBV ArkDPI-derived vaccine is a stable and effective vaccine, which drastically reduces the emergence of Ark-like viruses both at vaccination and after challenge.

Key Words: infectious bronchitis virus, coronavirus, virus adaptation, genetic variation, vaccine

T141 Development of a potential IBV Arkansas serotype vaccine candidate: Arkansas GA Grace Albanese*^{GS}, Deborah Hilt, Mark Jackwood, Brian Jordan *University of Georgia*

Avian infectious bronchitis virus (IBV) is a gammacoronavirus that causes infectious bronchitis (IB), an economically significant upper-respiratory disease of chickens. Almost all commercial poultry are vaccinated against IBV using live-attenuated, serotype-specific vaccines applied by spray in the hatchery. Previous work by our laboratory and others has shown that the Arkansas DPI (ArkDPI) serotype vaccine does not infect and replicate like a typical (Mass) IBV vaccine after spray application, is constantly isolated in the field, and does not provide adequate protection from challenge. A previous Ark serotype vaccine, Arkansas 99 (Ark99), was the first Ark-type virus to be attenuated and used as a vaccine in the field. The original Ark99 protected from challenge, but caused severe reactions post-vaccination, leading to its discontinued use when ArkDPI was produced. This study proposed to revive Ark99 and further evaluate its potential as a vaccine. The Ark99 vaccine seed stock was first passaged 60 times in embryonating eggs to produce a more attenuated vaccine, Arkansas GA (ArkGA). Following attenuation, the replication efficiency and protection from challenge of ArkGA was evaluated. ArkGA was administered to 100 one-day-old broiler chicks using a spray cabinet at a dose of 1×10^4 EID₅₀ per chick. Choanal swabs were taken from each chick at multiple time points post-vaccination for qRT-PCR to verify that ArkGA was infecting and replicating in a pattern typical for IBV, and for sequencing to confirm that the virus population replicating in the birds was the same as the ArkGA vaccine. Twenty-eight days post-vaccination, birds were challenged with pathogenic ArkDPI and a necropsy was performed five days later during which choanal swabs were taken for virus detection by qRT-PCR and virus isolation, clinical signs were recorded, and tracheas were collected for ciliostasis scoring. The results from this trial indicate that ArkGA is a suitable Ark-type vaccine candidate, showing efficient infection and replication post vaccination and consistent protection from challenge.

Key Words: Broiler, Vaccine, Infectious Bronchitis Virus, Arkansas

T142 Rapid and specific identification of infectious bronchitis virus (IBV) by real time reverse transcriptase-polymerase chain reaction (RT-PCR) with synthetic DNA templates and clinical specimens Jongseo Mo*^{GS1}, Michael Angelichio², Lisa Gow², Valerie Leathers², Mark Jackwood¹ ¹*Poultry Diagnostic and Research Center, University of Georgia*; ²*IDEXX Laboratories*

Rapid identification of infectious bronchitis virus (IBV) is not only important for control of the disease, but also to rule out other important respiratory diseases including infectious laryngotracheitis, Newcastle disease, and avian influenza. Real-time PCR has nowadays become one of the most common methods of gene quantitation due to its large dynamic range, high sensitivity, and specificity. Since vaccine control strategies are only effective when designed around the currently circulating IBV types, it is imperative to detect and differentiate these serotypes in an accurate and rapid fashion. Pan-real time RT-PCR test for IBV as well as specific tests for common types found in the field were developed. We also utilized synthetic DNA templates that resemble the hypervariable region in the S1 gene subunit of IBV to generate an standard curve to quantify the presence of the target gene. An internal positive control was also added to verify the integrity of

the test and its effect on sensitivity and specificity was assessed. Lastly, clinical specimens obtained from bird studies conducted by our laboratory were processed for validating the authenticity of these assays.

Key Words: Infectious Bronchitis, Real-time PCR

T143 Improved protection by including infectious bronchitis virus S2 ectodomain Fatma Eldemery*^{GS}, Kellye Joiner, Haroldo Toro, Vicki van Santen *Department of Pathobiology, College of Veterinary Medicine, Auburn University*

Infectious bronchitis virus (IBV) quickly evolves by point mutations, recombination, and selection processes that result in continuous emergence of new serotypes, which prevents effective vaccination. The spike (S) protein is the most variable protein of IBV and the major inducer of neutralizing antibodies. While the spike S1 subunit mediates viral attachment to host cells, the S2 subunit, which is more conserved among IBV strains, is responsible for membrane fusion and likely assists in virus attachment. Based on our previous results showing increased binding to chicken tissues of S1+S2 ectodomain compared to S1 alone, we hypothesized that immunization with S1+S2 ectodomain protein confers more effective protection against challenge than immunization with S1 protein. We produced IBV Arkansas-type (Ark) strep-tagged glycosylated soluble trimeric recombi-

nant S1 and S1+S2 proteins from codon-optimized constructs in HEK293T cells. Specific-pathogen-free chickens in groups A and B were primed at 12 days of age with 10 µg of S1 or 20 µg of S1+S2 protein emulsified in Sepic Montanide™ ISA 71 VG adjuvant respectively, then boosted 21 days later. Groups C and D were unimmunized (adjuvant only)/challenged and unimmunized/unchallenged control groups. Chickens in groups A, B and C were challenged with virulent Ark IBV 21 days after boost. Chickens immunized with recombinant S1+S2 protein showed statistically significantly ($P < 0.05$) reduced viral loads as determined by qRT-PCR 5 days post-challenge in both tears and tracheas compared to chickens immunized with recombinant S1 protein. Consistent with viral loads, significantly reduced ($P < 0.05$) tracheal mucosal thickness, lymphocyte infiltration, deciliation and necrosis revealed that immunization with recombinant S1+S2 protein provided improved protection of tracheal integrity 5 days post-challenge compared to immunization with recombinant S1 protein alone. These results indicate that recombinant S1+S2 ectodomain protein confers better protection against challenge than recombinant S1 protein, suggesting that the S2 domain has an important role in inducing protective immunity. Thus, including the S2 domain with S1 might be promising for better viral vectored and/or subunit vaccine strategies.

Key Words: infectious bronchitis, coronavirus, recombinant spike protein, S2, immunization

SCAD III

T144 Effect of pullet vaccination on development and longevity of immunity Emily Aston*^{GS}, Brian Jordan, Maricarmen Garcia, Mark Jackwood *University of Georgia*

Avian respiratory disease causes significant economic losses in commercial poultry operations. To protect against these respiratory diseases, standard vaccination protocols commonly target viral diseases caused by infectious bronchitis virus (IBV), Newcastle disease virus (NDV), and infectious laryngotracheitis virus (ILT). Typically, these practices involve serial vaccinations administered at certain time intervals *in ovo*, at the hatchery, or in the poultry house. Most of these vaccines are live attenuated and offer good protection against homologous challenge when they are individually administered. However, little research has been performed to investigate how the timing of immunization with multiple live attenuated vaccines affects the development of antibodies and protection against challenge in poultry. The aim of this study was to examine the effect of serially administered, live attenuated vaccines against IBV, NDV, and ILTV on the development of mucosal and systemic immunity and protection against challenge in long-lived birds. SPF White Leghorns were administered a combination of multiple live attenuated vaccines against IBV, NDV, and ILTV until sixteen weeks of age, after which certain groups were challenged with IBV, NDV, or ILTV at 20, 24, 28, 32, and 36 weeks of age. Post-challenge, clinical signs were recorded and samples were collected to determine antibody levels, ciliostasis, and viral load in respiratory tissues. Immunized birds were protected from challenge. Compared to vaccinated birds in their respective challenge groups, nonvaccinated birds challenged with IBV displayed clear differences in ciliostasis and significantly increased clinical signs, and nonvaccinated birds challenged with ILTV exhibited significantly more severe clinical signs. Compared to vaccinated birds challenged with NDV, clear differences in ciliostasis and clinical signs of nonvaccinated birds challenged with NDV were not observed. Understanding how the administration of multiple live attenuated vaccines impacts the development of immunity and protection from challenge will contribute key information leading to improved vaccination programs that achieve maximum immune protection from field challenge in long-lived birds.

Key Words: Infectious bronchitis, Newcastle, Infectious laryngotracheitis, Vaccination, Immunity

T145 Cytokine expression patterns in conjunctiva, Harderian gland and trachea after ocular or oral inoculation with a virulent strain of infectious laryngotracheitis virus (ILT) Gabriela Beltrán*^{GS1}, Sylva M. Riblet¹, Wanderley Moreno Quinteiro², Leah Read², Shayan Sharif², Maricarmen Garcia¹ *¹The University of Georgia; ²University of Guelph*

Infectious laryngotracheitis virus primarily infects the upper respiratory tract of chickens. The main sites of ILTV lytic replication are the conjunctiva, nasal cavity and the trachea mucosa. We have previously showed that the route of inoculation greatly alters the replication patterns of virulent ILTV strain 63140. When strain 63140 was administered via the ocular route viral replication was detected in trachea, conjunctiva and nasal cavity. In contrast when administered via the nasal or oral routes replication was limited to the nasal cavity. The nasal cavity, conjunctiva and the Harderian gland are structures that although not anatomically connected to the respiratory system are the first to come in contact with the virus and contain associated lymphoid tissues which play essential roles in induction of local immune responses. The specific objective of this study was to determine how the route of inoculation of virulent ILTV strain 63140 influenced cytokine gene expression in conjunctiva, Harderian gland and trachea tissues after ocular or oral inoculation. Relative quantification of host gene expression for type I interferon (IFN alpha and beta), type II interferon (IFN gamma), interleukines IL1b, IL6, and inducible nitric oxide (iNOS) was performed by reverse transcriptase real-time PCR. Preliminary analysis shows that three days post ocular inoculation significant up regulation of IFN alpha, beta, and gamma gene expression was detected in conjunctiva of infected chickens. While in conjunctiva of chickens inoculated via the oral route five days post-inoculation significant up regulation of IFN-gamma, IL6, and iNOS gene expression was detected. Further analysis of cytokine gene expression in Harderian gland and trachea will be presented.

Key Words: Infectious laryngotracheitis, ILTV replication patterns, Host cytokine gene expression, ILTV lytic replication, Routes of inoculation

T146 The role of litter beetles, water, and rodents in avian influenza virus transmission Isabelle Kallenberg*^{GS}, Joe Giambrone, Ken Macklin, Teresa Dormitorio *Auburn University*

Avian Influenza (AI) is an infectious respiratory disease of birds caused by Avian Influenza Virus (AIV). AIVs commonly infect poultry and wild birds; however, some strains, e.g., H5N1, H1N1, H7N9, have infected and

caused mortality in a variety of mammals including humans. Wild waterfowl are the natural reservoir of influenza A viruses and serve as a continuous source of virus for domestic poultry and other animal species including humans. Waterfowl are typically asymptomatic whereas poultry commonly exhibit extreme respiratory distress, discolored wattles, high morbidity, and even mortality. Despite the implementation of biosecurity measures, the United States suffered from an H5N2 highly pathogenic AIV (HPAIV) outbreak from late 2014 to mid-2015 that affected almost 50 million birds and cost about \$3.3 billion for depopulation and indemnification of farmers. Possible means of AIV transmission onto poultry farms include wild waterfowl, contaminated shoes, equipment, and trucks, but not much is currently known about other modes of AIV transmission. Darkling beetles, biofilm-containing waterlines, and rodents have been shown to transmit infectious laryngotracheitis virus (ILTV), and therefore our current studies will determine if AIV can also be transmitted via these vectors. Preliminary results showed that AIV was detectable by RRT-PCR in feed, beetles, and water lines up to 5 days, 3 days, and 24 hours, respectively. Cp values ranged from 23 to 40. Experiments will be replicated to confirm results and egg passages will be performed to determine virus viability. AIV transmission in rodents will be included in future studies.

Key Words: avian influenza virus, rodent, beetle, water, transmission

T147 Progress of passive immunity in broilers and efficacy of rNDV-AI vector vaccine against highly pathogenic avian influenza virus Kateri Bertran*, Charles Balzli, Dong-Hun Lee, Lindsay Killmaster, David Swayne *SEPRL, USDA*

Maternal antibodies provide early protection from disease, but may interfere with the vaccination efficacy in the chick. In highly pathogenic avian influenza virus (HPAIV) enzootic countries, broilers typically have maternal antibodies against Newcastle disease virus (NDV) and AIV, among others. Interest has arisen regarding a live recombinant vector vaccine that can overcome passive immunity and is mass-applicable at the farm. This study seeks to: 1) monitor active and passive immunity in breeders and progeny, respectively; and 2) assess the efficacy of a spray-applied live rNDV expressing the H5 gene from clade 2.3.4.4 H5N1 HPAIV (rNDV-H5). We used commercial broiler breeders vaccinated with NDV, among others. Once in SEPRL, half of the breeders were vaccinated with an inactivated rgH5N1 vaccine to mimic conditions in HPAIV enzootic countries; progeny from this group was "AIV Ab⁺". The other half were not vaccinated against AIV and produced progeny "AIV Ab⁻". Both AIV Ab⁺ and AIV Ab⁻ progeny groups were divided into an rNDV-H5 spray-vaccinated group at 3 weeks old, and a sham unvaccinated group. All birds were challenged at 5 weeks old with a stringent dose of clade 2.3.4.4 H5N2 HPAIV. AIV and NDV antibodies reached log₂ 6.2-8 GMT in breeders' serum and log₂ 8.4-9.1 GMT in eggs' yolks. Starting at 1 day old with log₂ 5.5 (NDV) and 5.4 (AIV) GMT, progeny's passive immunity progressively declined to <3.0 GMT at 4 weeks old. However, both groups that received rNDV-H5 at 3 weeks had mounted an antibody response of log₂ 6.1 (NDV) and 3.9 (AIV) GMT by challenge. All sham birds died within 3 days with a statistically not different mean death time (MDT); 20% (AIV Ab⁻) and 30% (AIV Ab⁺) of vaccinated birds died, with statistically different MDT of 9.5 and 5 days, respectively. Vaccinated birds had significantly reduced virus shedding titers compared to sham birds. At termination, all survivors had log₂ ≥6.0 GMT against NDV and AIV. These results suggest that mass-applied rNDV-H5 at the farm can partially control HPAIV in enzootic countries, but optimal efficacy might require a prime-boost strategy.

Key Words: highly pathogenic avian influenza virus, mass vaccination, rNDV-H5, maternal antibody interference

T148 Pathogenicity of the 2016 Indiana H7N8 highly pathogenic and low pathogenicity avian influenza viruses in chickens, turkeys and mallards Mary Pantin-Jackwood*, Erica Spackman, Chris Stephens, David Suarez, David Swayne *Exotic and Emerging Avian Viral Diseases Unit, Southeast Poultry Research Laboratory, U.S. National Poultry Research Center, U.S. Dept. of Agriculture, Agricultural Research Service*

In January 2016 a H7N8 highly pathogenic avian influenza (HPAI) virus was isolated from a turkey farm in southern Indiana. Subsequent active surveillance identified 8 additional turkey farms infected with H7N8 low pathogenicity avian influenza (LPAI) virus. Sequence analysis showed all the virus isolates to be closely related, with all eight gene segments of North American origin and sequence similarity to recent wild bird isolates. Experimental studies were performed to evaluate the infectivity, pathogenicity, and transmission of these viruses in turkeys, chickens and mallards. Results demonstrated that in all 3 species the infectious dose was lower with the HPAI virus than the LPAI virus. Also the HPAI isolate was shed at significantly higher titers and by a significantly higher proportion of birds than the LPAI isolate. The H7N8 HPAI isolate killed all the turkeys and contacts regardless of the dose given, most turkeys presenting severe lethargy and neurological signs; the H7N8 LPAI isolate produced mild respiratory disease when given at a high dose. In chickens, the clinical signs for the HPAI virus were typical of HPAI, killing all birds with a mean death time of 2.7 days; however, chickens were not infected with the lower dose of the virus and there was no transmission to contacts. No disease was observed in chickens exposed to the LPAI virus or in the mallards exposed to either the HPAI or the LPAI virus. Mallards given moderate to high titers of the LPAI and HPAI virus became infected and transmitted to contacts. In conclusion, turkeys were more susceptible to infection with the H7N8 LPAI and HPAI viruses than chickens and mallards, but the viruses still retained the ability to infect and transmit in mallards.

Key Words: H7N8, avian influenza, turkeys, chickens, mallards

T149 Heat inactivation of avian influenza virus in chicken litter as a potential means to decontaminate poultry houses Christopher Stephens*, Erica Spackman *Southeast Poultry Research Laboratory, US National Poultry Research Center, US Dept. of Agriculture-Agricultural Research Service*

Recovery from an outbreak of avian influenza virus (AIV) requires extensive cleaning and disinfection procedures, including removal of all organic material. These practices can be labor intensive and expensive. An alternative to removing all the organic material is to inactivate AIV with high temperatures within the house. Litter, which normally has a high virus load and is a difficult material to decontaminate, was used as a matrix to evaluate the inactivation profiles of low pathogenic (LP) and highly pathogenic (HP) AIV. Inactivation profiles were evaluated at 50°F-120°F at 10° intervals for LPAIV, and 50°F-110°F at 20° intervals for HPAIV. Litter temperature and moisture levels were monitored for each temperature evaluated. Samples were taken at regular intervals for each temperature. Virus was extracted from each sample, and titrated in embryonated chicken eggs to determine when inactivation occurred. RNA was also extracted from each sample for rRT-PCR analysis to determine the rate of viral RNA decay relative to virus inactivation. LPAIV was inactivated within 1 day at the higher temperatures (80°F-120°F). At the lower temperatures, inactivation times increased and became more variable (2-6 days). HPAIV followed a similar trend, with inactivation occurring after 1 day at 110°F and 90°F, and requiring 2-5 days for inactivation at the lower temperatures. Avian influenza virus RNA was detectable by rRT-PCR at all virus isolation endpoints with both the LPAIV and HPAIV samples with minimal degradation. The results can be used as a guide for the length of incubation time required, at a specific temperature that will inactivate AIV inside of a poultry house.

Key Words: Avian Influenza Virus, Heat Inactivation, Poultry Litter

Metabolism & Nutrition VI

T150 Organic acid based product reduces BCO lameness in broilers
Leon Broom^{*1}, Aikaterini Konstanti¹, David Harrington¹, Adnan Ali Khalaf Al-Rubaye², Douglas Rhoads², Young Min Kwon² ¹Anpario PLC; ²University of Arkansas

Lameness can be a significant issue for bird welfare and performance. Bacterial chondronecrosis with osteomyelitis (BCO) is recognised as one of the key causes of lameness and mortality in broilers, and a common problem for poultry operations. BCO lameness is thought to primarily occur following a breakdown in gut health and integrity, which allows bacteria to translocate from the intestine to the proximal femoral and tibial heads. *Staphylococcus agnetis* has been identified from BCO poultry and capable of inducing lameness at up to 80%. pHorce (Anpario, UK) is a feed additive based on formic and propionic acids, and their salts, on a micro-pearl carrier. pHorce helps to promote a favourable gut environment and intestinal health. This study determined the effects of pHorce on lameness in broilers in a *S. agnetis* challenge model. A total of 480 Cobb500 birds were split into two groups (4 reps/group). The two groups were: control (C) and pHorce (pHo) at 1.5 kg per tonne of feed. Birds were provided with a nutrient sufficient diet, and water, *ad-libitum*. Birds were raised from days 1-56 on wire flooring. On days 20 and 21, birds were challenged via drinking water with *S. agnetis* isolate 908 at 10⁵ CFU per ml of drinking water. Birds were assessed for lameness twice a day from day 22. Those birds deemed clinically lame were humanely euthanized, necropsied and cause of lameness determined. Birds that died naturally were also necropsied and assessed. The ileal mucosa-associated microbiota was obtained from 5 apparently healthy birds per group on days 14 and at the end of the experiment for molecular analysis. During the 56 day experiment, pHo reduced the incidence of lameness compared to control (pHo: 42% vs C: 77%; p<0.01). In addition, pHo reduced ileal mucosal *Enterobacteriaceae* on day 14. This work demonstrated that pHorce reduced broiler lameness in a BCO-induced model, which may be due to beneficial changes to the intestinal microbiota and health.

Key Words: Organic Acids, Lameness, Gut health, Microbiota, Broilers

T151 Confirmation of the presence of *Enterococcus faecium* M74 in the gastrointestinal tract of young chicks from eggs inoculated with GalliPro Hatch Alfred Blanch^{*1}, Line Skjoet-Rasmussen¹, Elke Brockmann¹, Jannie Schnabl¹, Mickael Rouault¹, Dorthe Sandvang¹, Frank Jin², Aaron Kiess³ ¹Christian Hansen A/S; ²Chr. Hansen, Inc; ³Mississippi State University

Artificial incubation in modern poultry production delays enteric tract colonization by desirable microorganisms due to lack of contact with adult birds. Initial microbe colonization is not only important to prevent colonization by pathogenic bacteria, but it is also very important to stimulate the development of the immune system and therefore to secure livability of young chicks. *In ovo* colonization with probiotics can become an important tool to combat post-hatching intestinal infections, reinforcing gut development and bird viability. It has previously been reported that the *in ovo* inoculation of GalliPro Hatch (*Enterococcus faecium* M74, 1.4E+07 CFU or 50 µl/egg) reduces the first 7-day mortality by 50% (1.316% vs 2.632%). The presence of the probiotic strain in the gut is a critical measurement to prove that the inoculated bacteria are viable in the intestinal tract. The objective of this study was to confirm the occurrence of M74 in newly hatched 1- and 7-day-old chickens from eggs inoculated with GalliPro Hatch using Pulsed Field Gel Electrophoresis (PFGE) typing. Six samples from yolk sac (YS), caecal tonsils (CT), and the rest of the intestinal tract (IT) from 1-day-old and 7-day-old chickens were recovered for analysis. Counting of CFUs was undertaken using TSA blood agar and *Enterococcus* selective agar. In general, a high number of uniform bacterial cultures was discovered. When visually inspecting the colonies, many looked homologous and showed the typical colony morphology of an *Enterococcus*. One randomly collected colony from each sample of YS, CT and IT was

cultivated to ensure purity in preparation for PFGE typing. A M74 reference strain and the collected colonies from the intestinal sample cultures were typed by PFGE. Results showed that *Enterococcus faecium* (M74) from the product GalliPro Hatch was present in high concentration in the yolk sac (2.0E+08–6.0E+09 CFU/g), caecal (2.0E+06–7.0E+08 CFU/g) and intestinal samples (5.0E+04–1.0E+08 CFU/g) of 1-day-old and 7-day-old chickens. Results demonstrate that the inoculated strain (M74) is absolutely viable for intestinal colonization through *in ovo* injection.

Key Words: *Enterococcus faecium* M74, *in ovo*, gut colonization

T152 Pre-hydrolysis of inositol hexakisphosphate (IP6) in the gizzard-proventriculus step reduced Ca-phytate precipitation in the small intestine: An in-vitro study Luis Romero^{*1}, Rie Mejldal², Trine Christensen², Yueming Dersjant-Li¹, Luis Romero¹ ¹Danisco Animal Nutrition, DuPont Industrial Biosciences; ²DuPont Nutrition Biosciences ApS, DuPont Industrial Biosciences

Dietary Calcium (Ca) can bind to phytate at the pH of the small intestine, which decreases phosphorus (P) availability and reduces the efficacy of phytase. Three new-generation commercial phytases from *Butiauxella* sp. (B; expressed in *T. reesei*), *E. coli* (E; expressed in *T. reesei*), and *Citrobacter* (C; expressed in *A. oryzae*) were evaluated in a chicken *in-vitro* model system. The phytic acid bound P corresponded to 0.27 % of diet and Ca corresponded to 0.9% of diet to mimic their levels in a corn-soybean meal diet. A 2:1 water to diet ratio was applied. Glycine-HCL buffer at pH 2.5 containing Na phytate and CaCO₃ were prepared. At this pH, no physical Ca-phytate precipitate was observed. Phytase at a dose of 750 FTU/kg was added to the solution and hydrolysis was carried out at 37°C for 0, 15, 30, 60 and 120 min with or without phytase. At the end of each incubation time, pH was adjusted to pH 6.5 with sodium hydroxide to mimic the transfer to the small intestine. Ca-phytate precipitated out at this pH. Suspensions were phase-separated by centrifugation and supernatant was decanted away, collected, and quantified. Supernatant and precipitate were analyzed for amount of Ca and P by ICP-OES.

Without phytase, the precipitate was 11-12% of total weight. Phytase B showed significantly lower precipitate and increased the soluble P and Ca fraction compared to phytases E or C at 30 and 60 min. After 30 min incubation, the precipitate was reduced to 5%, 9%, and 10%, and after 60 min incubation, it was further reduced to 3%, 6% and 8% of total weight by phytase B, E, or C, respectively. Without phytase, P was below detection limit in the supernatant in control samples throughout the 120 min, indicating all phytate P was in the precipitate. After 60 min, phytase B increased the soluble P fraction to 72%, whereas phytase E and C increased the soluble P fraction to 51 and 42%, respectively. Similar results were seen for the fraction of soluble Ca. After 60 min incubation, phytases B, E, and C increased the level of soluble Ca from 64% in the control to 87%, 78%, and 76%, respectively. A rapid degradation of IP6 at low pH (e.g. gizzard-proventriculus) reduces the Ca-phytate precipitation in the small intestine, which may explain differences in bio-efficacy among phytases.

Key Words: *in-vitro* chicken, Ca-phytate, *Butiauxella* phytase, *E. coli* phytase, *Citrobacter* phytase

T153 The effect of Sangrovit® WS on production parameters in broiler chickens. Jocelyn Romano^{*} *Phytobiotics NA, LLC*

With increasing regulation and oversight surrounding the judicious use of antibiotics in production, the poultry industry has been searching for alternative strategies aimed at minimizing antibiotic use without compromising animal health and welfare. This study evaluated the performance of broiler chickens receiving Sangrovit® WS (water soluble). In this paired house trial, three of the six (25,000 bird) broiler houses received Sangrovit® WS (50 g per 264 gallons of water) on days 6-13, 18-22, and 37-40, while the remaining houses served as controls. All houses were maintained

under the same management, vaccination schedule, and dietary program. Body weights were collected at various times and compared to reference weights specified in the Cobb 500 Performance and Nutrition Supplement. The data was transformed to improve linearity and to enable linear regression analysis and slope comparison. The control group had a significantly lower slope than either Sangrovit® WS ($p < 0.001$) or Cobb 500 Reference ($p = 0.002$), suggesting that birds receiving Sangrovit® WS grew at a more similar rate to Cobb 500 Reference birds than did the controls. In addition, upper intestinal, middle intestinal, and cecum were evaluated and scored throughout the study. Significantly few lesions were observed in middle intestines ($p < 0.01$) and cecum ($p < 0.01$) of birds receiving Sangrovit® WS when compared to controls. This study suggests that Sangrovit® WS may have a beneficial effect at promoting gut health in broilers.

Key Words: Feed additive, Broilers, Phytogenics, Nutrition, Gut health

T154 Corn varieties as well as carbohydrases supplementation affects digestibility for broilers Catarina Stefanello^{*1}, Heitor Rios¹, Sergio Vieira¹, Patrícia Soster¹, Catarina Stefanello¹, Cristina Simões¹, José Sorbara² ¹UFRRGS; ²DSM Nutritional Products

A study was conducted to evaluate the effects of three different varieties of corn and five carbohydrase supplementations on energy and nutrient digestibility of broiler chickens. A total of 840 one-day-old Cobb 500 broiler chicks was placed in 60 battery cages, 7 birds per cage allocated by their average weight and fed common diets to 15 d. Experimental diets were fed from 16 to 24 d with treatments distributed in a completely randomized design, using a 3 x 5 factorial arrangement (3 corn varieties - waxy, semi-hard and semi-dent; and 5 carbohydrase combinations: no supplementation, amylase, xylanase, amylase + xylanase, and an enzymatic complex composed of β -xylanase and β -glucanase). The study was replicated twice in time. Common diets fed before treatment distribution had 3,050 of AME/kg; 21.7% of CP; 1.05% Ca, and 0.53% Av.P. Treatment diets had 95.91% corn and were formulated with 1,000 FYT of phytase and celite at 1% as a marker. Total excreta collection were conducted between 21 and 23 d, twice a day, to evaluate the total tract retention of dry matter (DM), crude protein (CP), ether extract (EE), and apparent metabolizable energy corrected for N zero retention (AME_N). At 24 d, all birds were slaughtered such that ileal content collection was performed in order to determine the ileal digestibility of DM (IDM), CP (ICP), EE (IEE) and ileal digestible energy (IDE). Higher AME_N and IDE were observed in broilers fed diets supplemented with carbohydrases compared to birds fed diets with no supplementation ($P < 0.05$). The AME_N values for corn varieties supplemented with amylase, xylanase, amylase and xylanase, and the enzymatic complex were 3,292; 3,309; 3,291, and 3,298 kcal/kg, and these diets had higher ($P < 0.05$) energy values when compared to the diet without enzyme (3,233 kcal/kg). No interactions between corn and carbohydrases were observed for any variable analysed. Hard and semi-dent corn had higher IEE ($P < 0.05$), with values of 88.1 and 86.8%, respectively, when compared to waxy corn (81.4%). Results in this study showed benefits of the supplementation with carbohydrases on energy utilization by broilers, regardless of the variety utilized. Corn source delivered varying energy values for broiler chickens.

Key Words: broiler, digestibility, corn, carbohydrases

T155 Effects of an exogenous Amylase and a composite enzyme on broiler performance and body composition Maria Mayorga^{*}, Katie Hilton, Garret Mullenix, Michael Schlumbohm, Pramir Maharjan, Judith England, Craig Coon *University of Arkansas*

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+ Victus composite enzyme, 3) Negative control+ Victus composite enzyme +Amylase (recommended level). Feed intake (FI), body weight (BW), and feed conversion ratio (FCR) were calculated for the starter (0-14d), grower

(15-28d) and finisher (29-49d) phase. Weekly, three birds per pen were euthanized by CO₂ inhalation and scanned for body composition. Birds fed NC exhibited significantly ($P < 0.05$) lower FI during the starter and grower phase compared with broilers fed Victus enzyme supplemented diets. As expected, BWG was significantly ($P < 0.05$) increased by the addition of the composite enzyme either alone or in combination with Amylase during the grower and finisher phase. FCR was significantly ($P < 0.05$) improved by the Victus composite enzyme either alone or in combination with the Amylase in all phases. Broilers fed the Victus composite enzyme+ Amylase for the entire 1-49 study showed an 8.2% ($P < 0.05$) positive effect on FCR. Body composition (DEXA) showed that the Victus composite enzyme elicited a significantly higher ($P < 0.05$) lean mass (g) on day 14 and 42. In summary, broilers fed diets supplemented with Victus alone or in combination with an Amylase increased dietary energy retention ($P < 0.0001$) and improved FCR compared to those fed NC.

Key Words: body composition, broiler, enzymes, performance

T156 Protease provides additive effects on protein digestibility beyond carbohydrases in simple and complex corn/soy based diets in 21d old broiler chicks Luke Barnard^{*1}, Peter Plumstead², Luis Romero¹, Velmurugu Ravindran³ ¹DuPont Industrial Biosciences - Danisco Animal Nutrition; ²Chemunike; ³Massey University

The aim was to investigate the effect of an exogenous subtilisin protease (P) enzyme on top of exogenous xylanase (X) and amylase (A) on the ileal digestibility of amino acids (AA) and retention of nitrogen (N) and energy (AMEn) in broilers fed two corn based diets.

The study was designed as a 2x2x3 factorial with diet (simple, corn/SBM or complex, corn/SBM/DDGs/canola), XA dose (1000U/kg X, 100U/kg A or 2000U/kg X, 200U/kg A) and P dose (0, 2500 or 5000U/kg), plus a NC diet with no enzymes for each diet type, totalling 14 treatments. Each diet had 6 replicates and 5 birds/ replicate. Birds were raised in floor pens on a common feed until d12, when birds were allocated to treatment cages. Excreta was collected from d17. On d21 birds were euthanized and contents of the lower ileum were collected by flushing with distilled water. Samples were analysed for N, AA, energy and an TiO₂ as inert marker to calculate digestibility. Data were analysed as a 2x2x3 factorial, significance was considered at $P < 0.05$.

There was a significant interaction of XA x diet on AA digestibility with a numerical increase in AA digestibility in the complex diet with increasing XA, and a numerical decrease in the simple diet. There were also significant main effects of diet type and P, with higher AA digestibility observed in simple diets and diets with increasing P supplementation. There were significant increases in digestibility of 12 out of 16 AA measured in diets with 5000U/kg P relative to diets without P.

There were no significant interactions on AMEn. There was a significant effect of XA, with higher XA levels increasing AMEn by a further 28kcal/kg relative to the lower XA level. There was a difference of 117kcal/kg between the high XA dose and the NC.

There were no significant interactions on N retention. There was a significant effect of P, with the high P dose levels increasing N retention by 2.4% relative to diets without P.

This study shows that protease can significantly increase the digestibility of protein when added to diets on top of X and A. The combination of X, A and P is suitable for use in both diets, providing flexibility in commercial formulation.

Key Words: Broilers, protease, xylanase, amylase, enzymes

T157 Effects of a commercial xylanase supplemented to reduced-energy, corn-soy-based diets on live performance of broilers raised in SE Asia Basheer Nusairat^{*1}, Takawan Sooksridang², James Tyus¹, Jeng-jie Wang¹ ¹BioResource International Inc.; ²Bangkok Animal Research Center Co., Ltd.

A study was conducted to evaluate the effects of a single, thermostable xylanase (Xylamax[®], BioResource International Inc.), supplemented to reduced-energy, corn-soy-based diets, on the performance of broilers raised to 42 days. A total of 576 Arbor Acres+ broiler chicks were assigned to 36 floor pens with 16 birds per pen. A 3x2 factorial arrangement of three levels of ME: breed-standard ME (Control), -65 kcal/kg, and -130 kcal/kg, and two levels of xylanase: 0 or 15 XU/g of feed (0, -65, and -130 kcal/kg) and two levels of xylanase (0, 15 XU/g of feed) were used in the starter (0-14 d), grower (15-28 d), and finisher (29-42 d) phases. Data were analyzed as randomized complete block design. The BW and feed intake were not affected by the dietary treatments. Both energy levels and inclusion of xylanase had significant effect on FCR at 14, 28, and 42 d. At 14 d, FCR was better ($P \leq 0.05$) in birds fed control diet compared to -65 and -130 kcal/kg; values were 1.09, 1.12, and 1.13 for 0, -65, and -130 kcal/kg, respectively. Same trend for FCR improvement continued at 28 and 42 d. Adding xylanase to diets improved ($P \leq 0.05$) FCR at 14, 28, and 42 d. Adding xylanase improved FCR by 2 points at each age period; values were 1.10 vs 1.12, 1.34 vs 1.36, and 1.60 vs 1.62 for diets with vs without xylanase at 14, 28, and 42 d, respectively. No interaction between xylanase and ME levels. Results indicate that xylanase, provided at 15 XU/g of feed, can improve broiler performance in a broad range of dietary ME levels, especially during the finisher phase.

Key Words: Broiler, Xylanase, FCR, ME

T158 Evaluation of xylanase and glucanase, alone or in combination, on performance and caecal fermentation of broiler chickens fed wheat or corn based diets Gemma González-Ortiz^{*1}, Kirsi Vienola², Juha Apajalahti², Michael R. Bedford¹ ¹AB Vista; ²Alimetrix

The objective of this study was to evaluate the effect of xylanase and glucanase, alone or in combination, on performance and caecal fermentation of broiler chickens fed wheat or corn based diets. Eight hundred forty male Ross 308 broiler chicks (1-day-old) were placed in eight experimental treatments with two levels of cereal, wheat or corn, and four levels of enzyme combination (control, xylanase, glucanase or the combination of both enzymes). Xylanase and glucanase were supplemented at 16,000 BXU/kg and 200 BU/kg, respectively. Treatments had nine or seven replicates, with 14 animals each. Starter and grower diets and water were available *ad libitum*. Body weight gain (BWG) and feed intake (FI) were measured from 0-20-d, 20-42-d and 0-42-d and feed efficiency corrected for body weight (FE) calculated. The profile of short-chain fatty acids (SCFA), volatile fatty acids (VFA) and branched-chain fatty acids (BCFA) in the caecal digesta on days 20 and 42 were analyzed. Data were statistically analyzed by the GLM procedure of JMP 12 and means separated using Students multiple range test at $P < 0.05$. In general, birds fed corn diets were heavier and xylanase/glucanase supplementation increased gain 111g compared with the corn control treatment although it was not statistically significant. No significant effects of enzyme were observed on BWG in birds fed wheat-based diets; however there was a significant reduction in FI for birds fed the wheat control diets compared with all enzyme treatments. Feed efficiency was improved by 11 points when xylanase was supplemented in wheat-based diets ($P < 0.001$), with no improvements when glucanase or xylanase/glucanase were fed. In contrast, FE tended to be reduced by 5 points in corn-based diets when xylanase/glucanase was supplemented ($P = 0.092$). The caecal fermentation patterns at 20 and 42d responded more to the cereal type than the enzyme type supplemented. In general terms, birds fed wheat-based diets had higher concentrations of acetic and butyric acid, total VFA and total SCFA compared to birds fed corn. Supplementation of wheat with xylanase resulted in the best broiler performance for

this cereal, whereas xylanase/glucanase in corn-based diets was the most effective treatment.

Key Words: xylanase, glucanase, wheat, corn, fermentation

T159 Debranching enzymes in Victus[®] act in synergy with xylanases to degrade corn arabinoxylan in vitro Miriam Sluis^{*1}, Ryan Saller¹, Ninfa Pedersen², Nelson Ward³ ¹Novozymes North America, Inc.; ²Novozymes A/S; ³DSM Nutritional Products, Inc.

Intact plant cell walls in milled corn are indigestible for poultry and swine. As a consequence, protein and starch that remains trapped within cell walls cannot be utilized by the animals. Arabinofuranosidases (Abf) are widely recognized to remove side-chain arabinose sugars from the arabinoxylan component of corn cell walls. This provides greater access to the xylan main-chain by the xylanases (Xyn) to more effectively cleave the xylose polymer into shorter, soluble polysaccharides. Arabinofuranosidases and xylanases from Victus[®] were studied individually and together to investigate enzymatic degradation and any potential synergy.

Two Abfs and two Xyns purified from Victus[®] were incubated with fiber-enriched corn individually and together at pH 6.5, 40°C for 4 hours. Xylanases were tested alone and with 3 doses of Abf. Soluble xylan and arabinose sugar products were quantified by HPLC using an ion exchange column and expressed as percent of arabinoxylan solubilized. Arabinose and xylose signals were significantly ($P < 0.05$, $n=3$) above the negative controls (without enzyme). The two Xyns were significantly different ($P < 0.05$) in solubilization of arabinoxylan. The addition of one of the Abfs, significantly increased xylan solubilization ($P < 0.05$) when coupled with either of the Xyn enzymes, whereas the Abf alone had little effect on xylan solubilization. The Abf debranching enzymes alone solubilized less than 1% xylan. However, the addition of one of the Abfs to one of the Xyns significantly increased xylan solubilization by more than 2-fold from 6% (without Abf) to 13% (with Abf) ($P < 0.05$). Microscopy results obtained with the Victus[®] product also demonstrated enzyme-dependent degradation of intact corn cell walls.

The effect of arabinofuranosidase on the performance of several Xyns in the degradation of corn arabinoxylan was investigated. The debranching effect from coupling Abfs with Xyns provided a statistically significant increase in cell wall solubilization over Xyn alone. The observed degradation of arabinoxylan could be definitively attributed to enzymes present in Victus[®]. Microscopy results provided further evidence of the importance of enzymatic degradation of intact corn cell walls in the release of entrapped nutrients.

Key Words: debranching enzymes, corn, arabinoxylan, xylanase, arabinofuranosidase

T160 Effects of feeding corn-expressed phytase in four 42-day broiler feeding trials. Jonathan Broomhead^{*1}, Philip Lessard¹, R. Michael Raab¹, Mike Lanahan¹, Dan Moore² ¹Agrivida; ²Colorado Quality Research, Inc

Four broiler studies were conducted to determine efficacy of titrating corn-expressed phytase (CEP; Grainzyme[®], Agrivida) in reduced phosphorus diets through 42 days of age. The studies were conducted with day-old Cobb broilers in 96 floor-pen facilities with pelleted feed (crumbled in starter). Within each study there were 8 dietary treatments with 12 replicate pens each and 17 birds per pen, including a positive control (PC) and negative control (NC), with phosphorus (P) reduced by 0.15%. A commercial phytase (500 FTU/kg; in 2 studies) or CEP (ranging from 250 to 60,000 FTU/kg) were added to the NC diet. Titanium dioxide was added to the feed and ileal digesta was collected, along with tibia bones, from 3 euthanized birds per pen at 21d and 42d to determine P digestibility and bone ash. Studies were analyzed separately as randomized complete block designs with pen location within the building as blocking criteria. Data was analyzed using fit least squares procedure of JMP and mean values were separated using Tukey's test. Compared to NC, ≥ 250 FTU CEP/kg had statistically ($P < 0.05$) higher 21d and 42d body weight gain (BWG) in all studies and

lower feed conversion (FCR) in 3 studies. Compared to PC, ≥ 500 FTU CEP/kg had statistically ($P < 0.05$) better 21d FCR in 3 out of 4 studies, with ≥ 750 FTU CEP/kg being better in the other study. Through 42d, ≥ 250 , ≥ 500 , or $\geq 1,000$ FTU CEP/kg had better ($P < 0.05$) FCR than PC in 3 different studies, respectively. Through 21d, $\geq 3,000$ FTU CEP/kg had higher ($P < 0.05$) BWG than PC in 3 studies. Equivalent ($P > 0.05$) BWG, FCR, and bone ash were observed between the commercial phytase and CEP at 500 FTU/kg, with the exception of 42d bone ash weight in one study where 750 FTU CEP/kg was equivalent. In all studies, ≥ 250 FTU CEP/kg had greater ($P < 0.05$) 21d and 42d bone ash weight than NC. Feeding 60,000 FTU CEP/kg increased ($P < 0.05$) 21d and 42d BWG and bone ash weight compared to the PC. Ileal P digestibility increased ($P < 0.05$) at 21d when feeding 3,000 (2 studies) or 30,000 FTU CEP/kg and at 42d when feeding 30,000 or 60,000 FTU CEP/kg compared to NC. Results of the research show that 250 FTU CEP/kg improves growth and bone ash in a reduced P diet and increasing to higher levels can improve performance beyond standard P diet.

Key Words: Corn-expressed phytase, broilers, reduced phosphorus diet, bone ash, ileal digestibility

T161 Dose-response comparison of two phytase products on broiler performance, bone parameters and nutrient digestibility Roger Davin^{*1,2}, Megharaja Manangi², Fenglan Yan², Mercedes Vázquez-Añón²
¹University of Missouri; ²Novus International Inc

A battery trial was conducted to evaluate the dose-response of two phytase products (Phytase A: CIBENZA® PHYTAVERSE®, Novus International Inc. and Phytase B: modified *E. coli* phytase) on growth performance, bone ash and mineral digestibility in broilers fed corn soy based diets with 4% rice bran. Diets were offered in crumbled form. The study consisted of 10 dietary treatments including a positive control (PC) with 0.45% NPP and 0.93% Ca, and a negative control (NC) with 0.30% NPP and 0.78% Ca. Phytase products were added to NC at 0, 250, 500, 1000 and 2000 U/kg. Each treatment had 7 replicate pens of 8 male broilers. Body weight, feed intake, FCR and mortality were determined at 17 d. On d 18 right tibias from 6 birds/cage and ileum content from all birds/cage were collected. Tibias were analyzed for ash concentration, and ileum content was used for mineral digestibility calculations. Data were analyzed with one way ANOVA and orthogonal polynomial contrasts were used to test the linear and quadratic effects of phytase, a P -value ≤ 0.05 was considered significantly different.

Reduction of NPP and Ca decreased Weight gain (0.709 vs. 0.573 kg; 21.2%), bone ash % (52.6 vs. 43.0%) and P digestibility (54.3 vs. 49.9%). Weight gain was clearly improved by phytase supplementation ($P < 0.0001$), both enzymes showed a quadratic response ($P < 0.0001$). Wt gain was similar between both products at all doses, except for 250 U/kg in which Phytase A showed a greater Wt gain compared to Phytase B (0.684 vs. 0.644 kg). Bone ash % and amount of ash per bone were improved by phytase

supplementation ($P < 0.0001$), and both enzymes responded quadratically ($P < 0.0001$). Interestingly, P digestibility was affected by phytase supplementation ($P < 0.0001$), and responded in a linear manner ($P < 0.0001$). Phytase levels beyond 500 U/kg of both enzymes outperformed PC. In summary, both phytases showed a similar dose response for performance, bone and P digestibility, except for an advantage of 250 U/g of Phytase A vs. Phytase B in Wt gain. P digestibility responded in a different way than performance and bone ash

Key Words: bone ash, P digestibility, performance, phytase

T162 Effect of a new 6-phytase on broiler performance, phosphorus ileal digestibility, bone mineralization and phosphorus excretion Mike Coelho^{*1}, Maria Francesch², Peter Ader³ ¹BASF Corp; ²IRTA Monogastric Nutrition; ³BASF SE

The aim of the study was to investigate the efficacy of a novel 6-phytase, Natuphos E, at graded dose levels on broiler performance, apparent ileal digestibility (AID) and excretion of P, and tibia mineralization. Male Ross 308 broilers were used in a randomized complete block design (35 birds x 5 diets x 8 replicates). Treatments were: a positive control (PC) diet (9.0 g/kg Ca and 6.8 g/kg P from 0-21 d; 8.6 g/kg Ca and 6.6 g/kg P from 21-43 d) and a negative control (NC) diet, with reduced P and Ca (6.1 g/kg Ca and 4.3 g/kg P from 0-21 d; 5.5 g/kg Ca and 4.1 g/kg P from 21-43 d). The NC diet was supplemented with phytase at 0, 125, 250 and 500 FTU/kg feed. Performance from 0-42 d; and AID of P; P excretion and tibia mineralization at d 43 were measured. Data were subjected to ANOVA and orthogonal contrasts were used to determine linear and quadratic responses to increasing doses of phytase. From 0-42 d, the NC diet reduced weight gain (-5.8%) and feed intake (-6.5%) relative to the PC diet ($P < 0.05$). Phytase linearly increased weight gain and linearly and quadratically feed intake ($P < 0.05$). At 125 FTU/kg feed, weight gain and feed intake was increased by 3.1% and 2.8%, respectively ($P < 0.05$). The AID of P was lower in the NC diet relative to the PC diet ($P < 0.05$), and relative to NC diets supplemented with phytase ($P < 0.01$). There were linear and quadratic ($P < 0.01$) increases in the AID of P with increased phytase dose. The excretion of P was higher with the PC diet compared with all NC diets ($P < 0.05$), supplemented or not with phytase, and phytase linearly decreased ($P < 0.01$) P excretion. There was a linear increase ($P < 0.05$) in total ash and a linear and quadratic increase ($P < 0.05$) in total Ca content in tibia with increased phytase dose. Moreover, phytase tended to increase linearly ($P < 0.07$) total P in tibia. Phytase at 500 FTU/kg restored the total ash, P and Ca in tibia to that of the PC. In summary, the new Natuphos E 6-phytase was efficacious in increasing performance, apparent ileal digestibility of P, total ash, P and Ca tibia content and in reducing P excretion in broilers fed a reduced P and Ca diet. The responses to phytase were dose dependent. Phytase at 500 FTU/kg restored bone mineralization to that of the PC.

Key Words: novel 6-phytase, performance, bone ash, broilers, Phosphorus excretion

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T163 Quality and Proximate Analysis of Eggs from different Chicken Genotypes in Pakistan Athar Mahmud^{*}, Sumera Musarrat, Jibran Hussain, Faisal Hussain, Khalid Javed *University of Veterinary and Animal Sciences, Lahore-Pakistan*

Present study evaluated egg quality traits and proximate analysis among different chicken genotypes located at Pakistan. To this end, a total of thirty (5 birds from each breed; Aseel, Fayoumi, Naked Neck, Rhode Island Red, Leghorn, White Plymouth Rock) 40-50 weeks old birds were collected from the local market and maintained at Indigenous Chicken Genetic Resource Center (ICGRC) under similar environmental and managemental conditions. After ten days of adaptation period, twenty (20) eggs from each breed were collected and subjected to the egg characteristics and proximate analysis. Regarding egg quality traits, higher egg specific gravity and yolk

color were observed in Fayoumi, whereas albumen % and Haugh unit were noted to be higher in Rhode Island Red. However, yolk % was better in Aseel. In egg proximate analysis, dry matter and protein % were higher in Aseel whereas moisture and carbohydrate % were higher in Leghorn. Similarly, lipid % was higher in White Plymouth Rock. In conclusion, significant variation exist among different chicken genotypes regarding egg quality and proximate composition.

Key Words: Egg quality, Proximate Analysis, Genotypes, Chicken

T164 The prevalence of *Salmonella* Heidelberg in broiler chickens is influenced by isoquinoline alkaloids Anja Pastor^{*1}, Greg Mathis², Charles Hofacre³ ¹*Phytobiotics Futterzusatzstoffe GmbH*; ²*Southern Poultry Research, Inc.*; ³*The University of Georgia, PDRC*

Every year, tens of millions human cases are reported worldwide for salmonellosis. *Salmonella enterica* serovar Heidelberg was identified as one of the most common serovars involved in human salmonellosis. The aim of the study was to evaluate the effect of a standardized blend of plant-derived isoquinoline alkaloids (IQs, Sangrovit® G Premix) in broiler chickens infected with *Salmonella enterica* serovar Heidelberg. 2 trial groups were tested: 1) Control (CON), infected, no feed additive 2) IQ: infected, IQs (120 ppm, day (d) 1-35). 1,200 day-old male broiler chicks (Ross 308) were randomly distributed to the trial groups. Each group consisted of 12 replicates, with 50 birds/replicate. Birds had *ad libitum* access to non-medicated feed. At d 4, 13 birds/pen were orally gavaged with 4×10^5 CFU/ml of a nalidixic-acid resistant *Salmonella enterica* serovar Heidelberg. These tagged birds served as natural seeder birds. On d 14 and 35, bootsock swab samples were collected for *Salmonella* environmental contamination determination from all pens. On d 35, cecal sampling was completed for determining *Salmonella* counts using Most Probable Number. 10 non-tagged birds were euthanized and cecas aseptically removed. Feed intake and average weight gain did not differ between CON and IQ. FCR was significantly improved in birds receiving IQs compared to CON birds (1.744 and 1.799, respectively). A numerical reduction in *Salmonella* prevalence obtained from bootsock swabs was observed in IQ treated birds (87.5 and 100 %, respectively). Furthermore, ceca *Salmonella* MPNs for culture-positive ceca samples were lower in IQ fed birds than in untreated birds (0.40 and 0.55; $P > 0.05$). Prevalance and *Salmonella* level in the positive ceca were reduced, if IQs were applied. Consequently, a decreased pathogen pressure for the next growout period can be expected, possibly leading to a significant *Salmonella* reduction in the broiler house over time. In conclusion, IQs offers an economical solution to support broiler chickens infected with *Salmonella*, contributing to food safety in broiler production.

Key Words: Broilers, *Salmonella* Heidelberg, Isoquinoline Alkaloids

T165 Nutritive value of pigeon pea (*Cajanus cajan*) seeds soaked in wood ash extract in broilers diet. Stanley Omoikhoje*, Dick Obasoye, Sylvester Okosun *Ambrose Alli University*

An eight (8) weeks feeding trial was conducted to assess the effect of feeding graded levels of soaked pigeon pea meal (SPPM) in wood ash extract on the growth performance, haematological and serum biochemical indices of broiler chickens. A total of 144 day-old chicks (Anak 2000) were randomly allotted to four (4) treatment diets (1, 2, 3 and 4) in a completely randomized design (CRD). Each treatment group was replicated three (3) times with twelve (12) birds per replicate, thus, having thirty-six (36) chicks per treatment group. Diets 1, 2, 3 and 4 were formulated to contain 0, 25, 50 and 75% levels of inclusion of SPPM in place of soybean meal. Data on growth performance showed that the average live weight, daily weight gain and feed intake as well as protein efficiency ratio of broilers were significantly ($P < 0.05$) influenced by the dietary treatments at the finisher phase. Broiler chickens fed 25% SPPM based diet had higher ($P < 0.05$) values in live weight, weight gain and protein efficiency ratio compared to other test diets at the finisher phase. The haematological and serum biochemical indices revealed that the albumin value was highest ($P < 0.05$) in birds fed the test diets, whereas, the cholesterol values were lowest in broilers fed the test diets. It therefore implies that soaked pigeon pea meal can be partially included in broiler diets up to 25% level with optimum growth performance and without any detrimental effect on the blood profile of broiler chickens.

Key Words: Broilers, Haematology, Performance, Pigeon pea, Serum

T166 Effect of enzyme addition in the beer well on the metabolizable energy of distiller's dried grains and solubles E. Ernest Pierson*, Sebastian Wiesen, Marco Krämer, Albrecht Läufer *Direvo Industrial Biotechnology GmbH*

A proprietary blend (Blend) of enzymes (BluZy® D; Direvo Industrial Biotechnology GmbH) was designed to be added in the beer well of the ethanol plant with the specific purpose of improving the feeding value of distiller's dried grains and solubles (DDGS). The Blend was evaluated in a commercial ethanol plant (approx. 50,000,000 gallons per year capacity) in which oil was removed from the DDGS. Untreated negative control (NC) and Blend treated (TR) DDGS (DG-Max™; Direvo Industrial Biotechnology GmbH) were subsequently compared in nitrogen corrected true metabolizable energy (TMEn, n=10) and apparent metabolizable energy (AMEn, n=12) bioassays (both, as is) in male adult Single Comb White Leghorn (SCWL) roosters and 21 day old commercial male broilers, respectively. Blend addition in the beer well of a commercial ethanol plant resulted in a DDGS which had 162 kcal/kg - 6.6% higher (unpaired t-test, $p < 0.0001$) TMEn (2604 +/- 52 kcal/kg; Coefficient of Variation - CV 2.0%) than the NC DDGS (2442 +/- 78 kcal/kg; CV 3.2%). Compared to the NC DDGS, TR DDGS had a 154 kcal/kg - 6.0% higher (unpaired t-test, $p < 0.0001$) AMEn (2714 +/- 71 kcal/kg; CV 2.6% Vs 2560 +/- 64 kcal/kg; CV 2.5%). AMEn values from the chick bioassay were higher than TMEn values from the adult rooster bioassays. The higher metabolizable energy of TR DDGS as measured by two bioassays demonstrated that it can be a commercially attractive feed ingredient.

Key Words: DDGS, Metabolizable energy, Broilers, Beer well enzymes, Bioassays

T167 Synthetic antioxidant improves oxidative stability of breast meat and reduces incidence of Wooden breast myopathy in broilers fed diets containing oxidized fat Megharaja Manangi^{*1}, Juxing Chen¹, Chelsie Foran¹, Mercedes Vazquez-Anon¹, Kim Walter², Sandro Cerrate², Alex Corzo², John Halley², Bryan Fancher² ¹*Novus International, Inc.*; ²*Aviagen Group*

Wooden breast (WB) is a degenerative myopathy which could be associated with increased hypoxia as well as oxidative stress, intracellular calcium imbalance, and fiber-type switching. A 59d broiler study was conducted to determine the effects of synthetic antioxidant {SANTOQUIN® M6 with 66.6% Ethoxyquin (ETX)} along with Vit-E & C on incidence of severe category Wooden breast (WB) and other tissue changes. Day old YPM x 708 male chicks (n=1188; 11chicks/pen; 18pens/treatment) were randomly assigned to 6 treatments: fresh fat without ETX (T1) or with ETX (T2), and oxidized fat without ETX (T3), with 125ppm ETX (T4), with 180IU/kg diet Vit-E & 200ppm Vit-C (T5), and with Vit-E & C, and ETX (T6). For T3 to T6 diets, oxidized soy oil was added to get to 5meq peroxide/kg in the starter and 7meq peroxide/kg in the grower and finisher diets. The study was carried out as RCBD and data were analyzed with 2 sets of factorial designs: T1 to T4 (fat sources/ ETX levels); T3 to T6 (ETX/ Vitamins). In addition to severe WB incidence, plasma lactate dehydrogenase (LDH) and raw meat (10d of refrigerated storage) thiobarbituric acid reactive substances (TBARS) levels were determined indicating tissue damage and lipid peroxidation (LP), respectively. For T1 to T4, no interaction ($P > 0.05$) was observed for fat sources and ETX on TBARS, and LDH. Interaction was observed for WB ($P = 0.02$) indicating birds fed oxidized fat with ETX (T4) reduced the severe WB incidence by 14 percentage points compared to birds fed oxidized fat with no ETX (T3). The main effects indicated that feeding oxidized fat increased TBARS ($P = 0.08$), and LDH ($P < 0.05$) compared to birds fed fresh fat. Supplementing ETX reduced TBARS ($P = 0.098$) and LDH ($P = 0.02$) compared to birds fed no ETX. Within oxidized fat fed groups (T3 to T6), no interactions ($P > 0.05$) was observed for ETX and vitamins on TBARS, LDH, and WB. The main effects for ETX indicated reduction ($P < 0.05$) of TBARS and LDH while vitamins indicated tendency to reduce LDH ($P = 0.08$) but not for TBARS ($P = 0.42$). Overall, feeding oxidized fat appears to be a contributing factor for increased muscle LP, tissue damage and WB. ETX reduced severity of

WB, LP, and tissue damage while vitamins E&C reduced severity of WB and tissue damage.

Key Words: Antioxidant, Wooden Breast, Santoquin, Vit-E &C

T168 Variation in the hardness of soybean cultivars John Brake* *North Carolina State University*

A number of university and USDA soybean breeding programs have been engaged in efforts to improve the value of soybeans and soybean meal (SBM). Obviously, the major value of SBM has been derived from feeding to animals such as poultry. Feeding value has been severally assessed through wet chemical analyses, amino acid analyses, rooster based true metabolizable energy evaluations, ileal digestibility evaluations, and feeding to growing broilers. During the course of a series of studies assessing a wide range of cultivars a clear linkage between classic chemical measures and actual live performance has been elusive. However, it was observed during individual bean analysis that there was a perceived difference in "hardness" among cultivars. Therefore, 25 beans weighing 130-145 mg from each of 12 cultivars were subjected to Instron analysis and highly significant differences ($P \leq 0.01$) were observed. The breaking force varied from 118-223 Newtons and the elasticity exhibited prior to breaking varied from 0.70 to 1.28 mm. This range of variation was related to different particle size distributions among the resulting SBM, which could influence feeding value and help explain why poultry often do not demonstrate differences in feeding value that were suggested by chemical analyses.

Key Words: soybean, hardness, soybean meal, soybean feeding value

T169 Occurrence of masked and emerging mycotoxins in US feed and corn samples from 2014 to 2016 G. Raj Murugesan¹, Erika Hendel¹, Chasity Pender¹, Eduardo Vicuña¹, Timothy Jenkins² *¹BIOMIN America, Inc.; ²BIOMIN Holding GmbH*

Mycotoxins are harmful fungal metabolites commonly found in commercial crops. Type B trichothecenes, mycotoxins produced by *Fusarium* fungi, are detrimental to gut health, decreasing mucus production, compromising intestinal epithelial tight junctions, increasing intestinal inflammation, and suppressing immune function. The Type B trichothecenes (B-Trich) include deoxynivalenol (DON), nivalenol (NIV), and fusarenon-X. Additionally, fungi produce acetylated forms of DON (3-ADON, and 15-ADON). Mycotoxins can also be masked by plants with added glucose or sulfate molecules, rendering them undetectable to conventional analysis. Masked B-Trich (DON-3-glucoside; DON 3-G, and NIV-glucoside; NIV-G), are broken down to DON and NIV, respectively, within the stomach and are thus equivalent in toxicity to unmodified toxins. Emerging mycotoxins are newly identified fungal metabolites. Tenuzoic acid (TA), produced by *Alternaria* and *Phoma* fungi, inhibits protein synthesis and is equivalent to DON in toxicity. TA is known to cause gizzard erosion in poultry. These masked and emerging mycotoxins present a challenge for mycotoxin risk management; these metabolites are not tested by US diagnostic laboratories, and literature examining their presence, toxicity, kinetics, and multiple mycotoxin interactions is sparse. To investigate the prevalence of masked B-Trich and TA in the US, we further analyzed results from 96 samples submitted as part of the BIOMIN® PROcheck program from 2014-2016 for multi-mycotoxin testing at the University of IFA-Tulln, Austria (Spectrum 380®). These samples consisted of corn, corn silage, and complete feed for multiple livestock industries (cattle, swine, and poultry). Of the 96 samples, 63% had detectable DON, 5% 3-ADON, 12% 15-ADON and 49% had detectable DON-3-G. The median positive level of DON-3-G was 37 ppb with a maximum of 326 ppb. NIV was less commonly detected than DON (20% of samples) and only 2% of samples tested positive for NIV-G. The emerging mycotoxin TA was present in most samples (70%) with some high values (median 54 ppb, max 4942 ppb). Collectively these results represent an increased risk to animal gut health beyond what is suggested by current detection methods in the US.

Key Words: Masked mycotoxin, Trichothecene, Tenuzoic acid, Leaky gut, TER

T170 Field observation: in contrast to soybean meal, in commercial full-fat soybeans (FFSB) there is no correlation between urease activity (delta pH) and trypsin inhibitors. Nelson Ruiz^{*1}, Fabiola de Belalcázar² *¹Nelson Ruiz Nutrition, LLC; ²Nutrianalysis*

At the 2012 Arkansas Nutrition Conference evidence was presented that databases of commercial soybean meal (SBM) for urease activity (delta pH) and trypsin inhibitors (mg/g) were highly correlated (r-square values above 0.80). The objective of this presentation is to report that the analysis of the database at Nutrianalysis of commercial full-fat soybeans (FFSB) show a low correlation between urease activity and trypsin inhibitors. A total of 179 samples of commercial FFSB originated at different Andean Pact countries between 2012 and 2016 were analyzed for both urease activity (AOCS method Ba 9-58, 2011) and trypsin inhibitors (ISO 14902:2001). The urease activity range was 0.000-2.151 pH units; the trypsin inhibitors range was 0.50-22.50 mg/g of FFSB. The r-square value was only 0.34. These data confirm the report by Azcona et al. (2012) indicating the inconsistency in the correlation when laboratory experimental models of dry and wet extrusion of FFSB were compared. The database presented and discussed here is composed entirely of commercial samples derived from different technological processes (roasting, dry extrusion, wet extrusion, cooking), hence a field observation. A selection of 38 samples (out of 179) from a single company and processed by a single unit of wet extrusion displayed a correlation of 0.98 between urease activity and trypsin inhibitors suggesting that processing technology may be a major factor determining the existence of a statistically significant correlation. However, there were not enough number of samples for other processing technologies in the database at this time to confirm this observation. The practical implication of a correlation between urease activity and trypsin inhibitors is that urease activity is faster and more economical to conduct on a routine basis at a commercial facility to evaluate the antinutritional status of specific lots of soy products intended for animal nutrition. In contrast, the overwhelming majority of commercial SBM is solvent extracted and a desolventizer-toaster is the standard deactivation unit. The latter may help to explain why databases of analyzed commercial SBM samples tend to display a statistically significant correlation between urease activity (delta pH) and trypsin inhibitors. FFSB are generated worldwide in relatively small processing units utilizing very different deactivation technologies.

Key Words: Full-fat soybeans, Soybean meal, Urease activity, Trypsin inhibitors

T171 Mycotoxin Prevalence in the 2016 Corn Crop Eduardo Vicuña*, Erika Hendel, Timothy Jenkins, Ganapathi Murugesan *Biomim*

Mycotoxins are harmful secondary metabolites produced by fungal species capable of infesting various commercial crops. These fungal species are roughly divided into two groups: those predominantly producing mycotoxins on the field (e.g. *Fusarium* spp.) and those predominantly occurring in storage (e.g. *Aspergillus* and *Penicillium* spp.). Mycotoxin contamination of feed materials is a global concern, as exposure to mycotoxins significantly impacts animal health and productivity. BIOMIN has been conducting annual global surveys of commodity crops and completed feeds since 2004, including annual corn surveys in the United States since 2012.

A total of 77 corn samples collected from mid-August to October 2016 were analyzed utilizing the LC-MS/MS method. The six major mycotoxin groups analyzed comprised of aflatoxins, type A trichothecenes such as T-2 toxin, type B trichothecenes such as deoxynivalenol (DON; vomitoxin), ochratoxin-A, fumonisins (FUM), and zearalenone (ZEN) derivatives. A high proportion of samples contained at least one detected mycotoxin type (83%), similar to the situation in 2015 (84% positive, 321 samples). However, there was a 15% increase in the number of samples contaminated with multiple mycotoxins (≥ 2 mycotoxins, 2016: 58%; 2015: 43%). This is primarily due to increased prevalence of FUM and ZEN in the 2016 crop (FUM: 64%, ZEN: 26%) compared to the 2015 crop (FUM: 50%, ZEN 14%). In addition to the increased FUM prevalence, the concentrations of FUM in positive samples tended to be higher in 2016 than 2015.

The percent of positive samples of FUM over 1000 ppb have increased by 24% compared to the 2015 harvest. In contrast, the most prevalent mycotoxin DON had relatively unchanged prevalence and contamination levels (2016: 66% prevalence, 2015: 69%; 2015-16: 14% positive samples over 1000 ppb).

The preliminary results from the 2016 corn harvest suggest an increased occurrence of co-occurrence with mycotoxins produced by *Fusarium* fungal species. This includes increased contamination with DON and FUM (2016: 34%, 2015: 28%), and with FUM, DON, and ZEN (2016: 14%, 2015: 7.5%). Because of the high frequency of multi-mycotoxin contamination in samples thus far, multiple strategies of mitigating risk are needed beyond adsorption, including biotransformation and providing support to immune and liver function.

Key Words: Deoxynivalenol, Fumonisin, Co-occurrence, Zearalenone, Biotransformation

T172 Live performance and footpad health in broilers fed an additive composed of secondary plant compounds (SPC) and vaccinated for coccidiosis Wilmer Pacheco^{*1}, Wallace Berry¹, Joseph Hess¹, Rafael Cabrera², Mark Richards² ¹Auburn University; ²EW Nutrition USA, INC

Growing interest in antibiotic free production of poultry meat and eggs has led to a rise in non-antibiotic growth and health enhancers in poultry production. This trial examined the influence of a commercial product composed of secondary plant compounds (SPC) (Activo, EW Nutrition, USA, Des Moines, IA) on broiler live performance and footpad health. A coccidiosis vaccine (Advent, Huvepharma, Sofia, Bulgaria) was sprayed onto chicks at placement. Male broilers (25 birds/pen, 8 pens per treatment) were raised to 42 d on used litter to test the influence of SPC on broiler live performance at 14, 25, 35 and 42 d and footpad quality at 42 d of age. Treatments included a negative control (NC); negative control plus SPC at 100 grams/ton of feed; negative control plus SPC at 130 grams/ton of feed and a positive control (PC) including Monteban (72g/ton starter, 81 g/ton grower) and BMD (50 g/ton starter and grower). A three-phase feeding program was used with 0.68 kg starter, 2.27 kg grower, and finisher to 42 days. Paw lesions and litter caking were recorded at 42 days of age. Body weights were generally higher from 21 d for birds fed 100g/ton SPC and those fed PC. Body weight gains from 14 to 21 d and 35 to 42 d were significantly higher for both SPC and PC trt. While feed consumption was lowest in NC, FCR adjusted for mortality was significantly reduced with the PC-fed birds. No differences between treatments were noted regarding footpad lesions, mortality or litter caking. In summary, Activo fed birds showed competitive body weights at 21, 35 and 42 days of age. Feed conversion efficiency improvements were less defined, although birds fed 100 g/ton Activo were intermediate to the negative and positive controls at several ages.

Key Words: Broiler live performance, Secondary plant compounds, Footpad quality, Coccidiosis vaccination

T173 The effect of a specific mixture of MCFA's on reproductive traits in laying hens Manu De Laet^{*}, Renato Costa, Rob Goedegebuure Nuscience

In the layer breeder industry, it is crucial to maintain an excellent egg quality to maximise hatchability and day old chick quality in order to optimise the reproduction cost. As genetic differences exist in productive, reproductive and egg quality traits, the effect of a feed supplement – containing medium chain fatty acids (MCFA's) (Shellbionic) – on zootechnical parameters was evaluated.

This experiment was carried out with 2 different types of breeds (Leghorn type and Rhode Island Red type) at a grandparent operation of Novogen. In this trial, 4 groups of 1600 breeder layers, placed on floor pens (100%), were used. From 38 weeks onwards, 1 group of each breed received a dietary supplementation of 1 kg/ton Shellbionic. During this trial hen day production, mortality, egg weight, feed intake and 2nd grade eggs were measured until 58 weeks of age. Hatchability, day old chick quality and specific

egg quality parameters were measured at 31 and 54 weeks of age. Each treatment consisted of 8 pens with 50 birds per pen. For statistical analyses, SAS software is used.

Adding 1 kg of Shellbionic resulted in a significant improvement for both breeds of the percentage of laying rate (90.9% vs. 91.1%) (P<0.01), 2nd grade eggs (1.5% vs. 1.4%) (P<0.05) and hair cracks (6.7% vs. 1.7%) (P<0.05). Additionally, positive effects were observed for hatch of fertiles in both breeds and day old chick quality for the Leghorn type breed.

Overall, supplementing commercial layer breeder feed with MCFA's resulted in 1.2% more day old chicks. This trial indicates that improving egg quality in commercial layer breeders by supplementing the feed with a specific mixture of MCFA's improves the reproductive traits.

Key Words: egg quality, Shellbionic, day old chick quality, hatchability

T174 Impact of PrimaLac[®] on production, quality and composition of eggs from free-range hens in late cycle 90 to 110 wks of age Ramon Malheiros^{*}, Rafael Crivellari, Kenneth Anderson *Prestage Poultry Science Department, NC State University*

Probiotics Direct-Fed Microbial (DFM) consists of a live cultured bacteria mix that are used as a feed additive to improve the gastrointestinal tract of poultry, thereby improving nutrient uptake. Probiotics have also been shown to have an immunological improvement potential protecting the host against exogenous pathogens by competitive exclusion. This study was designed to examine the impact of PrimaLac[®] on hens during the later stage of production, to potentially improve egg quality and characteristics, and production criteria. The study was conducted at the NCDA&CS Piedmont Research Station, Salisbury, NC. We used 400 commercial egg hens, during a late cycle, housed in a Free-range system. The flock was divided in to two treatment groups of 200 hens for each group, 50 hens per replicate making 8 replicates. Four replicates of control feed and four replicates provided PrimaLac[®] at 3 lbs/ton. All diets were provided *ad libitum*, based upon the hens feed consumption and productivity over the previous 28 d period. From 90 to 110wk of age egg production characteristics and mortality data were collected. In each period eggs were collected for USDA grading, egg size distribution, and external and internal egg physical quality. In periods 1, 3, and 5 whole liquid egg pools were collected and analyzed for egg nutrient composition. The experiment was a completely randomized design, all data was analyzed using JMP[®], Student's T test were used to compare PrimaLac[®] vs. Control. In the overall PrimaLac[®] vs Control, showed greater HH% (56.54 vs 50.30), Daily Egg Mass (40.33 vs 37.17 g egg/day), and better feed conversion (.359 vs .310 g egg/g feed). The mortality trended lower in the PrimaLac[®] group (P>0.05). The USDA egg grades were not affected by PrimaLac[®] in any of the parameters observed when compared with the control group eggs. In external or internal egg quality, just the vitelline membrane elasticity was better in PrimaLac[®] group (5.23 vs 4.85 mm). The egg composition factors analyzed (Vit D, Vit E, Total Fat%, Saturated Fat %, Monounsaturated Fat %, and Polyunsaturated Fat%) were not affected in any period or in the overall by the PrimaLac[®] inclusion. In conclusion, the use of the PrimaLac[®] in the free-range hens in late cycle, have some beneficial aspect in the improvement of the number of eggs per HH%, and in the internal egg quality.

Key Words: Laying Hen, Egg Production, Direct-Fed-Microbial, PrimaLac, Free Range hens

T175 Efficacy of a specific fumonisin esterase to alleviate the detrimental effect of fumonisins on laying hens Verena Starkl^{*}, Sabine Masching, Roger Berrios, Ursula Hofstetter *Biomim Holding GmbH*

According to the BIOMIN Mycotoxin Survey in 2016, 86% of all analyzed corn samples were contaminated with fumonisin B1 globally. The very high prevalence of fumonisins as well as a possible negative impact on layer's health and performance reveals the necessity on successful counteraction of these toxins.

FUMzyme® biotransforms the toxic fumonisin B1 (FB1), cleaving off two tricarballic acid side chains resulting in the much less toxic hydrolyzed fumonisin B1 (HFB1). The level of FB1 and HFB1 in feces are recognized biomarkers.

A group of laying hens (Lohmann Brown Classic) were randomized and separated into 30 pens with 4 hens each. Layers were 25 weeks of age when the trial started and three groups were formed: A negative control (standard diet without mycotoxin contamination (NC)), a control group (NC + 8 ppm FB1 (CG)) and a trial group (CG + fumonisin esterase (FUMzyme®); TG). Feces samples were taken at D0, D7 and D14 from each pen. Eggs were counted and weighed daily.

Results showed significantly higher levels of HFB1 in the group supplemented with FB1 + FUMzyme® (TG). The level of excreted FB1 was high-

est in the control group (CG) and significantly reduced in the trial group (TG). The addition of 8 ppm of FB1 to the diet (CG) led to a decreased average weight of the laying hens after 14 days of trial compared to the group that received mycotoxin-free feed (NC). Additionally, laying rate (%) and average egg weight (g) tended to be reduced in the control group (CG: 93%, 58g), compared to both the negative control group (NG: 96%, 59g) and the trial group (TG: 97%, 59g).

The results of this trial suggest that fumonisins even at levels lower than the FDA guidance levels can negatively affect performance of laying hens. The specific fumonisin esterase (FUMzyme®) is effective at biotransforming fumonisins in the intestinal tract of animals and reducing their negative impact.

Key Words: Fumonisin, Biotransformation, Enzyme, Layer

Metabolism & Nutrition VIII

T176 Evaluation of different growth promoters fed continuously or alternately in broiler chickens Sergio Gomez*¹, Maria Angeles¹, Raul Cortes² ¹INIFAP; ²NUTRIAD

The objective of the study was to evaluate the growth performance of broiler chickens from 1 to 42 d of age fed diets added with butyric acid (BA), a yeast derivative product (YP) and essential oils (EO) continuously or added with the same products in different growth periods. A total of 1080 Ross B308 males were allocated in 30 floor-pens with 30 birds in each and randomly assigned to five dietary treatments: 1) Control group fed diets added with an antibiotic growth promoter and anticoccidial drugs; 2) Diets added with BA; 3) Diets added with YP; 4) Diets added with EO; and 5) Diets added with BA from 1-14 d, YP from 14-28 d, and EO from 28-42 d of age. Starter, grower and finisher diets were formulated to meet or exceed the nutrient recommendations of the strain. The control diet was added with BMD as growth promoter. Monensin was added as anticoccidial drug from 1-21 d of age, and then was substituted by salinomycin from 21-42 d of age. The growth performance parameters were registered every week. Data was subjected to ANOVA. From 1-21 d, the weight gain was lower ($P < 0.05$) in broilers fed EO but was similar for the rest of the groups. No differences were observed in the feed intake and feed conversion. At 35 d of age, the body weight tended to be higher in broilers fed the control, BA and the combination of BA/YP/EO; from 1-35 d of age the feed conversion was lower ($P < 0.05$) in broilers fed the control and BA diets. At 42 d of age, the body weight and productive parameters were similar among all the treatments. At 35 d of age, the L values were higher ($P < 0.05$) in the breast of broilers fed the control treatment, and the b values were higher ($P < 0.05$) in the control, BA and the combination of BA/YP/EO treatments. At 42 d of age, no differences were observed among treatments in the color of the breast. It is concluded that broilers chickens fed diets added with BA, YP and EO, continuously or alternatively had similar growth performance as the broilers fed a diet added with an antibiotic growth promoter and anticoccidial drugs.

Key Words: Broiler chickens, Butyric acid, Yeast product, Essential oils, Performance

T177 Including copper sulphate or dicopper oxide in the diet up to 300 mg/Kg of feed affects performance and Cu accumulation in broiler chickens Stephane Durososy*¹, Manel Hamdi², David Sola-Oriol³, Rosa Franco-Rossello², Jose Francisco Perez² ¹Animine; ²Animal Nutrition and Welfare Service (SNIWA). Departament de Ciència Animal i dels Aliments. Universitat Autònoma de Barcelona

Copper supplementation (125 to 250 mg Cu/Kg) in poultry diets is a common practice in many countries to enhance bird health, but high amounts of Cu may affect animal growth performance and interact with phytate. However, these effects could directly depend on the nature of the Cu source. The objective of the present work was to compare the effect of copper sulphate (CuSO₄) and dicopper oxide (Cu₂O, CoRouge®) at 3 different levels of

dietary Cu (15, 150, 300 mg/kg) in the diets following a 2 x 3 factorial arrangement. A total of 576 one-day male broiler chickens (Ross 308) were randomly distributed into 6 experimental groups (8 pens per treatment, with 12 birds per pen). Body weight (BW) and feed intake (FI) were recorded weekly up to d 35. On d 35 post hatch, 1 bird per replicate was euthanized, skin fat and breast muscle were sampled, and liver and kidney were collected and weighted for Cu determination. Cu sources were also evaluated in vitro to measure Cu solubility, PP (phytic phosphorus) hydrolysis by phytase at pH 2.5, 4.5 and 6.5. The use of 300 mg Cu/Kg from CuSO₄ decreased ($P = 0.001$) BW on d 14, 28 and 35 and increased ($P = 0.04$) liver Cu content in comparison with the use of 300 mg Cu/Kg from Cu₂O (7.91 vs 4.63 µg/g). Feed conversion ratio increased ($P = 0.0004$) for chicken feeds with 300 mg Cu/Kg from CuSO₄ (2.19) in comparison to those feeds with 300 mg Cu/Kg from Cu₂O (1.84). The use of high level of Cu (300 mg/kg), either from Cu₂O or CuSO₄, also increased ($P < 0.001$) Cu accumulated in kidney and breast muscle in comparison to 15 and 150 mg Cu/Kg. Solubility of Cu from Cu₂O and CuSO₄ was higher at pH=2.5 but it decreased at higher pHs. Including a level of 300 mg Cu/kg from CuSO₄ reduced PP solubility (68.66%) in comparison to Cu₂O (97.41%). Increasing the levels of Cu with both sources reduced PP hydrolysis by phytase at pH=4.5 and 6.5. It can be concluded that dietary levels of 150 and 300 ppm Cu from Cu₂O are adequate to ensure broiler growth performance and limit organ accumulation in comparison to CuSO₄.

Key Words: Broiler, Copper source, Phytate phosphorous, Solubility

T178 The effect of zinc oxide nano particles on mucosal enzyme activity and jejunum morphology traits on 14 and 28 days of age in Japanese quail Farhad Ahmadi*¹, Farhad Ahmadi¹, Afshin Rashidi², Jamshid Ghaleh Kandi³, Foad Zand karimi² ¹Department of Animal Science, Faculty of Agriculture, Sanandaj Branch, Islamic Azad University, Sanandaj, Kurdistan, Iran; ²Department of Animal Science, Faculty of Agriculture, Sanandaj Branch, Islamic Azad University, Sanandaj, Iran; ³Department of Animal Science, Faculty of Agriculture, Shabestar Branch, Islamic Azad University, Shabestar, Iran

This research was carried out to investigate the effect of different levels of zinc oxide nano particles on the mucosal enzymes and morphology traits of the jejunum of Japanese quail. In this research were used 180 one day of Japanese quail that distributed in a CRD, including 4 treatments, 3 replicate and 15 birds in each experimental treatment. The experimental birds used water and feed as *ad-lib* duration 28 days of research. On 14 and 28 days of study selected one bird selected from any experimental pen and slaughtered, then open abdominal cavity and removed small intestine. Removed 5 cm from medium section of jejunum section and then divided two sections to the analysis of ALP, amylase, lipase (-80°C) and traits of jejunum morphology (10 % formalin). The results indicated that the addition of zinc oxide nano particles in the bird that fed basal diet including 40 and 80 mg ZnO-NPs/kg had significantly ($P < 0.05$) effected on the amylase and lipase activity in

comparison to control treatment. No observation difference with regards to be the mention enzyme's activity among treatment on 28 days. Also, the addition of ZnO- NPs to the basal diet had not signed ($P>0.05$) effected on the morphological traits of jejunum. In conclusion, supplementation with 40 mg/kg ZnO-NPs improved the mucosal enzyme activity of Japans quail in the jejunum section duration 14 days of age.

Key Words: Quail, Nano particles, Mucosal, enzyme, Gut morphology

T179 Bioavailability of zinc oxide sources in broilers Stephane Durosoy^{*1}, Agnès Narcy², Agathe Roméo¹, Yves Nys² ¹*Animine*; ²*INRA*

The objective of the study was to evaluate Zn bioavailability in three sources of zinc oxide (ZnO): two sources available on the European (ZnE) and the American (ZnA) market and a novel source (ZnHZ, HiZox®), using ZnSO₄ monohydrate (ZnS) as a reference. A low-Zn basal diet was formulated in which plant feedstuffs were the only source of Zn (22 ppm). Twelve other diets were then prepared by adding to the basal diet 7, 14 or 21 ppm of Zn for each source. Nine male ROSS broilers par treatment were included and allocated in individual cages. Birds received one of the 13 experimental diets from d 5 to d 21 of age. At 21 d of age, a sample of blood was removed and the right tibia excised. Results indicate a significant interaction between the source and the level of Zn ($P<0.001$) on plasma and tibia ash Zn concentrations. Indeed, ZnHZ induced a 16 and 29% increase of plasma Zn compared to the other sources suggesting a higher digestive availability. In the same way, bone Zn concentration was 7, 12 and 26% higher in birds having received ZnHZ compared to those fed ZnS, ZnE and ZnA respectively. Corroborating the idea under which this better bioavailability may be linked to a faster disappearance of Zn from the lumen, total and soluble Zn concentrations in the gizzard and the small intestine were lower in birds fed the novel source compared to the others. This study confirmed that Zn bioavailability in ZnO is variable and dependent of its origin and its processing. It also showed that a well characterized source of zinc oxide can show a higher bioavailability than zinc sulfate.

Key Words: Zinc, Bioavailability, Broiler

T180 The effect of encapsulated butyric acid and zinc on performance and gut integrity in heat stressed male broiler chickens Karen Vignale^{*1}, Dawn Koltjes², Jordan Weil², Skyler West², Shawna Weimer², Vanessa Iseri¹, Karen Christensen² ¹*Kemin Industries*; ²*University of Arkansas*

The aim of the present study was to evaluate the impact of encapsulated butyric acid and zinc compared to encapsulated butyric acid on performance parameters and gut integrity during heat stress in male broiler chickens reared to 47 days of age. The trial was a randomized complete block design with 756 day old male broiler chicks divided into three treatments, replicated in 16 blocks with 14 birds per pen. The 3 treatments were as follows: basal diet (control), basal diet + 1lb/ton encapsulated butyric acid and zinc (BZ), basal diet + 0.66 lb/ton encapsulated butyric acid and calcium (BA). From d29 to d47, broilers were subjected to cyclic heat stress (HS) stress by exposing them to $28 \pm 2^\circ\text{C}$ from 0800 to 1800 and 22°C from 1800 to 0800. On d28 (before HS) and on d32 (4 days after HS), intestinal samples were taken from 8 birds/treatment and intestinal permeability was measured. Statistical analyses were performed using JMP software. BZ showed significantly higher feed intake than the control at d47 ($P < 0.05$). Whereas BA was similar to the control. During HS period (d29-d47), BZ showed significantly higher BWG compared to the control and BA ($P < 0.05$). At d47, BZ showed a numerical improvement on FCR of 6 points when compared to the control. Additionally, intestinal macromolecule permeability of BZ was numerically lower than the control and BA at d28 which indicates a more intact tight junction in the BZ birds. At d32, intestinal macromolecule permeability of BZ was numerically lower than the control. Encapsulated butyric acid and zinc showed a synergistic effect by having a greater impact on performance and gut integrity than butyric acid and calcium. The data

provides evidence BZ may alleviate the negative effects of heat stress on growth performance and intestinal integrity.

Key Words: butyric acid, zinc, heat stress, intestinal integrity, performance

T181 The effect of chromium propionate on performance responses in heat stressed male broiler chickens Karen Vignale^{*1}, Dawn Koltjes², Jordan Weil², Skyler West², Shawna Weimer², Vanessa Iseri¹, Karen Christensen² ¹*Kemin Industries*; ²*University of Arkansas*

The aim of the present study was to evaluate the impact of chromium propionate (CrProp) on performance parameters during heat stress in male broiler chickens reared to 60 days of age. The trial was a randomized block design in which 720 day old male broiler chicks were divided into five treatments, replicated in 12 blocks with 12 birds per pen. The 5 treatments were as follows: Treatment 1 (T1)=0 ppb CrProp added to the diet, Treatment 2 (T2)=200 ppb CrProp added to the diet, Treatment 3 (T3)=200 ppb CrProp added to the diet for 28d then 100 ppb CrProp added to the diet for the remainder of the study, Treatment 4 (T4)=100 ppb CrProp added to the diet for 28d then 200 ppb CrProp added to the diet for the remainder of the study, Treatment 5 (T5)=100 ppb CrProp added to the diet. From d29 to d60, broilers were subjected to cyclic heat stress by exposing them to $28 \pm 2^\circ\text{C}$ from 0800 to 1800 and 22°C from 1800 to 0800. Statistical analyses were performed using JMP software. All CrProp treatments were significantly greater in BW at 14d compared to control ($P<0.001$). Birds that were fed CrProp had numerically higher body weight at 28d than the control ($P=0.091$). There was a trend for BW improvement for 60 birds when fed CrProp ($P=0.085$) with the exception of treatment 5 which was similar to the control. CrProp significantly improved FCR at 14d and 28d ($P<0.05$). T4 was significantly different than the control at 14d and 28d showing an improvement of FCR of 3 and 4 points, respectively. At 42d, T3 and T4 showed a numerical improvement on FCR of 4 and 3 points, respectively ($P=0.076$). At 60d, T4 showed a numerical improvement on FCR of 9 points. Adding CrProp to the diet showed a positive effect on FCR and BW. Chromium supplementation may alleviate the negative effects of heat stress on growth performance.

Key Words: Chromium propionate, feed conversion ratio, body weight, heat stress, broilers

T182 The use of Presan-FY as an alternative to antibiotic growth promoters in broiler production. Kellie Hogan^{*1}, Scott Webster¹, Greg Page² ¹*Trouw Nutrition USA, Highland, IL*; ²*Trouw Nutrition Agresearch, Guelph, ON, Canada*

This study explored the use of Presan-FY (Trouw Nutrition), a commercially available blend of short chain fatty acids (SCFA), medium chain fatty acids (MCFA), slow release MCFA and a phytogetic compound. The goal of the study was to determine if Presan-FY could replace a common antimicrobial growth promoter (AGP), BMD, without negatively impacting the performance of broilers.

The study was performed at Southern Poultry Research, Inc. in Athens, Georgia. A total of 3600 Ross 708 male chicks were randomly and equally assigned to the treatments. The chicks were placed on re-used litter from the previous flock. The broilers received a typical corn soy diet as the negative control. Broilers were grown to a final weight of approx. 2.5 kg (49 days) or 3.6 kg (63 days). Pen weights were recorded at days 0, 15 and 30, and the treatment averages were calculated. On days 40 and 63, weights were measured for the 3.6 kg group, while the final weight date for the 2.5 kg group was measured on day 49. The treatment groups received Presan-FY (Standard: 1.5 – 1.0 – 0.5 kg/t starter - grower - finisher, or; Elevated: 2.0 – 1.5 – 1.0 kg/t starter – grower - finisher) or BMD at 55 ppm dosage. The results were analyzed using SAS 9.4 statistical software using the ANOVA procedure to assess multiple comparisons.

The observed body weight gains of the Presan-FY group were comparable with the AGP group, and significantly higher than the negative control ($p < 0.05$), although the elevated levels of Presan-FY gave no performance

advantage, even in the larger sized broilers. It was observed that the FCR of the birds in the Presan-FY group was significantly lower than that of the negative control group ($p < 0.001$). The FCR observed from the BMD group was similar to that of the Presan-FY group (standard) at the end of the growing periods for both sizes of broilers. The body weight gain of the Presan-FY group was significantly higher than the negative control in the finisher period of the heavy birds ($p = 0.002$). The results from this study suggest that when compared to a diet containing BMD, Presan-FY could replace AGPs in broilers of both a 2.5 kg and 3.6 kg final weight.

Key Words: Feed additives, Broilers, Organic acids, Antibiotic replacement

T183 Effects of Ration Plus TM applied to feed or drinking water on performance of broiler chickens fed diets with or without antibiotics in two heat stress trials D. Hall^{*1}, B. Prakash², P. Wiatnak¹, E. Wozniak¹, J. McNaughton³ ¹Cytozyme Laboratories, Inc.; ²CAR – Directorate of Poultry Research; ³AhPharma, Inc.

The objective of these studies was to evaluate various application methods of Ration PlusTM for Poultry (RP; AAFCO 36.11 Dried *Lactobacillus Acidophilus* Fermentation Product) to different diets or to drinking water, on live performance and processing traits of broilers exposed to heat stress. At ICAR-DPR, India, in a 42 day (d) trial with 240 VennCobb broilers (4 treatments x 10 replicates) liquid RP was applied at 0 or 1 L/1000 kg feed to normal (NME) or 2.5% lower energy (LME) corn-soy diets containing Tylosin. At d 42 the RP treatment improved body weight from 1.806^a in the control to 1.982^{bc} in a NME diet and from 1.841^{ab} to 1.915^c kg in LME diet, and reduced feed/gain from 1.718^{ab} to 1.654^{ab} and from 1.773^b to 1.612^a, respectively ($P < 0.05$). Mortality averaged 5.8% and was not affected by treatment. Blood glutathione and reductase activities were not affected by treatment, but lipid peroxidation (nmol MDA/g protein) was significantly decreased ($P < 0.05$) in birds fed RP. At AHPPharma, USA, in a 49 d heat stress, used-litter trial with 700 Ross 708 broilers (4 treatments x 10 replicates), RP was evaluated in antibiotic-free diets with applications through feed (0.05% RP dry), drinking water (RP liquid, equal to 0.05% daily RP dry intake) or feed and water combined. Heat stress was maintained at 41°C (105°F) for d15-49. RP in feed, water or combination feed and water, significantly ($P < 0.05$) improved d 49 body weights (2.93^a, 3.06^b, 3.08^{bc}, 3.11^c), carcass yield % live weight (70.67^a, 70.95^{ab}, 70.74^{ab}, 71.36^b), breast weight, % live weight (17.45^a, 17.70^{ab}, 17.73^{ab}, 17.80^b) and feed efficiency (1.90^a, 1.85^b, 1.86^{bc}, 1.83^c), respectively. RP also reduced intestine lesion score, intestine bacteria (*E. coli* and *Salmonella*) and mortality (10.0^a, 6.6^{bc}, 6.2^{bc}, 4.8^c, respectively) in combined feed and water application ($P < 0.05$). The data demonstrated that different application methods of Ration PlusTM liquid and dry showed similar effects of improved weight gain and feed efficiency in broilers exposed to heat stress, fed diets with or without antibiotics. These positive effects may partially be explained by lower lipid peroxidation in blood, reduced intestine lesions, and lower *E. coli* and *Salmonella* counts.

Key Words: Broiler, Ration Plus TM, heat stress, antibiotic-free, performance

T184 1. Effects of Ration Plus® on Broiler Chickens Fed Antibiotic-Free Diets Added Pre- or Post-Pelleting in Heat Stress Environments. D. Hall^{*1}, E. Wozniak¹, M. Sims² ¹Cytozyme Laboratories, Inc.; ²Virginia Diversified Research Corp

A trial was conducted with Ration Plus[®] for Poultry (RP; AAFCO 36.11 *Lactobacillus acidophilus* fermentation product). RP was supplemented at levels of 0, 0.05 or 0.10% to antibiotic-free, corn-soy based diets pre-pelleting or 0.05% post-pelleting with soy oil carrier (~76.7° C or 170° F) for 21d. Straight-run Cobb 500 broiler (n= 768) chicks were randomly assigned to 32 pens of 24 chicks (8 reps/group). A live coccidia vaccine was administered at the hatchery. On d 4, chicks were exposed to used litter from a healthy flock. Heat stress was at bird-level ~35°C (95°F/ d 0-7), ~38°C (100°F/ d 7-14), and ~40°C (105° F/ d 14-21). Results showed that Body Weights were not affected by the supplement. Final results further

demonstrated that the mortality adjusted feed conversion of the control group (1.458 kg/kg) was significantly ($P < 0.05$) higher than 0.05% Liquid RP (1.300 kg/kg) and both 0.05% and 0.10% Dry RP (1.364 and 1.343 kg/kg) and that the 3 RP groups Liquid, 0.05% Dry and 0.1% dry had significantly ($P < 0.05$) lower mortality (13.1, 18.75 and 15.63%) than that of the controls (30.73%). RP improved mortality adjusted feed efficiency and lowered mortality in broilers. Comparison of RP results pre and post pelleting indicate that RP is pellet stable under these trial conditions. These data suggest that RP may be effective in minimizing mortality from heart stress during the extremes of hot summer weather conditions.

Key Words: broilers, heat stress, pellet, antibiotic free, Ration Plus TM

T185 Effects of feeding different sources of basic copper chloride on the growth performance and intestinal lesion scores of broilers exposed to a sub-clinical challenge from 0 to 21 days of age Kurt Perryman^{*1}, Terri Parr¹, James Usry¹, Nickki Sriperm², Jeff Cohen¹ ¹Micronutrients USA LLC; ²Nutritional Statistics LLC

Basic copper chloride (BCC) is a source of complexed copper currently marketed as a feed additive. Recently, multiple sources of BCC have entered the market with each having distinct crystalline properties due to differences in manufacturing processes. Carefully calibrated production conditions are necessary for the generation of BCC with a majority of alpha-type crystals (IntelliBond[®] C; IBC). When these conditions are not met, BCC tends to have a majority of beta-type crystals. Basic copper chloride with more beta-type crystals is more soluble at pH 4.7 compared to BCC with alpha-type crystals. Because these products are both marketed as a type of BCC, it is critical to assess the potential impacts that differences in source solubility have on broiler performance. A 21 d experiment was conducted to determine the effects of feeding either alpha- or beta-type BCC crystals on broiler performance and intestinal lesion scores when exposed to a sub-clinical disease challenge. The experiment utilized 5,184 Ross 708 mixed-sex broilers. Forty-eight birds were placed per floor pen and fed 1 of 9 treatments (12 replicates). Treatments included a corn-soybean meal diet with 0 added Cu and 8 treatments arranged as a 2x4 factorial design with 2 BCC sources (alpha or beta) x 4 Cu levels (50, 100, 150, or 200 ppm). Broilers received an anti-coccidial vaccine and were exposed to a sub-clinical challenge at d 7 (used litter inoculated with *E. acervulina* and *E. coli*). Lesion scores (0 to 4 scale) were determined from 4 birds per pen on d 21. Overall, increasing BCC concentrations in the diet improved (linear: $P < 0.001$) body weight gain (BWG), feed conversion ratio (FCR), and lesion scores regardless of crystal type. Titrating additional alpha-type BCC into the diet reduced (linear: $P < 0.001$) mortality. Conversely, mortality was unaffected (linear: $P = 0.72$) by supplementing more beta-type BCC. By comparing the slopes of the regression lines, the relative bioavailability values (RBV) of alpha-type BCC compared with the beta-type BCC for BWG, FCR, and lesion scores were 1.58, 1.34, and 1.71, respectively. In conclusion, supplementing IBC (alpha-type) to the diet from 0 to 200 ppm improved performance, reduced lesion scores, and limited mortality. Using performance metrics as the response variables, alpha-type BCC had a RBV between 1.34 and 1.58 times better than the beta-type BCC.

Key Words: IntelliBond C, Basic Copper Carbonate, Copper, Broiler, Bioavailability

T186 Feeding high concentrations of a hydroxy copper and zinc source improved performance and reduced mortality of broilers subjected to a necrotic enteritis challenge Terri Parr^{*}, Kurt Perryman, James Usry, Jeff Cohen *Micronutrients USA LLC*

As consumer preference continues to drive a reduction in the use of prophylactic antibiotics and potentially ionophores in animal agriculture, nutritionists and veterinarians will need to pursue other options to help maintain broiler performance when birds are exposed to a necrotic enteritis (NE) challenge. Two 28-d trials were designed to determine if increasing the levels of Cu and Zn in broiler diets during a NE challenge would allow birds to maintain performance and reduce mortality. Trial 1 utilized 11 replicates of 24 male Cobb 500 birds per pen. Treatments included: 1) Non-challenged

control (NCC; 125ppm CuSO₄, 60ppm ZnO, 30ppm ZnSO₄), 2) As 1 + challenge + Maxiban (72g/t), 3) As 2 – Maxiban, 4-9) 2x3 factorial with challenged birds fed 125 or 200ppm IntelliBond C (IBC) with 90, 120 or 150ppm IntelliBond Z (IBZ). Post-challenge (d 17 to 28) and overall (d 0 to 28), Maxiban fed birds had higher ($P < 0.05$) body weight gain (BWG) and lower ($P < 0.05$) mortality than the challenged broilers fed the control without Maxiban. Broilers fed 200ppm IBC and 120ppm IBZ had similar ($P > 0.05$) BWG and feed conversion ratio (FCR) to the birds fed the challenged control diet with Maxiban, but better ($P < 0.05$) BWG and FCR than broilers fed the challenged control diet without Maxiban. Mortality decreased ($P < 0.05$) with increasing copper levels, but did not achieve the Maxiban control level. Trial 2 had 10 replicate pens of Ross 708 males (27 birds/pen) which were fed for 28 d. All treatments were exposed to a less severe NE challenge than trial 1. Control birds were fed 125ppm IBC + 80ppm IBZ without (1) or with (2) Maxiban (72g/t). Treatments 3-11 included a 3x3 factorial of 175, 225 or 275ppm IBC and 80, 120 or 160ppm IBZ. For all parameters measured, Maxiban fed birds outperformed ($P < 0.05$) broilers fed the control diet without Maxiban. After the challenge, broilers fed diets formulated with 225 or 275ppm IBC, regardless of IBZ level, had similar ($P > 0.05$) BWG, FCR, and mortality compared with control birds fed the diet with Maxiban. Moreover, broilers fed diets with 275ppm IBC had better ($P < 0.05$) BWG, FCR, and mortality than birds fed the control diet without Maxiban. In conclusion, supplementing diets with high concentrations of Cu from IBC (> 175 ppm) improved performance and limited the mortality of broilers fed Maxiban-free diets when exposed to a NE challenge.

Key Words: IntelliBond C, IntelliBond Z, necrotic enteritis, *Clostridium perfringens*, broiler

T187 Effect of feeding Zn Methionine-Hydroxy-Analogue Chelate to broilers and its differential effects compared to feeding ZnSO₄ Ricardo Gonzalez-Esquerre^{*1}, Raquel Bighetti Araujo¹, Danilo Cavalcante², Fernando Perazzo², Eneas Lavosier Cavalcante², Bruno Vieira Lobato², Leonilson da Silva Dantas², Marcia das Neves Soares² ¹*Novus International Inc.*; ²*Universidade Federal da Paraíba*

Two floor-pen trials tested the effect of feeding Zn from MINTREX[®] Zn on performance, carcass and meat quality traits of male broilers from 1 to 42d, and MINTREX[®] Zn differential response when compared to ZnSO₄. A total of 1,080 and 1,620 Cobb 500 d-old cockerels were allotted to 9 reps of 24 or 20 birds in trials 1 (E1) and 2 (E2), respectively. Five treatment levels of Zn (0, 16, 32, 64 and 128ppm) were fed from MINTREX[®] Zn only for E1, or from either MINTREX[®] Zn or ZnSO₄ in a factorial 2 (Source) x 4 (levels) + Negative Control to test the differential Zn Source response for E2. Birds were fed isonutritional corn-SBM-PBM (E1) or corn-SBM with 500 FTUs of phytase (E2) diets across treatments except for Zn which was further added accordingly. Pens had reused litter and feeder space as in the field. Birds were vaccinated with Newcastle, IBD and Marek as used locally. ANOVA, Tukey test and regression analyses were used. Qualitative parameters and lesions (%) were analyzed by Kruskal-Wallis test. In E1, BWG, FCR and production efficiency (EPI) improved when adding MINTREX[®] Zn showing a cubic effect ($P < 0.05$) and reaching optimal performance at 39, 35 and 37 ppms of added Zn, respectively; and carcass and breast (g) improved and scratches and bruises incidence dropped ($P < 0.05$). In E2, BWG, FCR and EPI improved when adding Zn. Still, birds showed greater BWG (3.007 vs 3.049 kg $P < 0.05$), and EPI (432 vs. 448; $P < 0.005$), when fed MINTREX[®] Zn rather than ZnSO₄, while FCR was not different (1.577 vs 1.563 for MINTREX[®] Zn and ZnSO₄ respectively; $P = 0.19$). Optimum Zn levels were achieved at 35, 38 and 37 ppms for MINTREX[®] Zn; and at 41, 43 and 41 ppms of Zn from ZnSO₄ for BWG, FCR and EPI, respectively. Increasing Zn from ZnSO₄ beyond the aforementioned levels did not compensate for its presumed lower bioefficacy resulting in 42g and 17 points loss in BWG and EPI vs. MINTREX[®] Zn, respectively. In conclusion, aside from improving carcass and meat quality traits of broilers fed practical diets formulated with practical ingredients, MINTREX[®] Zn can improve live performance above that obtained with ZnSO₄. In spite of E1

and E2 having 0 or 500 FTUs of phytase, respectively, optimal Zn levels from MINTREX[®] Zn calculated for performance traits were very close in both trials.

Key Words: Mintrex Zn, Broilers, Zinc Requirements, Carcass, Meat quality

T188 Differential Performance Response of Broilers when Fed Cu from Cu - Methionine-Hydroxy-Analogue Chelate vs Sulfate Sources Ricardo Gonzalez-Esquerre^{*1}, Raquel Araujo Bighetti¹, Cesar Gonçalves de Lima², Jose Manocal Arce³, Carlos Lopez-Coello⁴, Ernesto Ávila-González⁴ ¹*Novus International Inc.*; ²*Universidade de São Paulo*; ³*Facultad de Medicina Veterinaria y Zootecnia, Universidad Michoacana de San Nicolás de Hidalgo*; ⁴*Facultad de Medicina Veterinaria y Zootecnia, Universidad Nacional Autónoma de México*

Two floor-pen trials studied the effect of feeding Cu at different levels either from MINTREX[®] Cu or from CuSO₄ on broilers from 1 to 42d of age. A total of 3,000 and 2,800 Ross 500 day-old non sexed chicks were used in trial 1 (E1) and 2 (E2), respectively. In both trials, birds were randomly distributed into 6 treatments with 5 pens of 100 birds (E1) and 9 or 10 reps of 50 broilers (E2). Six dietary treatments consisted of 3 levels of Cu (10, 30 or 120ppm) x 2 Cu sources (MINTREX[®] Cu- or CuSO₄) arranged in a factorial design. Broilers were fed corn-SBM-wheat bran-DDGS isonutritional based diets designed to have a commercial nutrient density across treatments except for added Cu levels. Phytase was used at 0 or 500 FTU's for E1 and E2, respectively. In both trials, pens had reused litter, commercial feeder space allowances and birds were vaccinated against Newcastle disease. The cell-mediated immune response was examined by cutaneous basophilic hypersensitivity test in E1 using intradermic inoculation of phytohemagglutinin. Performance (42d) of both trials was analyzed together in a combined mixed model. For each combined analysis, trial was defined as random. The linear, quadratic and source intercept terms were considered fixed effects. BIC was used as criteria to select the regression model that better describes the data based on goodness of fit. For immune response (E1) and carcass yield (E2), ANOVA and Tukey test were performed. There was no interaction between factors for any performance parameter tested. The interdigital thickness was greater for MINTREX[®] Cu vs CuSO₄ at all levels indicating a stronger cell mediated immune response ($P < 0.001$). For BWG the average source values across levels for MINTREX[®] Cu vs CuSO₄ were different at $P = 0.07$. The best fit equation (linear for both sources) predicted better BWG (+32g/bird) FCR (-0.032 points) and EPI (8.4 points) with MINTREX[®] Cu over CuSO₄ ($P = 0.04$) across all levels, and the comparison between predicted BWG, FCR and EPI values at level 10, 30 and 120 ppm were significantly better for MINTREX[®] vs. CuSO₄ at every level ($P < 0.05$). Overall, MINTREX[®] Cu optimized performance over CuSO₄ while optimal levels of added chelated Cu were achieved at 30 or 120 ppms.

Key Words: Mintrex Cu, Copper, Broilers, Cu requirements, Growth promoter

POSTER SESSION

Processing & Products

P189 The effects of replacing corn with sorghum processed at increasing temperatures on growth performance of broilers and TME digestibility in roosters. Guilherme Hosotani*^{GS}, Monty Kerley, Marcia Shannon *University of Missouri*

Two experiments were conducted to evaluate corn replacement by yellow sorghum processed at increasing temperatures using a rotary compression unit on growth performance of broilers and TME in cecectomized roosters. In Exp. 1, 150 1-d-old male broilers (Ross 308) were assigned to 6 dietary treatments with 5 replicates and 5 birds per replicate in a complete randomized block design. Broilers were allocated in battery cages in a temperature controlled room. Treatments were corn, non-cooked sorghum grain (RAW), or sorghum heated at 105, 115, 125, and 135°C. Diets were formulated to meet or exceed NRC (1994) and Aviagen nutrient requirements. Broilers were weighed and feed disappearance measured on d 10 and 21. In Exp. 2, 12 cecectomized roosters were randomly assigned to treatments in two 6 x 6 Latin squares. Roosters were individually allocated into cages with raised wire floors. Roosters were fasted for 24 h, then precision-fed 30 g of cereal grain, and excreta was collected for 24 h. Basal endogenous losses were measured using roosters fasted for 48 h. Statistical analyses were performed by ANOVA using PROC GLM of SAS followed by contrast analysis comparing corn vs RAW, RAW vs heat treated sorghum, and heat treated sorghum were analyzed using linear regression analysis. Differences among treatments were significant at $P \leq 0.05$. Overall, broilers fed RAW had greater ADG compared to corn ($P=0.039$; 39.4 vs 35.5 g, respectively). Increasing temperatures during sorghum processing did not result in linear response on ADG ($P=0.601$), ADFI ($P=0.876$), and FC ($P=0.065$) or response in contrast analysis (RAW vs heat treated sorghum) on ADG ($P=0.183$), ADFI ($P=0.359$), and FC ($P=0.297$). The TME of corn, RAW, 105, 115, 125, and 135°C were 3,298, 3,425, 3,353, 3,421, 3,412, and 3,364 kcal/kg, respectively. Contrast analysis showed no response for corn vs RAW ($P=0.068$), heating sorghum ($P=0.415$), and no linear response to increasing temperature ($P=0.747$). Heat processing sorghum at increasing temperatures from 105 to 135°C through compression and friction using a rotary dryer, did not affect growth performance or energy digestibility, however the effects of processing using rotary dryer should be tested on other sorghum sources.

Key Words: Soybean, TME, growth performance, broiler, rooster

P190 Using foodborne outbreak strains of *Salmonella* Heidelberg to investigate *Salmonella* colonization in muscle, bone and skin of experimentally infected turkeys Claire-Sophie Rimet*^{GS}, John Maurer, Roy Berghaus, Ana Villegas, Lisa Stabler, Kasey Johnson, Monique Franca *University of Georgia*

Poultry products contaminated with *Salmonella enterica* subsp. *enterica* serovar Heidelberg were implicated in 5 major human salmonellosis outbreaks in the United States between 2011 and 2014. *Salmonella* present on poultry carcasses and cross contamination with fecal material during processing are considered the main sources of *Salmonella* in poultry products. To our knowledge, limited information is available concerning the role of invasive *Salmonella* as a potential source of contamination in ground turkey. We hypothesized that *S. Heidelberg* strains isolated from foodborne outbreaks could colonize muscle of commercial turkeys after an oral inoculation at day of age. This hypothesis was made based on results from a previous study that revealed *S. Heidelberg* and *S. Typhimurium* in muscle lymphatics of specific-pathogen-free chickens at 42 days post oral inoculation.

S. Heidelberg strains isolated from foodborne outbreaks were tagged with mini-Tn5-*luxCDABE* transposon in order to detect infected tissue by bio-

luminescence imaging. One day old commercial turkeys were orally inoculated with a pooled, *Salmonella* cocktail containing five *S. Heidelberg* strains (oral dose: 10^7 CFU per bird). Muscle associated with lymphatics were collected at 6 and 11 weeks post inoculation and tested by bioluminescence imaging and bacteriology. Bacteriology was also performed in breast skin and tibiotarsus collected at 11 weeks of age.

All muscle samples were negative for *S. Heidelberg* by bioluminescence imaging and bacteriology at 6 and 11 weeks of age. All tibiotarsi collected at 11 weeks of age were culture negative for *S. Heidelberg*. Only breast skin samples were positive for *S. Heidelberg* at 11 weeks of age with 30.1% prevalence.

Therefore, the results of this study indicate that *Salmonella* presence in skin, rather than in infected tissue, appears to be the significant contributor to contamination of ground turkey.

Key Words: *Salmonella* Heidelberg, Ground turkey

P191 Cell Concentration of *Campylobacter coli/jejuni* in 24 Hour Broth Culture Katia DaCosta*^{UG}, Mark Berrang, Richard Meinersmann, Nelson Cox, Steven Knapp *USDA-ARS*

In previous studies, we have suspended colonies from agar plates in phosphate buffered saline and used spectrophotometric methods and calibration curves to estimate how many colony forming units (CFU's) were present per mL for inoculation studies. This method, which works well for *Salmonella*, is highly variable with *Campylobacter* making repeatability difficult. It would be helpful to have an improved method for predicting how many *Campylobacter* CFU's are present per mL for future studies. The objective of the current study was to determine how many *Campylobacter* CFU's are present per mL of a 24 h broth culture. Ten MLST sequence types of *Campylobacter* (five *coli* and five *jejuni*) were streaked for isolation onto Campy Cefex Agar (CCA) plates. An isolated colony of each subtype was transferred into a 9 mL tube of *Campylobacter* Enrichment Broth (Bolton formulation). After being incubated for 24 h, the broth from each tube was serially diluted and plated onto CCA. Colonies were counted, numbers log transformed, means calculated, and compared with GLM and Tukey's HSD test. Mean *C. coli* counts ranged from 7.9 to 8.4 with an overall mean of 8.1 log CFU/mL. Mean *C. jejuni* counts ranged from 7.6 to 8.2 with an overall mean of 8.0 log CFU/mL. For both species, there was a significant difference in final cell concentration depending on MLST sequence type. It can be anticipated that close to 10^8 *C. coli/jejuni* CFU/mL will be present in a 24 h broth culture. These data are useful for future studies involving inoculation of samples.

Key Words: *Campylobacter*, cell concentration, broth culture

P192 Isolation of *Campylobacter* in a commercial quail processing plant Nelson Cox*¹, Douglas Cosby¹, Harsha Thippareddi², Casey Ritz², Mark Berrang¹, Jeromey Jackson², Sanjay Kumar², Amanda Howard², Angela Rincon², Mayuri Ukidwe², Melissa Landrum², Charlene Jackson¹, Jonathan Frye¹, Kimberly Cook¹, Arthur Hinton, Jr.¹ ¹USDA, ARS, U.S. National Poultry Research Center; ²University of Georgia

There is very little published information about the presence of *Campylobacter* on commercially processed quail. Quail (*Coturnix japonica*) carcasses were sampled and cultured prior to chilling and the application of antimicrobial interventions. At the laboratory, each carcass was hand rinsed in 200 mL buffered peptone water in plastic bags for 1 min. A 30 mL aliquot of the rinsate was added to 30 mL of double strength Tecra broth and incubated at 42°C for 48 h under microaerobic conditions (5% O₂, 10% CO₂ and 85% N₂). After incubation, 10 µL of the enriched broth was streaked onto Campy Cefex plates and incubated as above. Three colonies,

typical of *Campylobacter*; from each plate were selected and confirmed by microscopic examination and latex confirmation. In replications 1, 2, 3 and 4, *Campylobacter* were recovered from 1/5, 1/10, 0/10 and 10/10 of the samples, respectively. Overall, 12/35 (34.3%) of the quail samples were positive for *Campylobacter*. Almost all of these positive samples occurred in replication 4, with the other 3 replications being predominately negative. Differences between replications 1, 2 and 3 and replication 4, such as breeder flock source, husbandry, etc., will be investigated to provide additional information which will further our understanding of the ecology of *Campylobacter* in quail and ultimately be applied to the commercial broiler industry.

Key Words: quail, *Campylobacter*, processing plant

P193 Presence of *Salmonella* in a commercial quail processing plant

Douglas Cosby^{*1}, Nelson Cox¹, Harsha Thippareddi², Casey Ritz², Mark Berrang¹, Jeromey Jackson², Sanjay Kumar², Amanda Howard², Angela Rincon², Mayuri Ukidwe², Melissa Landrum², Charlene Jackson¹, Jonathan Frye¹, Kimberly Cook¹, Arthur Hinton, Jr.¹ ¹USDA, ARS, U.S. National Poultry Research Center; ²University of Georgia

A limited amount of information is available regarding the presence of *Salmonella* on commercially processed quail and as they gain more of the exotic food market, this information will be valuable. Quail (*Coturnix japonica*) carcasses were obtained just before chilling and returned to the laboratory on ice. Each carcass was hand rinsed for 1 min in 200 mL buffered peptone water and 30 mL were removed and incubated at 37°C for 24 h. Following incubation, 0.5 mL of incubated rinsate was transferred to 9.5 mL tetrathionate broth (Hajna) and 0.1 mL to 9.9 mL of RV broth. After incubation in the selective enrichment tubes, 10 µL of broth was streaked onto one plate per tube of BG Sulfa and XLT-4 agar. After incubation, three colonies, typical of *Salmonella*, were selected per plate and inoculated into slants of triple sugar iron and lysine iron agar. Tubes showing typical reactions were then streaked onto plates of nutrient agar for purity and serogrouped using *Salmonella* poly O and confirmed using *Salmonella* poly H antisera. In replication 1, 2, 3 and 4, *Salmonella* were found in 2/5, 10/10, 2/10, and 0/10 of the quail samples, respectively. Overall, 14/35 (40%) of the samples were positive for *Salmonella*, but there was considerable variation from sample date to sample date. All *Salmonella* isolates were found to be serogroup B and were frozen for serotyping and further analysis. Future research will sample different parts of the integrated system for the presence of *Salmonella* to obtain a more accurate view of the ecology of *Salmonella* in commercial quail in order to compare to commercial broilers.

Key Words: quail, *Salmonella*, processing plant

P194 Nutrient content of thigh meat from broilers and alternative breeds finished on the floor or on pasture Jacqueline Jacob^{*1}, Anthony Pescatore¹, Michael Ford¹, Tatijana Fisher¹, Sunday Adedokun¹, Tuoying Ao² ¹University of Kentucky; ²Alltech

This study compared the nutrient content of thigh meat from broilers (BR), and three alternative breeds (Rhode Island Red (RIR), Barred Plymouth Rock (BPR) and Black Australorp (BA)) raised in floor pens or finished on pasture. All chickens received the same diet (2866 kcal/kg; 19.2% CP). All the alternative breeds were started on the floor at the same time and half placed on pasture at 4 wk of age. The BR were started on the floor 7 wk after the alternative breeds and half placed on pasture at 3 wk of age. There were 3 reps of 24 chicks per treatment. At the end of the trial (7 wk for BR and 14 wk for alternative breeds), 2 males and 2 females from each replication were processed and thigh samples collected. Thigh samples were kept in a -80°C freezer until analyzed according to AOAC methods. Because of low meat yield for the alternative breeds, the third rep was divided in half and distributed to the other 2 reps. There was no significant ($P < 0.05$) effect of breed on moisture, cholesterol, saturated fatty acid (SFA), monounsaturated fatty acid (MUFA) and polyunsaturated fatty acid (PUFA) contents of the thigh meat. There were, however, significant ($P < 0.05$) breed differences in fat and protein contents in the thigh meat. Fat content was significantly

higher for BR (8.4%) than RIR (5.4%) with the other 2 breeds in-between. The BR thigh meat had slightly less protein (17.4%) than the other 3 breeds (average of 18.7%). There was a significant effect of sex on the moisture, fat and SFA content of the thigh meat. Moisture content was significantly higher in males (73.3 vs 72.5%), lower in fat (6.4 vs 7.5%), and lower in SFA (1.39 vs 1.72 g/100 g) than females. There was a significant location effect on all nutrients of the thigh meat except SFA content ($p = 0.0551$). The thigh meat from chickens finished on pasture had significantly ($P < 0.05$) higher moisture (73.6 vs 72.2%), protein (18.9 vs 17.9%), and cholesterol (78.58 vs 61.09 g/100g), but less fat (6.2 vs 7.7%), MUFA (1.52 vs 1.94 g/100g) and PUFA (1.37 vs 1.57 g/100g). While some consumers believe that raising chickens on pasture increases omega-3 fatty acids, this was not found to be the case with the thigh meat. The lower total PUFA content of the thigh meat may be because of lower total fat content.

Key Words: Meat, Alternative breeds, Pasture production

P195 Self-contained chlorine dioxide generation and delivery pods for controlling *Listeria monocytogenes* in model floor drains. Mark Berrang^{*1}, Mark Harrison², Richard Meinersmann¹, Gary Gamble¹ ¹USDA-ARS; ²University of Georgia

Listeria monocytogenes is a foodborne pathogen that has been associated with poultry products. This organism is ubiquitous in nature and has been found to enter poultry further processing plants on incoming raw product. Once in the plant, *L. monocytogenes* can become a long term persistent colonizer especially of floor drains. Floor drains are a concern because escape of *Listeria* and potential for contamination of product and product contact surfaces has been documented. The objective of this study was to test a self-contained chlorine dioxide generating and application device for killing both free-swimming and attached *L. monocytogenes* in a model floor drain system. Model drain pipes were constructed from PVC pipe and inoculated with *L. monocytogenes* to establish attached cells on the inner surface. Pipes were treated with placement of a pod at the top open end. Each pod contained two chemical precursors which, when combined, react to form gaseous ClO_2 . Once activated, pipes were exposed to the treatment for 4 or 24 h. A four hour treatment resulted in a decrease of more than 5 log CFU/mL free swimming *L. monocytogenes* and more than 2 log CFU attached cells. A 24 h treatment was significantly more effective. Commercially available, self-contained ClO_2 generating and delivery pods have potential as a means to sanitize floor drains to help control *L. monocytogenes* in poultry further processing plants.

Key Words: *Listeria monocytogenes*, floor drains, chlorine dioxide

P196 Antimicrobial Interventions for Improving Microbiological Quality of Quail Angela Rincon^{*1}, Sanjay Kumar¹, Amanda Howard¹, Mayuri Ukidwe¹, Melissa Landrum¹, Nelson Cox², Douglas Cosby², Harshavardhan Thippareddi¹, Casey Ritz¹, Mark Berrang², Jeromey Jackson², Charlene Jackson², Jonathan Frye², Kim Cook², Arthur Hinton, Jr.² ¹University of Georgia; ²US National Poultry Research Center; USDA-ARS

Quail (*Coturnix japonica*) is a delicacy and is sold in the United States in limited markets. Similar to poultry, quail is processed and marketed as fresh meat, with limited shelf life. The objective of the research was to evaluate the efficacy of antimicrobial interventions during slaughter on the microbiological quality and shelf life of quail during refrigerated storage. Fresh quail were obtained from a processor prior to chilling and transported on ice to the laboratory. Quail were subjected to the following antimicrobial interventions (immersion in solution with air agitation): peroxyacetic acid (PAA; 450 ppm), Citrilow (pH 1.2), and Cecure (cetylpyridinium chloride, 450 ppm), along with a water and non-treated control. The quail were packaged and stored under refrigeration (4°C) before sampling for microbial quality (aerobic plate counts (APC), psychrotroph counts (PC), *Enterobacteriaceae* counts (ENT), total coliform counts (TCC) and *E. coli* counts (ECC)) were determined on days 1, 4, 7 and 10. Minimal reductions (< 0.01 log CFU/mL; $p > 0.05$) in APC, PC, ENT, TCC and ECC were observed

with water treatment compared to control. Reductions in APC, PC, ENT, TCC and ECC populations of 0.61, 1.26, 0.57, 0.66 and 0.70 log CFU/mL, respectively, were obtained with PAA application, and the microbial reduction was similar for Citrilow. Greater reductions (2.22, 1.26, 1.47, 1.52, 1.59 log CFU/mL, respectively) were obtained with application of Cecure. Application of antimicrobial interventions resulted in a reduction in APC, PC and ENT populations subsequent to treatment (day 1) and throughout the storage period (day 10) of the Quail. These data indicate that the use of antimicrobial interventions subsequent to packaging can improve the shelf life of quail.

Key Words: quail, shelf life, antimicrobial interventions

P197 Nutrient content of meat from broilers finished on the floor or on pasture Jacqueline Jacob^{*1}, Anthony Pescatore¹, Michael Ford¹, Tatijana Fisher¹, Sunday Adedokun¹, Tuoying Ao² ¹*University of Kentucky*; ²*Alltech*

This study compared the effect of finishing meat chickens on pasture with those raised in floor pens. All chickens received the same diet (2866 kcal/kg; 19.2% CP). All the chicks were started in floor pens and half moved to pasture at 3 wk of age. There were 3 reps of 24 chicks per treatment. At the end of the trial, 2 males and 2 females from each replication were processed and breast and thigh samples collected. The samples were frozen in -80°C freezer until analyzed by AOAC methods. There was a significant difference ($P < 0.05$) in the nutrient content of the breast and thigh meat. Compared with thigh meat, breast meat was higher in moisture (75.4 vs 72.5%), protein (21.6 vs 17.4%) and ash (1.1 vs 0.9%), but lower in vitamin A (40.1 vs 95.0 IU/100 g), iron (0.28 vs 0.60 mg/100 g), fat (1.5 vs 8.4%), saturated fatty acid (0.38 vs 1.76 g/100 g), polyunsaturated fatty acid (0.30 vs 1.39 g/100 g), and mono-unsaturated fatty acid (0.41 vs 2.05 g/100 g). The only nutrient significantly ($P < 0.05$) affected by location was protein. Breast and thigh meat from broilers finished on pasture were higher in protein (20.1 vs 18.9%) than from those finished on the floor. Females had higher iron content in the meat than that of the males (0.48 vs 0.40 mg/100g, respectively). While many consumers believe that raising chickens on pasture increases vitamin A content, this was not found to be the case. There were, however, major differences between the breast and thigh meat. Vitamin A is fat soluble so it is logical that the meat with the highest fat content would have the highest vitamin A content.

Key Words: meat, pasture production

P198 Nutrient content of breast meat from broilers and alternative breeds finished on the floor or on pasture Jacqueline Jacob^{*1}, Anthony Pescatore¹, Michael Ford¹, Tatijana Fisher¹, Sunday Adedokun¹, Tuoying Ao² ¹*University of Kentucky*; ²*Alltech*

This study compared the nutrient content of breast meat from chickens finished on pasture vs those raised in floor pens. Broiler (BR), and three alternative breeds (Rhode Island Red (RIR), Barred Plymouth Rock (BPR) and Black Australorp (BA)) all received the same diet (2866 kcal/kg; 19.2% CP) and were started in floor pens. Half of the alternative breeds were moved to pasture at 4 wk of age while half the BR, which were started 7 wk after the other breeds, were placed on pasture at 3 wk of age. There were 3 reps of 24 chicks per treatment. At the end of the trial, 2 males and 2 females from each rep were processed and breast samples collected. The breast meat was kept at -80°C until analyzed by AOAC methods. Because of low meat yield for the alternative breeds, the third rep was divided in half and distributed to the other 2 reps. There was no effect of breed on breast fat, saturated fatty acid (SFA) and polyunsaturated fatty acids (PUFA) content. BR breast meat had lower CP content than that of the other breeds (21.6 vs 23.4%) and higher monounsaturated fatty acid (MUFA) content than that of RIR and AUS (0.41, 0.25 and 0.22 g/100g). A breed x location interactive effect on moisture content was detected. For RIR, breast meat from chickens finished on pasture had a higher moisture content than that of those finished on the floor. For BR and the other 2 breeds, location had no effect on the moisture content of the breast meat. Chickens finished on

pasture had less fat content in breast meat than those finished in floor pens (0.6 vs. 1.9%). There was a location x sex interactive effect on fat content. For those finished on the floor, the females had more fat in breast meat than the males (2.3 vs 1.4%). Similar results were observed with the MUFA content. Those finished on pasture had higher protein, lower SFA and lower PUFA content in breast meat than those finished on the floor. No effect of breed on fat, SFA and PUFA content in breast meat was noticed. Breast meat from BR had higher MUFA content than that from RIR or AUS (0.41, 0.25 and 0.22 g/100g). While there are differences among breeds for nutrient content of breast meat, no nutrient enhancement was observed with finishing chicks on pasture compared to those raised in floor pens.

Key Words: meat, alternative breeds, pasture production

P199 Panorama of Aviculture: Brazilian and International trade balance Rodrigo Garcia^{*}, Marli Aranda, Carla Heloisa Domingues, Sarah Sgavioli, Rodrigo Borille, Irenilza Naas, Fabiana Caldara *Universidade Federal da Grande Dourados*

Configuration panorama of broiler economic scenario could corroborate or rectify the possible strategies of Brazilian insertion in global market. The aim of the study was to achieve a trade balance of Brazilian and international poultry chain in order to describe the current economic situation of the sector. The study was conducted through qualitative approach, assuming an exploratory-descriptive. First was realized a balance of international trade of product with leading players of production, import and export worldwide. Later was characterized the poultry chain in Brazil, main producing and exporting states, as well as the fate of chicken meat produced in the country. It was used USDA (U.S. Department of Agriculture) and ABPA (Brazilian Association of Animal Protein) databases. Worldwide production is expected to increase about 2%, equivalent to 89.3 million tons of chicken meat in 2016. Considering the increasing world population expected to reach 9.2 billion people in 2050, mainly coming from China and India, production is expected to increase considerably in order to achieve the demand, warming up exports in general. US and Brazil are in the top of world production and export ranking, moving the largest share of this market. Japan, Saudi Arabia and Mexico are the world's largest importer of the product. In Brazil, states of Parana, Santa Catarina and Rio Grande do Sul are the largest producers and exporters of chicken meat, however, other states are increasingly investing in the sector, providing to the country increased production capacity over the years. Main destinations of chicken meat produced in Brazil are Saudi Arabia, Japan, Netherlands, China and Arab Emirates, demonstrating that Brazilian industry is achieving more the international market. Considering that the poultry chain has highly importance for Brazilian development, understanding the current scenario may result in public policies that support and fund this activity encouraging farmers to keep developing the sector.

Key Words: agribusiness, broiler, export, production

P200 Effects of sanitizers use in poultry carcasses for meat quality

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The trend in the use of sanitizers for the chemical decontamination of carcasses by chicken meat producer and exporter countries, raises the question whether such products may cause changes in meat characteristics. This study had the purpose to evaluate whether the use of sodium hypochlorite (HS), ozone (Oz) and lactic acid (LA) either alone or in combination, causes changes in meat quality in regards to pH, rancidity, color and taste following two storage conditions. The experiment included 27 treatments in a factorial 3 x 3 x 3 with three replications, each bird being one replicate. Tested factors were three concentrations of HS used in the water of the first stage of the "chiller" (zero, 1 and 5 ppm), three concentrations of Oz in the water of the second stage of the "chiller" (zero, 0.3 and 1.2 ppm) and three concentrations of AL (zero, 2 and 5%) sprayed on the carcasses after

precooling. HS and AL decreased the pH and increased lightness, while Oz increased pH of the refrigerated thigh meat. HS decreased the rancidity in the frozen meat, as well as redness and yellowness. Significant interactions were observed in rancidity values using HS with AL and HS with Oz, and in lightness with the use of HS combined with AL. Sensory analysis showed no difference among the treatments. It was concluded that, in general, all sanitizers caused changes in the characteristics studied, especially sodium hypochlorite. The use of the sanitizers, either alone or in combination, did not affect the acceptability of the chicken meat.

Key Words: lactic acid, sodium hypochlorite, ozone, color, taste

P201 Isolation and identification of amylase-producing, endospore-forming bacteria from the alimentary tract of commercially processed broilers Arthur Hinton Jr*, Kimberly Ingram *United States National Poultry Research Center*

Bacterial cultures of crop and cecal contents of adult poultry contain beneficial bacteria that reduce colonization of young poultry by *Salmonella*. Since endospore-forming bacteria may play a role in competitive exclusion of *Salmonella* in poultry, 3 trials were conducted to isolate these bacteria from the crop and cecal contents of commercially processed broilers. Pre-eviscerated, broiler carcasses were taken from a commercial poultry processing facility, placed on ice, and immediately transported to the laboratory for removal of crops and ceca. Crop and cecal contents were used to inoculate separate, 100 ml aliquots of media composed of (g/l) tryptose, 10; yeast extract, 5; sodium chloride, 5; glucose, 5; and beef extract, 2. Inoculated media was incubated aerobically or anaerobically at 35°C for 48 h. After incubation, 10 ml of each culture was transferred to test tubes and heated at 80°C for 10 min. Serial dilutions of the cultures were plated on Bacillus Agar, and plates were incubated at 30°C under the appropriate atmospheres for 24 h. Plates with isolated colonies were selected, and a replica plating tool was used to transfer colonies from the original plates to fresh Bacillus Agar plates. The original plates were flooded with Gram's iodine, and colonies with clear zones were identified as presumptive amylase producers. Isolates were screened for amylase production because starch is a major component of broiler diets. Replica plates were incubated for 24-48 h at 30°C, and replicas of colonies that exhibited amylase production on the original plates were selected for identification with the Biolog Bacterial Identification System. Endospore production was confirmed by phase microscopy. Amylase production by pure colonies was confirmed by streaking cultures on Starch Agar, incubating for 48 h, and observing for zones of clearing around colonies on plates flooded with Gram's iodine. Results

indicated that there was no significant ($p \leq 0.05$) difference in the number of endospore-formers recovered from crop or cecal cultures and no difference in the number of these bacteria recovered from aerobic or anaerobic cultures. Isolates were identified as *Bacillus pumilus*, *Bacillus niabensis*, *Paenibacillus provencensis*, *Paenibacillus borealis*, and *Paenibacillus tarimensis*. Findings indicate that endospore-forming, amylase-producing bacteria are part of the normal flora of commercially processed broilers. The ability of these bacteria to digest starch can increase the concentration of simple carbohydrates available for metabolism by other beneficial bacteria. Therefore, these bacteria may be important components of effective, defined probiotic cultures.

Key Words: broilers, endospore-formers, amylase-producers

P202 Trade barriers analysis to the export of poultry meat in the west central region of Brazil Marli Aranda*, Rodrigo Garcia, Carla Heloisa Domingues, Sarah Sgavioli *Universidade Federal da Grande Dourados*

With the trade liberalization in recent decades, also had a steady growth in negotiations between nations, due to tariff reduction. However, in the same period, market agents to replace these mechanisms created new forms of protection in order to promote domestic economic stability of countries and at the same time expand and guarantee trade between nations. The aim of the study was to analyze the main trade barriers imposed by the ten largest importers of poultry meat from Brazil and Mato Grosso do Sul (MS), highlighting the opportunities and challenges the sector faced within state. This is a documentary research and with primary data, exploratory descriptive with a qualitative approach. It was used semi-structured questionnaires with open and closed questions sent by Survey Monkey software to Brazilian Association of Animal Protein - ABPA and Secretary State of Production and Family Agriculture - SEPAF. The research was based on the top ten importers of Brazilian poultry meat, including Saudi Arabia, Japan, Netherlands, China, Arab Emirates, Hong Kong, Venezuela, Russia, United Kingdom and Germany. Results showed that the most present barriers among surveyed countries are in the first place technical ones followed by commercial ones and finally, general ones. This reinforces international concern with quality and safety of food products. Research showed that trade barriers are not a problem for MS growth of poultry meat export, and other issues need to be analyzed, such as those related to government incentives that encourage activity, such as incentives for companies' installation in region, tax issues and production costs.

Key Words: agribusiness, broilers, foreign market, protectionism

Pathology

P203 Evaluation of lymphocytes population in gut on *Salmonella* Enteritidis challenged broilers Larissa Pickler*, Elizabeth Santin *Universidade Federal do Paraná*

Human food poisoning caused by the consumption of meat and eggs contaminated with *Salmonella* sp., has significantly increased in the past few years. *Salmonella* is considered a facultative intracellular pathogen and cell-mediated immunity has an important role in memory and pathogen elimination from tissues, with T cells participation. The objective of this study was to evaluate the lymphocytes population in gut of *Salmonella* Enteritidis (SE) challenged broilers. One-day old broilers were placed in a *Salmonella*-free environment receiving water and food *ad libitum* and reared under continuous light. Broilers were orally challenged at 7 or 14 days of age with a SE suspension in two different concentrations: 10^5 or 10^8 CFU/mL. For T lymphocytes evaluation (CD4+ and CD8+ cells) immunohistochemistry was performed in ileum and cecum samples collected from euthanized and necropsied broilers at 28 days post challenged. Data were analyzed by ANOVA and different means were evaluated by Tukey test's using Statistix software. Results showed that broilers challenged at 7 days of age presented significantly higher CD4+ cells in ileum at 28 post-

challenge (23.70 ± 8.35) when compared to broilers challenged at 14 days of age (13.80 ± 3.26). They also presented significantly higher CD8+ cells in ileum (22.40 ± 6.20) and cecum (23.20 ± 7.56) when compared to broilers challenged at 14 days of age (13.30 ± 3.92 in ileum and 12.70 ± 3.83 in cecum) at 28 days post-challenge. In the evaluation of dose of challenge it was possible to observe that challenged broilers with 10^5 CFU presented significantly lower CD4+ cells in ileum (13.80 ± 3.25) when compared to broilers challenged with 10^8 CFU (23.70 ± 8.35) at 28 days post-challenge. Also, challenged broilers with 10^5 CFU presented lower number of CD8+ cells in ileum (13.30 ± 3.91) and cecum (12.70 ± 3.83) when compared to broilers challenged with 10^8 CFU (22.40 ± 6.20 in ileum and 23.20 ± 7.56 in cecum) at 28 days post-challenge. In conclusion, it was possible to observe that the age and dose of SE challenge have influence in CD4+ and CD8+ cells population in ileum and cecum. Younger broilers and higher SE doses resulted in more intense mobilization of T lymphocytes to the gastrointestinal tract.

Key Words: lymphocytes, immune response, *Salmonella*

P204 Evaluation of transference of aflatoxin B1 and biotransference to aflatoxin M1 in chicken breast by UHPLC-FLD. Victor Manuel Munoz Cazares*, Juan Carlos Medina Bravo, Jose Antonio Fierro Huesca, Oliver Montalvo Estrada *NUTEK SA de CV*

Aflatoxin B1 (AFB1) is a mycotoxin produced mainly by fungi *Aspergillus spp.*, AFB1 is the main mycotoxin and a known carcinogenic. Acute or chronic aflatoxicosis in poultry birds results in decreased meat/egg production, immuno-suppressant, and hepatotoxicosis. Aflatoxin M1 (AFM1) is the principal metabolite produced by AFB1, is metabolized in the liver by intervention of the enzyme P450 CYP1A2, AFB1 is hydroxylated to AFM1 in response of the organism to detoxify the AFB1 ingested.

An experiment was performed with the objective to analyze the quantity of AFB1 and AFM1 that can be present in chicken breast by a mean of transference and biotransference after 28 days of be ingested in a contaminated diet with AFB1. Forty-two chicken one-day-age Ross 308 broiler males were used, divided in two treatments. Diets were identified: T1, negative control without AFB1, and T2, positive control with 1000 ppb of AFB1; confirmation of the toxin concentration in feed was done by UHPLC-FLD. At the end of assay (28 days) twenty four chickens were killed for extract the chicken breast to analyze the concentration of AFB1 and AFM1. The following result was obtained: AFM1 in chicken breast were detected in a range of 1 – 5 ppt, and AFB1 between 3 - 24 ppt. The mean of feed consumed for treatment T2 was 2.8 kg, and 2 800 µg of toxin according with the results of diet analysis. The biotransference from AFB1 like AFM1 to breast chicken in 28 days in this study was 500,000:1 and the transference of AFB1 from feed to AFB1 in chicken breast was 83,000:1. According with this result, the chicken breast like food is considered “safe food” because it doesn’t have residues of aflatoxin B1 and M1 in highest levels. All the analysis of the presence and quantification of AFM1 were performed by UHPLC-FLD.

Key Words: Aflatoxin B1, Aflatoxin M1, chicken breast, biotransference, UHPLC-FLD

P205 Effect of 2- nitroethanol and 2- nitropropanol on the colonization and ileal immune gene expression in White Leghorns after challenge with Salmonella Enteritidis Pratima Adhikari*^{GS1}, Douglas Cosby², Nelson Cox², Woo Kyun Kim³ ¹*Department of Poultry Science, University of Georgia;* ²*USDA, ARS, The U.S. National Poultry Research Center;* ³*University of Georgia, Department of Poultry Science*

Foodborne disease caused by *Salmonella* Enteritidis is a significant public health and economic concern. Several dietary interventions have been investigated in broilers and/or layers to reduce *Salmonella* colonization, particularly in internal organs. Our study was designed using white leghorns to determine the effect of 2-nitroethanol (NE) or 2-nitropropanol (NP) on the colonization of internal organs and immune gene expression in the ileum of the hens. Thirty-six hens were orally gavaged with approximately 10⁸cfu/mL of nalidixic acid resistant *Salmonella* Enteritidis (SE^{NAR}). Hens were housed in individual, wire laying cages and randomly assigned to 6 dietary treatments: T1 – no challenge, no nitrocompounds (negative control – NC); T2 – SE^{NAR} challenge with no NE or NP (positive control – PC); T3 – SE^{NAR} challenge with 100 ppm NE; T4 – SE^{NAR} challenge with 200 ppm NE; T5 – SE^{NAR} challenge with 100 ppm NP; and T6 – SE^{NAR} challenge with 200 ppm NP. Hens were sampled 7 days post challenge. Ceca, liver with gall bladder (LGB) and ovaries were sampled for the presence of SE^{NAR}. The ileum was analyzed for immune gene expression. Dietary treatments 3 and 6 significantly lowered cecal SE^{NAR} counts (P<0.05) while treatments 4 and 5 were not different from the PC. There was no difference in SE^{NAR} counts in the LGB or ovaries due to the dietary supplementation with either NE or NP. Challenge with SE^{NAR} significantly upregulated pro and anti-inflammatory cytokine, including interferon (IFN)-γ, interleukin (IL)-1β, IL-6, toll-like receptors (TLR)-4 and IL-10 (P<0.05). A response in immune gene expression in the ileum after dietary supplementation with both NE or NP was demonstrated by reductions in IFN-γ, IL-6, TLR-4

and/or IL-10 genes. Nitrocompounds such as NE and NP can be used as an intervention strategy to reduce *Salmonella* in laying hens.

Key Words: nitroethanol, nitropropanol, hen, *Salmonella* Enteritidis

P206 A survey of Enterococcus cecorum isolates from a kinky-back affected broiler farm Evan Hutchison*, Xandra Smith, Tom Rehberger *Agro BioSciences, Inc.*

Enterococcal spondylitis (ES), commonly known as kinky-back, is an inflammatory disease in poultry caused by infection and inflammation of the avian caudal thoracic vertebrae. ES has garnered growing attention in the industry due to high mortality and loss associated with the disease in recent years. *Enterococcus cecorum* has been isolated from the spines of ES affected birds and has been identified as the causative bacterial agent *E. cecorum* is also a predominant commensal bacterium in the avian gastrointestinal tract. Previous research has indicated that virulent strains of *E. cecorum* have emerged in commercial poultry settings, which may explain the rapid increase of ES cases observed in broiler systems. To test this hypothesis, we collected *E. cecorum* isolates from the cecal contents and spines of 10 ES affected and 10 non-ES affected 42 day old birds from a southern US broiler farm suffering high ES mortality. The birds were sourced from two houses on the farm; 5 affected and 5 unaffected from the house experiencing the highest ES mortality (25.6%) and the same from the house experiencing the lowest mortality (12.8%). All *E. cecorum* isolates were screened by PCR for a set of five presumptive virulence factors and characterized using RAPD-PCR fingerprinting. Virulence screening results show that, of the factors tested, there is no single virulence factor or combination of virulence factors that correlates with *E. cecorum* isolates collected from ES affected birds or spines. Moreover, RAPD fingerprinting shows high diversity among all isolates, indicating a lack of genetic similarity. Clusters identified with greater than 95% similarity contain isolates from affected and unaffected birds and from both spine and cecal samples, preventing any distinctions to be made between virulent and commensal isolates. These results suggest that infection by *E. cecorum* may be host-associated (i.e. gut barrier integrity, immune status) and related to *E. cecorum* concentration in the gut rather than exclusively contingent on emergence of distinct virulence factors.

Key Words: *Enterococcus cecorum*, Broiler, Kinky-back, Enterococcal spondylitis, lameness

P207 Effect of Sal CURB® ASF liquid antimicrobial on Salmonella contamination in feed Dillon Mellick*, Mark Bienhoff, Sally Moore *Kemin Industries*

The effectiveness of Sal CURB® ASF liquid antimicrobial (SC) to reduce *Salmonella* in feed was evaluated in a 2x5 study design incorporating two levels of *Salmonella* (500 or 5000 CFU/g feed) and five treatment levels (1, 2, 3, 4 and 5 kg/t). A positive control (PC, feed inoculated/not treated) and a negative control (NC, feed not inoculated/not treated) were included. Feed was re-inoculated after 14 d to assess the ability of SC to maintain feed non-detectable for *Salmonella*. Samples were analyzed on d1, 3, 7 and 14 post inoculation and at two time points post re-inoculation using a standard viable plate count method. A dry *Salmonella* spp. cocktail consisting of *S. Seftenberg* (ATCC 43845), *S. Montevideo* (ATCC 8387), *S. Enteritidis* (ATCC 13076) and *S. Typhimurium* (ATCC 14028) was used as the inoculum in this study. At the inoculation level of 500 CFU/g, feed with SC at 1 kg/t was *Salmonella* (+) on d1 and 3 and was removed from the trial. Feed with SC at 2-5 kg/t was *Salmonella* (-) (<10 CFU/g) through d14. The NC was *Salmonella* (-) throughout the trial but removed on d14 due to mold growth. The PC was *Salmonella* (+) on each test day. Upon re-inoculation of the feed at 500 CFU/g, SC at 2 kg/t was *Salmonella* (+) on d15 and 17. Feed with SC at 3-5 kg/t was *Salmonella* (+) on d15 but *Salmonella* (-) on d17. At the inoculation level of 5000 CFU/g, feed with SC at 3-5 kg/t was *Salmonella* (-) on d1 and remained *Salmonella* (-) through d14. The NC was *Salmonella* (-) throughout the trial while the PC was *Salmonella* (+) on each test day. Upon re-inoculation of the feed at 5000 CFU/g, no treatment

level was able to maintain the feed *Salmonella* (-). In this study, when feed was inoculated with *Salmonella* at 500 CFU/g, SC rendered feed *Salmonella* (-) when applied at ≥ 2 kg/t however, ≥ 3 kg/t was required to maintain feed *Salmonella* (-) upon re-inoculation. When feed was inoculated with *Salmonella* at 5000 CFU/g, SC at ≥ 3 kg/t was required to render feed *Salmonella* (-). At the recommended label rate of 3.25 kg/t, SC can effectively maintain feed or feed ingredients *Salmonella* negative.

Key Words: Sal CURB, Formaldehyde, Salmonella

P208 Effect of Sal CURB® ASF liquid antimicrobial on PEDV transmission through feed Dillon Mellick^{*1}, Mark Bienhoff¹, Scott Dee²
¹Kemin Industries; ²Pipestone Applied Research, Pipestone Veterinary Clinic

The objective of the study was to determine the effective dose of a liquid antimicrobial, Sal CURB® ASF (SC) on Porcine Epidemic Diarrhea Virus (PEDV) in feed. SC is used to control *Salmonella* contamination in feed. Three levels of SC in complete feed (0.75, 1.5 or 3.25 kg/t) along with a negative control (NC, no SC or inoculation) were analyzed using a 16 day swine bioassay. Feed (45 kg) was treated with SC using a drum mixer. Following treatment, feed was placed into the feed hopper and inoculated with PEDV (100,000 FFU/mL) on d1, 3, 5, 8 and 10. Daily, clinical obser-

vations and rectal swabs for PCR were collected. Samples were collected from the feed hopper on d2, 4, 9, 11 and 12 for analysis by virus isolation. At the completion of the trial, pigs were euthanized and underwent necropsy. Treatments containing SC included 5 pigs/treatment, while the NC contained 2 pigs. Rectal swabs and clinical observations indicated pigs consuming NC were PEDV-negative throughout the trial. Pigs consuming 0.75 kg/t treatment became PEDV-positive on d4 (Ct=36.57 and 32.18) and lesions at necropsy indicated acute atrophic enteritis. Feed samples were PEDV-positive on d2, 4, 9, 11 and 12 (10,000, 10,000, 5,000, 10,000 and 2,560 FFU/mL respectively). Pigs consuming 1.5 kg/t treatment remained PEDV-negative until d12 (Ct=36.4) and lesions at necropsy indicated subacute atrophic enteritis. Feed samples were PEDV-negative until d11 and 12 (10,000 and 5,000 FFU/mL respectively). Pigs consuming 3.25 kg/t treatment remained PEDV-negative throughout the trial and exhibited normal intestinal morphology at necropsy. Feed samples remained PEDV-negative (<40 FFU/mL) throughout the trial. SC at the label rate of 3.25 kg/t was required to prevent transmission of clinical PEDV through feed. The 1.5 kg/t treatment held off viral challenge until d12 and upon necropsy a subacute infection was observed compared to the acute infection observed in the 0.75 kg/t treatment. The 0.75 kg/t treatment did not prevent clinical PEDV.

Key Words: PEDV, Formaldehyde, Feed, Antimicrobial

SCAD

P209 Presence of Gallibacterium anatis in respiratory tract of chicken flocks in Jordan Saad Gharaibeh^{*}, Mohammad Al-Natour, Nasr Jalboush
Jordan University of Science and Technology

Gallibacterium spp. is a new genus of the family Pasteurellaceae. These Gram-negative rods bacteria are considered as normal flora of the upper respiratory, reproductive, and digestive system, in different types of domestic and wild birds. They are also considered as opportunistic pathogens that were isolated from birds with pathological lesions or conditions. The objective of this study is to document the presence and to estimate the prevalence of *Gallibacterium anatis* in different types of chicken flocks by culture and serological techniques. Chickens from 50 broiler flocks were all negative by bacterial isolation except for one positive flock (2%), whereas 100% of the broiler-breeder, 66.7% of the layer pullets and 100% in production layer flocks were positive. All positively cultured isolates were confirmed to be *G. anatis* by specific PCR assay. According to ELISA results, all tested layer flocks were positive for the 3 biogroups except 2 layer flocks aged 8 weeks were negative to biogroup 4, whereas in broiler flocks 64.4% were positive for any of the 3 biogroups. In conclusion, it appeared that hemolytic *Gallibacterium* spp. is widely distributed in commercial chicken flocks in Jordan. Results showed that presence of *G. anatis* is influenced by age of the chicken flocks tested. It was isolated only from chickens older than 5 weeks of age and all chickens above 8 weeks of age were positive by isolation and serology. Further studies are recommended to compare the prevalence of the bacteria in healthy flocks and flocks suffering from decrease in egg production, respiratory, and reproductive diseases. Also *in vivo* studies should be carried out to investigate the pathogenicity of the acquired isolates in broiler, layer, and broiler-breeder chickens.

Key Words: Gallibacterium anatis, chicken, Jordan

P210 The antibody-guided vaccine delivery method provides full protection against H5N1 challenge. Christine Vuong^{*1}, Wen-Ko Chou¹, Whitney Briggs², Amanda Wolfenden³, Olivia Faulkner³, Melina Jonas⁴, Darrell Kapeczynski⁵, Billy Hargis³, Lisa Bielke², Luc Berghman¹
¹Texas A&M University; ²Ohio State University; ³University of Arkansas; ⁴Medion Vaccine Company; ⁵United States Department of Agriculture

Antibody-guided vaccine delivery has been previously examined in poultry, characterized by vaccine targeting to the CD40-receptor expressed on all professional antigen presenting cells to provide direct delivery of

vaccine targets to the immune system. Previous assessment of this system in poultry has been limited to delivery of synthetic peptide epitopes and measuring induced immunogenicity, which demonstrated increased serum IgG and tracheal IgA levels in vaccinated birds within one week of vaccine administration. In this study, the antibody-guided vaccine model was modified to allow binding of a whole pathogen in lieu of a short synthetic peptide. Avian influenza virus (AIV) was chosen as the pathogen target due to its single-factorial disease causation and well-defined benchmark for functional protection (survival past 4 days post-challenge). Initial immunogenicity studies using the AIV-loaded antibody-guided vaccine showed statistically higher hemagglutination inhibition (HI) titers compared to traditional oil-emulsion based AIV vaccines. Further analysis of the AIV-loaded guided vaccine revealed subcutaneous administration was able to induce sustained HI titers up to 4-weeks post-vaccination. When tested for functional protection, the subcutaneously-administered vaccine was able to provide 64% survival after highly pathogenic H5N1 AIV challenge; and if boosted, 100% survival. Data from this study demonstrates the antibody-guided system can be loaded with whole pathogen, avoiding the need to purify and identify specific protective epitopes, while also successfully providing proof of protection.

Key Words: antibody-guided, vaccine, avian influenza, protection

P211 Comparison of the application of coccidia vaccines by gel and spray Laura Tensa^{*GS}, Grace Albanese, Brian Jordan
University of Georgia

Coccidiosis is an enteric disease of economic significance in commercial poultry. Clinical disease in poultry is caused by parasitic protozoa of the *Eimeria* spp. Coccidia vaccines have typically been administered via spray cabinet in day old chicks, however a new gel based delivery system has recently been introduced to the poultry production market. The gel delivery system is designed to increase the number of oocysts ingested by the chick by increasing the time that the gel vaccine droplets remains on the chick, thus elongating the preening time. Previous research in our laboratory has shown that there was no difference in oocyst shedding numbers when chicks were vaccinated with the same coccidia vaccine that was applied by either gel or spray, but the actual application parameters were not evaluated. The purpose of this trial was to evaluate the application properties of both gel and spray as they relate to coccidia vaccination, using a high oocyst dose by spray vaccine and a low oocyst dose by gel. Initially,

each vaccine was mixed as per the manufacturer's instructions and samples were collected from different levels in the mixture over time to determine how well the oocysts remained in suspension. Since the spray based vaccine is typically aerated, a comparison was made between using aeration to continually mix the vaccine and not mixing. The second portion of the experiment was to assess vaccine application. Application patterns for both methods were evaluated, the size and number of droplets applied onto a plexiglass sheet on top of a chick basket were counted, droplets of each obtainable size were collected, and oocyst enumeration and speciation was performed. Results show that no settling occurs in either the spray or gel based delivery systems if they are mixed according to the manufacturer's instructions. There were no differences in oocyst delivery from front to back or side to side for either delivery system. As expected, the number of oocysts per droplet increased as droplet size of the spray administration increased, but stayed constant in the gel administration since the gel droplets were of uniform size. Taken together, this data will aid poultry producers in deciding which vaccine application method will work best in their production system.

Key Words: Coccidia, Vaccination

P212 Examination of binding properties of Arkansas-type spike proteins to chicken tissues Christina Leyson*, Mark Jackwood, Brian Jordan *University of Georgia*

Infectious bronchitis virus (IBV) is an economically important respiratory pathogen in commercial poultry. Despite extensive vaccination in the United States, the Arkansas-type (Ark) IBV has been the most commonly isolated serotype from diagnostic cases. A live-attenuated vaccine called Arkansas 99 (Ark99) was initially used in the 1980s to protect against Ark-type IBV. While Ark99 exhibited good replication and protection in vaccinated birds, harsh vaccine reactions were observed upon its application. Another vaccine called ArkDPI (Arkansas Delmarva Poultry Industry) was thus developed. ArkDPI is the only Ark vaccine in the market today. However, field applications of ArkDPI have shown that ArkDPI vaccine exhibits poor replication in birds. This lead to low vaccine coverage and to limited protection for the flock. One hypothesis to explain poor replication of ArkDPI in birds is that its virions cannot attach efficiently to chicken tracheal cells. Specifically, this hypothesis purports that the attachment protein of IBV namely, the S1 spike protein, does not bind well to tracheal cells. Indeed, examination of the ArkDPI vaccine S1 spike protein binding onto chicken tissues have shown that the vaccinal ArkDPI S1 spike does not bind well to chicken tracheal tissue. Moreover, a particular amino acid change is necessary to observe appreciable binding to tracheal tissue. For this study, we propose that Ark99 vaccine is able to enter host cells more efficiently than ArkDPI vaccine since the Ark99 vaccine S1 spike protein is able to bind more strongly to chicken tracheal tissue. To this end, we cloned, expressed, and purified recombinant S1 spike proteins from Ark99

and ArkDPI vaccine strains. The recombinant S1 spike proteins were used as reagents for protein histochemistry on chicken tracheal tissues, and the binding of Ark99 and ArkDPI S1 spike to tracheal tissue was compared. Analysis of the binding properties of the S1 spike protein to chicken tissues is important since attachment to the host cell is the first step in infection and critical for vaccine efficacy.

Key Words: Infectious bronchitis virus, IBV, Ark99, ArkDPI, S1 spike

P213 Characterization of an IBV-like Coronavirus causing RSS in broiler chickens Sabrina Ramos*, Rudiger Hauck, H.L. Shivaprasad, Rodrigo Gallardo *University of California, Davis*

Runting Stunting Syndrome (RSS) is a disease condition that affects broilers and causes impaired growth and poor feed conversion due to enteritis characterized by pale and distended small intestines with watery contents. The etiology of the disease is multifactorial and a large variety of viral agents have been implicated. Prior to these experiments we isolated an infectious bronchitis virus -like coronavirus (IBV-ent.) from the intestines of 14 days-old Brown/Red broiler chicks. The birds showed typical clinical signs of RSS including stunting and uneven growth. The results of a first infection study suggested a broader tissue tropism of this isolate. In this project we attempted to determine the intestinal tropism of this coronavirus in commercial broiler chickens. For that we created 5 different broiler chicken groups (n=20) G1: IBV-ent. inoculated into the crop, G2: IBV-M41 inoculated into the crop, G3: IBV-ent. inoculated via oculo-nasal route, G4: IBV-M41 inoculated via oculo-nasal route and finally an uninfected control. Tears and cloacal swabs were collected for viral load measurements at 1, 2, 4, 6, 10 and 14 days post infection (dpi). Tissues such as trachea and intestines were collected for histopathology and immune histochemistry from 5 chickens per group at the same days post infection. Respiratory signs were assessed at 4, 6, 10 and 14 dpi. Finally, blood was collected at 14dpi for humoral response evaluation.

Preliminary results show that viruses, IBV-ent and M41, inoculated via oculo-nasal route have a higher viral load in tears ($p<0.05$) 1dpi compared with viruses that are inoculated via crop. At 2, 4, 6 and 10 dpi higher IBV loads in tears are detected in both IBV-M41 groups disregarding the route of inoculation ($p<0.05$). The IBV-ent. virus showed higher viral loads in the cloaca compared to the tears starting at 2 dpi and very clearly so 14 dpi ($p>0.05$). Respiratory signs assessments showed significant differences between IBV-M41 inoculated oculo-nasally showing the highest level of respiratory sounds compared with IBV-ent via crop showing almost no respiratory signs at 4, 6, 10 and 14dpi.

With these preliminary results we can conclude that IBV-ent. shows enteric tropism.

Key Words: IBV, Tissue tropism, Broilers

Physiology, Reproduction and Endocrinology

P214 Lipid production and adipogenic gene expression between 18 day embryo livers of ACRB and COBB Haein Kim*, Chongxiao Chen², Paula Sedlacek², Woo Kyun Kim² *¹North Oconee High School; ²University of Georgia*

Excess fat deposits in broilers reduces the meat yield and feed efficiency, which are concerns for the poultry industry. Because there is a greater amount of fat accumulation in the body of commercial chickens selected for fast growth than in the body of unselected chickens, the objectives of this study were 1) to compare lipid production in 18 day embryo livers of Athens Canadian Random Breed (ACRB) and COBB and 2) to investigate if the expression of key adipogenic genes was greater in COBB chickens starting from the embryogenic period. Liver samples were collected from 18day embryos of ACRB and COBB for hepatocyte culture, histochemistry and adipogenic gene expression. The expression of key adipogenic

genes, such as Peroxisome Proliferator Activated Receptor-gamma (PPAR-gamma), fatty acid synthase (FAS), fatty acid binding protein 4 (FABP4), was detected by quantitative RT-PCR between the 18 day old embryo livers of ACRB and COBB to compare the amount of expression of the genes. Gene expression data showed that in the liver cells from the 18 day embryo of COBB and ACRB, the mRNA expression of FAS (key enzyme for fatty acid biosynthesis in the liver) in the COBB liver was seven times greater than in the ACRB liver during the embryogenic period, indicating that one of the major factors for fat accumulation in COBB would be the production of higher hepatic fatty acids in the liver. However, there were no significant differences in PPAR-gamma and FABP4 mRNA expression. In addition, hepatocyte culture showed higher lipid accumulation in the cells from COBB than in those from ACRB, whereas the liver histochemical analyses did not show considerable differences in fat accumulation in the livers of ACRB and COBB at the 18-day embryonic stage, indicating that the liver

appears to have limited capacity to accumulate lipid and export excess fatty acids to other organs through blood stream. In conclusion, there is a need for reducing excess lipid production in chickens selected for fast growth, bred specifically for human consumption, to facilitate the production of broilers with the high meat quality and yield. Overproduction of fatty acids in the liver may cause COBB chickens to produce excess lipids in other parts of the body, including the muscle.

Key Words: ACRB, COBB, Fatty Acid Synthase, Hepatocyte, lipid production

P215 Variation in growth and efficiency among Pekin Duck strains Chelsea Phillips^{*1}, Zachary Lowman¹, Gavin Hitchener² ¹*North Carolina State University*; ²*Cornell University Duck Research Laboratory*

The United States duck industry began on Long Island, NY in 1886 with 67 individuals imported from Asia. Since that time significant advances have resulted in 26 million birds processed annually. The purpose of this trial was to highlight areas for future selection programs by analyzing different phenotypes in three duck strains: an Asian strain (AS), American strain (AM), and an unselected Long Island strain (LI). The eggs used for this study were obtained from similar aged breeder flocks from each source and were all incubated in the same incubator. At hatch, straight run ducklings from each strain (n=216 per strain) were sorted and grown in 24 randomly distributed floor pens (n= 8/strain). Pen dimensions were 5.5ft x 16ft providing 3.26 ft² per duckling. Feed consumption and body weights were recorded weekly by pen. When the birds reached 39 days, two birds per pen (n=16/strain) were randomly selected, and processed. All data was analyzed using the one-way ANOVA function of JMP 12 with a threshold of p≤0.05. Significant differences were observed in 39d body weight, breast size, fat composition, and feed conversion ratio (FCR). The AM strain had the lowest mean body weight (6.20lb) yet the largest mean breast weight (0.93lb), the lowest fat composition (0.22lbs), and the lowest FCR (2.01). The LI strain had a similar body weight compared with AM line, but with a significantly smaller mean breast weight (0.66lb), increased fat composition (0.26lbs), and significantly poorer FCR (2.43). The AS strain had the highest mean body weight (6.81lb), an intermediate mean breast weight

(0.85lb), the highest fat composition (0.35lbs), and the highest FCR (2.47). Although the duck industry is selecting for fast growth, greater muscle yield, and improved FCR, continued progress depends on prudent selection for these traits without co-selecting for unintended consequences.

Key Words: Pekin, phenotypes, FCR, body weight, fat composition

P216 Effect of autophagy on feed efficiency in two avian species Alissa Piekarski-Welsher^{*}, Elizabeth Greene, Kentu Lassiter, Alex Gilley, Nicholas Anthony, Byung-Whi Kong, Sami Dridi, Walter Bottje *University of Arkansas*

Feed Efficiency (FE) is a very important genetic trait in poultry and livestock that can be negatively impacted by stress of any kind. Preliminary data from this laboratory indicates that autophagy expression of several genes (AMPKα1, mTOR, Atg16L1, and Atg7) were upregulated in breast muscle of pedigree male broilers exhibiting a high FE phenotype compared to ones exhibiting low FE. This suggests that part of the cellular basis of FE may hinge on the ability of the cell to maintain optimal functionality by a more active endogenous repair system offered by the autophagy pathway. Furthermore, using two experimental Japanese quail lines selected for low FE or high FE phenotypes it was found that the expression of several autophagy-related genes were increased in the low FE line of 30 wk old quail with expression in the high FE group showing significant increases in only two genes (mTOR and Atg3). This suggests that there may be a difference in the pathway between poultry species as well as a possible age effect (autophagy is known to have a decrease in activity as an organism ages). This increase in mTOR would essentially block the autophagy pathway which is seen by the decrease in expression of all subsequent autophagy genes. Since autophagy has been shown to play a key role in stress (such as starvation), as well as fat metabolism, the differential expression of autophagy-related genes between the lines indicated that these birds, as well as future studies with stress resistant and susceptible quail, would be a very useful model to study the differences between low FE and high FE animals giving us greater insight into autophagy and feed efficiency.

Key Words: Autophagy, Feed efficiency, Broiler, Quail

Environment Management

P217 Gait score and latency to lie correlation in broilers supplemented with organic and inorganic minerals Iane Almeida^{*1}, Ibiara Almeida Paz¹, Jose Roberto Sartori¹, Grace Baldo¹, Alba Fireman², Edivaldo Garcia¹, Andrea Molino³, Caio Ouros¹, Jessica Cruvinel¹, Marcel Contin⁴ ¹*UNESP - FMVZ*; ²*Zinpro Animal Nutrition*; ³*USP*; ⁴*FATEC*

The aim of this study was correlated two welfare assessment methodologies in broilers, gait score (GS) and latency to lie (LTL). For this, were used 2835 male chicks one day old of the Cobb 500 strain, equally distributed in the treatments. The experimental design was a randomized blocks with five treatments (T1: control, T2: 40 ppm of Zn, 80 ppm Mn and 10 ppm inorganic Cu + 40 ppm Zn organic between 1-42 days; T3: 80 ppm Mn and 10 ppm inorganic Cu + 40 ppm Zn Organic from 1 to 42 days; T4: 40 ppm Zn, 40 ppm of Mn and 7 ppm Cu organic between 1 and 21 days and 40 ppm Zn, 80 ppm of Mn and 10ppm inorganic Cu + organic Zn 40ppm between 22 to 42 days; T5 = 40 ppm Zn, 40 ppm of Mn and 7 ppm Cu organic between 1 and 21 days and 80 ppm Mn and 10ppm inorganic Cu + 40 ppm Zn organic between 22 to 42 days) and 9 repetitions with 63 birds each. When the broilers reached an average weight of 2.8 kg were evaluated for gait score and latency to lie. That are, respectively, the walking ability and the length of time that birds remained standing in shallow water and, after, this methodologies were compared and correlated. The GS was based on subjective observations of the way in which birds walk for a distance of 1 linear meter, delimited within the pens. All birds were evaluated. The scores ranging from 0 to 5, with score 0 - animal walking normally - more than 10 uninterrupted steps and 5 - the birds did not walk when standing.

The LTL assessment the length of time that birds remained standing when exposed an unusual and uncomfortable situation. For this, was added water into a plastic box to an average depth of 3 cm, and were allocated six broilers at a time. A digital stopwatch was used. As soon as any bird lay down it was removed, even if it stood up again, and the time since the stopwatch had been started was recorded. The test was finalized after 600s. The data were analyzed using the statistical program SAS 9.2. There was a mean (p<0,0001) correlation between the birds gait scores and their latency to lie down (-0.6408) for spearman correlation. Thus, the LTL for GS substitution is practicable. The gait score (p=0.6848) and latency to lie (p=0.4946) were not affected by treatments, maybe because was stipulated that the weights would be the same for all birds. (FAPESP PROC 2016/04613-5)

Key Words: walking ability, animal production

P218 Gait score in broilers fed with different nutritional plans Grace Baldo^{*}, Ibiara Almeida Paz, Iane Almeida, Edivaldo Garcia, Andrea Molino, Tatiane Vincunas, Andressa Montenegro, Jessica Cruvinel, Ricardo Santos *UNESP - FMVZ*

The aim of this study was assessment the gait score, in two ages of broilers subjected to different nutritional plans. For this, were used 2400 male chicks one day old of two commercial strains, equally distributed in the treatments. The experimental design was a randomized blocks in a 2x3 factorial arrangement (Cobb 500 and Ross AP95 strains and requirements for regular, medium or higher performance). The nutritional levels was, pre-starter (1-7d) 2925kcal ME and 22% CP, starter (8-21d) 2980 kcal ME

and 20% CP, grower (22-35d) 3050 kcal ME and 19% CP, finisher (36-42d) 3100 kcal ME and 17.80% CP for regular performance; pre-starter (1-7d) 2950kcal ME and 22.20% CP, starter (8-21d) 3000 kcal ME and 20.80% CP, grower (22-35d) 3100 kcal ME and 19.50% CP, finisher (36-42d) 3150 kcal ME and 18% CP for medium performance; and pre-starter (1-7d) 2960kcal ME and 22.40% CP, starter (8-21d) 3050 kcal ME and 21.20% CP, grower (22-35d) 3150 kcal ME and 19.80% CP, finisher (36-42d) 3200 kcal ME and 18.40% CP for higher performance. The gait score was evaluated to 34 and 41 days of breeding in 200 birds/treatment (4 repetitions/treatment) and was based on subjective observations of the way in which birds walk for a distance of 1 linear meter, delimited within the pens. The scores ranging from 0 to 2, with score 0 - animal walking normally - more than 10 uninterrupted steps, 1 - animal that walked with some difficulty and - between six and ten steps, 2 - animal that walked with much difficulty - less than six steps or the birds did not walk when standing. The data were analyzed using the statistical program SAS 9.2 and the frequencies compared by Chi-quadrado test ($p < 0.05$). For the Cobb 500 strain the attendance of gait score 1 was higher at 34 and 41 days of breeding ($p = 0.0077$ e $p = 0.0053$; respectively). The nutritional plans not influenced the gait score incidence at 34 ($p = 0.7872$) e and 41 days of breeding ($p = 0.7872$). In conclusion, the broilers of Cobb 500 strain walking better and the feed energy levels not affected the gait score. (FAPESP PROC 2015/12774-6 and 2015/19225-8)

Key Words: welfare, alking ability, energy levels, poultry

P219 Metabolic disorders and organs weight correlations in broilers Grace Baldo^{*1}, Ibiara Almeida Paz¹, Iane Almeida¹, Edivaldo Garcia¹, Andrea Molino¹, Caio Ouros¹, Marcel Contin², Bruno Gilli¹, Ana Carolina Rocha¹ ¹UNESP - FMVZ; ²FATEC

The objective of this study was correlated metabolic disorders such as ascites and sudden death syndrome with the organ weight of broilers. For this, were used 2400 male chicks one day old, 1200 of Cobb 500 strain and 1200 of Ross AP95 strain. The birds, were housed in experimental broiler house and equally distributed in the treatments. The experimental design was a randomized blocks. The death birds were weight and macroscopically evaluated for aspect, then necropsied and the death cause was recorded. The sudden death syndrome, was diagnosed when the death broilers were found in supine with one or both legs contracted and had good body condition, intestinal tract with food, enlarged heart and/or congested lung. The ascites was diagnosed when the broilers showed good body condition, but congested mucosa, cyanotic and fluid in the pericardial and/or abdominal cavity. Moreover, the birds heart, liver and lungs were removed and weighed. The data were analyzed using the statistical program SAS 9.2., there was no difference for strain, then the data were pooled for show the results. Were used the Spearman test ($p < 0.0001$) to establish the correlations. There was no correlation ($p = 0.7131$) between, ascites and sudden death syndrome, and broilers weight, heart weight ($p = 0.1199$), liver ($p = 0.4432$) and lungs ($p = 0.6566$). However, the body weight was highly correlated with the heart weight (0.90), liver (0.92) and lungs (0.95). In the organs weight correlations, was observed that the heart weight was highly correlated with the lung weight (0.81) and the liver weight (0.88). Therefore, in conclusion, in this study the ascites and/or sudden death syndrome did not changes in heart, liver and lung weight. The organs weight were associated, probably, because their functions are directly linked. (FAPESP PROC 2015/12774-6 and 2015/19225-8)

Key Words: sudden death syndrome, ascites, poultry

P220 Performance of commercial broilers strain subjected to different nutritional plans Ibiara Almeida Paz^{*1}, Grace Baldo¹, Iane Almeida¹, Edivaldo Garcia¹, Andrea Molino², Caio Ouros¹, Marcel Contin³, Jessica Cruvinel¹, Tatiane Vicunas¹, Bruno Gilli¹ ¹UNESP - FMVZ; ²USP; ³FATEC

The aim of this study was assessment the performance of broilers subjected to different nutritional plans. For this, were used 2400 male chicks one day old of two commercial strains, equally distributed in the treatments.

The experimental design was a randomized blocks in a 2x3 factorial arrangement (Cobb 500 and Ross 308 strains and requirements for regular, medium or higher performance). The nutritional levels was, pre-starter (1-7d) 2925kcal ME and 22% CP, starter (8-21d) 2980 kcal ME and 20% CP, grower (22-35d) 3050 kcal ME and 19% CP, finisher (36-42d) 3100 kcal ME and 17.80% CP for regular performance; pre-starter (1-7d) 2950kcal ME and 22.20% CP, starter (8-21d) 3000 kcal ME and 20.80% CP, grower (22-35d) 3100 kcal ME and 19.50% CP, finisher (36-42d) 3150 kcal ME and 18% CP for medium performance; and pre-starter (1-7d) 2960kcal ME and 22.40% CP, starter (8-21d) 3050 kcal ME and 21.20% CP, grower (22-35d) 3150 kcal ME and 19.80% CP, finisher (36-42d) 3200 kcal ME and 18.40% CP for higher performance. The Performance was evaluated by feed intake, weight gain, feed conversion ratio, viability and production efficiency factor. After 36 and 43 days of housed 144 birds (three birds/treatment/repetition) were slaughtered. The carcass and cuts were weighted and the yield was calculated. The data were analyzed using the statistical program SAS 9.2. The performance of Ross AP95 strain was higher of Cobb 500 strain. The carcass and cuts yield were not affected by strain and nutritional plans, for both housed phases. As, the regular, medium and higher performance nutritional plans to offers growing energy levels, can use requirements for regular performance and get the same results that the others. The treatments with higher energy levels, independently of strain showed higher number of cull birds. In conclusion, the Ross AP95 strain comparing to Cobb 500 strain showed the higher productive characteristics. Nutritional plan for regular performance can be recommended, because improve the feed conversion ratio and no difference of the others for carcass and cuts yield. (FAPESP PROC 2015/19225-8 and 2015/12774-6)

Key Words: Animal production, carcass yield

P221 Metabolic disorders of two commercial broilers strains subjected to three nutritional plans Ibiara Almeida Paz^{*1}, Grace Baldo¹, Iane Almeida¹, Edivaldo Garcia¹, Andrea Molino¹, Caio Ouros¹, Jessica Cruvinel¹, Marcel Contin², Andressa Montenegro¹ ¹UNESP - FMVZ; ²FATEC

The aim of this study was evaluated the death incidence from metabolic disorders of broilers subjected to different nutritional plans. The nutritional levels was, pre-starter (1-7d) 2925kcal ME and 22% CP, starter (8-21d) 2980 kcal ME and 20% CP, grower (22-35d) 3050 kcal ME and 19% CP, finisher (36-42d) 3100 kcal ME and 17.80% CP for regular performance; pre-starter (1-7d) 2950kcal ME and 22.20% CP, starter (8-21d) 3000 kcal ME and 20.80% CP, grower (22-35d) 3100 kcal ME and 19.50% CP, finisher (36-42d) 3150 kcal ME and 18% CP for medium performance; and pre-starter (1-7d) 2960kcal ME and 22.40% CP, starter (8-21d) 3050 kcal ME and 21.20% CP, grower (22-35d) 3150 kcal ME and 19.80% CP, finisher (36-42d) 3200 kcal ME and 18.40% CP for higher performance. For this, were used 2400 male chicks one day old of two commercial strains, equally distributed in the treatments. The experimental design was a randomized blocks in a 2x3 factorial arrangement (Cobb 500 and Ross AP95 strains and requirements for regular, medium or higher performance). For the treatments with higher energy levels, independently of strain, the number of cull birds were higher, with 2.5% of birds showed this death cause, and the others treatment, with lower energy levels, together reached 2.2%. In these treatments, expected higher number of metabolic problem death, but this did not occur (only 0.5% of birds showed this death cause). For the Ross AP95 strain, independently of nutritional plan, the death for ascites and sudden death syndrome index or the combination for both problems were higher, with 2.62% of birds showed this death cause and 1.25% for Cobb strain. In conclusion, the nutritional plans used influenced a little the death for metabolic problems, however, improve the number of cull birds. (FAPESP PROC 2015/19225-8 and 2015/12774-6)

Key Words: Ascites, Sudden death syndrome, Animal production

P222 Chamomile as feed additive on behavior and temperature of laying Japanese quails Rodrigo Garcia*, Karine Tenório, Sarah Sgavioli, Carla Heloisa Domingues, Rodrigo Borille, Fabiana Caldara, Irenilza Naas *Universidade Federal da Grande Dourados*

Quail egg production is stressful for the birds due to rearing system. It is known that phytotherapies have properties to soothe and minimize stress in humans, therefore, this knowledge could be applied to birds. The aim of this study was evaluate the effect of herbal chamomile (*Matricaria recutita*) on quails, through analysis of the surface temperature parameters, body injury and tonic immobility. A total of 108 laying Japanese quail hens with 180 days of age were distributed in a completely randomized design, considering three treatments (0, 250 and 500 g of chamomile/kg diet) with six replicates and six birds each, evaluated in six repeated measures of time (14, 28, 42, 56, 70 and 84 days of experiment). Behavioural parameters (time of tonic immobility and body injury) and surface temperature of the birds were evaluated. After preliminary analysis, behavioural characteristics were submitted to variance analysis using SAS MIXED procedure for mixed models and in case of significance effect ($P < 0.05$), the days average were compared by Tukey test, and regression analyzes (linear and quadratic) were performed to the chamomile levels. Chamomile levels were considered fixed effects and periods were considered repeated measures. For back injuries, tail and wing frequency test was performed and means were compared using chi-square 5% of probability. Body surface temperature and amount of head injuries showed effect ($P < 0.05$) only in relation to the data collection days, with higher surface temperature on 14th day of experiment, and higher incidence of head injuries on 42th day, not differing from the 84th day. On the 14th day the birds were adapting to the environment and social hierarchy, therefore, they became agitated, resulting in a possible heat metabolic excess by homeostasis alteration. The increasing additions of chamomile in quails' diet were not able to exert effects on surface temperature, intensity of injury and tonic immobility, which does not predispose a reduction of stress.

Key Words: Coturnix coturnix japonica, body injury, infrared thermography, phytotherapies, tonic immobility

P223 Correlation analysis of core body temperature of broilers and heat index during transport in the Southeast United States Kaushik Luthra*^{GS}, Yi Liang *University of Arkansas*

Broilers experience multiple stressors during transport from farm to the processing plant. Heat stress is one of the major stressor and currently the top most concerned issue in the broiler industry of the Southeast United States. Higher "Death on Arrivals (DOA)" during summer can cause huge economical loss to the industry and also reduces the wellbeing of broilers that survive the heat. Being the largest broiler industry with the largest export in the world, it is highly essential to understand the broilers response to the micro-environment that exists on trailers during summer. In this study, we have recorded the core body temperature of a small group of broilers during transport along with temperature and humidity on the trailer. Based on the temperature and humidity, we calculated an integrated index known as Apparent Equivalent Temperature (AET). It combines the effect of temperature and humidity and allows prediction of the biological responses. Miniature temperature loggers were fed to 8 broilers the day before they were sold. They were marked with food colors for identification and were placed in a middle module on a trailer that moved around 4,000 birds for 50 minutes in the middle of a summer day. Before the slaughter of broilers instrumented birds were separated from the rest and sacrificed with the data loggers retrieved and later downloaded. Correlation analysis was performed amongst the core body temperature of each broiler with the ambient AET. The correlation coefficients varied from 0.22 ± 0.084 and 0.46 ± 0.078 which are significant at 95% confidence level. The results suggest that there is a positive linear relation between core body temperature of broilers during transport and on-board temperature/humidity conditions. This indicates that as the temperature/humidity increases there is an increase in the core body temperature of broilers. The lower values of correlation coefficients

show the presence of multiple stressors during transport which can intensify the heat stress on broilers. Some factors such as wetting of broilers, use of blast fans to blow the wind just before the transport can have a conducive effect. Additional research under better controlled environment is needed to pinpoint the effect of different management practices on the homeostatic effort of broilers.

Key Words: broiler transportation, core body temperature, heat stress, heat index, micro-environment

P224 Bacterial litter amendments to control ammonia Brittany Singh*^{GS}, James Krehling, Elle Chadwick, Bradley Schrader, Kenneth Macklin *Auburn University*

Ammonia volatilization from poultry litter often causes high levels of atmospheric ammonia in poultry houses, which is detrimental to both farm workers and birds. Microbial litter amendments were analyzed to determine their effectiveness in reducing ammonia volatilization. Litter obtained for this trial had been previously used as bedding for broiler studies at the Auburn University Research Farm. The six treatments consisted of Product A(A) and Product B(B) individually across high and low concentrations, sodium bisulfate (BS), and a control. Each treatment was performed in triplicate, resulting in eighteen total plastic boxes. A total of 3.0 kg of activated poultry litter was placed into each plastic box. This litter had been activated three days prior to the initiation of the trial by the addition of water, to obtain a moisture content of 30-35%. Ammonia measurements were determined using a Drager CMS Analyzer equipped with a remote air sampling pump, as a closed container was inverted over the litter bed. Litter samples were collected before the application of treatments on day 1 and then again on days 4-8. For each sample taken litter pH and litter moisture was determined. Data was analyzed using GLM and when appropriate ($P < 0.05$) Tukeys HSD using SPSS. The results showed there was no difference in regards to pH among the four tested products; however, there was a significant difference in pH between the products and BS. No detectable litter moisture difference was observed on days 5-8 for any of the samples. Throughout the trial, BS significantly reduced ammonia compared to the tested products except on days 5 (B) and day 8 (A). For both A and B, it was the lower application rate that produced the greatest reduction in ammonia, either early or late in the trial. Ammonia levels were reduced the first two days with product B; however, on days 4 and 5 of the trial, product A had shown promise as being able to control ammonia, potentially for a long duration.

Key Words: Ammonia, Litter

P225 Economic Assessment of a Highly Pathogenic Avian Influenza Outbreak in Washington and Benton Counties in Arkansas Antonio Beitia*^{GS}, Karen Christensen, Lawton Nalley, Grant West, Jordan Weil, Christopher Sims, Fred Clark, Harold Goodwin *University of Arkansas*

Highly Pathogenic Avian Influenza (HPAI) presents substantial risk to the poultry growing industry. Domestic fowl contract HPAI primarily through contact with migratory fowl, and outbreaks can inflict remarkable economic losses on growers and the poultry industry at large. HPAI outbreaks in 2014 and 2015 caused an estimated \$1.6 billion in losses (CDC 2016) and led to poultry shortages and rising prices (Anni et al. 2005). Even acute outbreaks of HPAI inflict substantial damages as USDA-APHIS guidelines necessitate a 10-km quarantine and cull. Previous literature evaluates economic damages from AI predominantly using case studies of past outbreaks, but appropriate consideration of potential monetary losses resulting from HPAI outbreaks in critical industry regions has been given less attention. We assess economic damages to the grower, poultry company, and government resulting from an HPAI outbreak across spatially-explicit chicken house locations in the high-value poultry growing region of Washington and Benton counties in Arkansas. With a simulation model built using Statistical Analysis System (SAS 9.4), we assign poultry operation types (Broilers, Breeders, Layers, Pullets, and Turkeys) to facilities using discrete non-uniform probabilities from known county-level poultry type distributions

reported by USDA. A single facility is randomly infected with HPAI, and houses within the cull zone are identified based on a distance matrix calculated in a GIS (ArcGIS for Desktop 10.4). The value of economic damages is determined using mean bird values with respect to lifecycle. Because the total damages and number of impacted houses depends on house types and the location of the initial infection, we simulate the model 1000 times to account for random spatial variability. Results show that on average, 395 poultry houses are impacted by an infection in Benton or Washington county, including Broiler (293), Pullet (17), Breeder (43), Layer (4), and Turkey (38) houses. The greatest economic losses are incurred by the government (\$134.4 million) through indemnity payments while the poultry company (\$36.7 million) and grower (\$3.0 million) incur opportunity costs from quarantine time.

Key Words: avian influenza, disease outbreak, economic effect, poultry production

P226 Water Quality Laboratory: Providing the poultry industry with assistance for evaluating drinking water Samantha Cox^{*GS}, Susan Watkins *University of Arkansas*

Water is the single most important nutrient poultry consume. However, its value as a nutrient is often overlooked because 1) the economic value of water used in production is not as easy to determine as feed ingredients and 2) the cost of water is reflected as a farm not nutrition expense. Feed ingredients such as corn, soybean meal and fat undergo rigorous quality assurance programs but the quality of water supplies on many farms remains unknown. Nutrients in the water can impact performance either by oversupplying the birds requirements (sodium and chloride >200 ppm) or through promoting microbial growth which impairs digestibility and health (iron and manganese, any level) or by restricting flow (calcium and magnesium >40-60 ppm). Due to changing production strategies such as no antibiotics ever (NAE), the industry is giving water quality more consideration to help assure bird performance is not compromised. The goal of the Water Quality Lab is to provide the poultry industry with water testing protocols, as well as a low cost analysis for minerals, pH, bacteria, yeast and mold and then tools for interpreting the results. Over 5,000 water analysis have been conducted in the last 3 years and an analysis of these indicate that microbial contamination in the well is not a significant challenge but water microbial quality does consistently deteriorate after it leaves the source if no sanitizer is present.

In the past year, 334 water samples from poultry farms were analyzed for pH and mineral content. The following are max, min and mean values for keys contaminants in parts per million (ppm): Sodium- 1,253, 0, 46.6; Iron- 16.2, 0, .71; Manganese- 5.82, 0, .14; Calcium- 149.9, 0, 35.6; Magnesium- 79.7, 0, 12.8; Sulfur; 67.9, .01, 6.7. This analysis shows poultry farm source water can have a pH mean of 7.7 and a range of 5.45 to 9.7. In conclusion, these results show that water supplies can have variable mineral content which may need to be addressed in order to optimize bird performance.

Key Words: water, quality, minerals, microbial, poultry

P227 Incidence estimation of foot pad dermatitis in broiler chickens reared in two different systems Nilsa Lima^{*3}, Rodrigo Garcia², Beatriz Roriz², Irenilza Nääs¹, Cristina Ayala², Sarah Sgavioli², Flavia Jacob¹, Marta Baracho² *¹University of Campinas; ²Federal University of Grande Dourados; ³Universidade Estadual de Campinas*

The aim of this research was to evaluate the incidence of lesions in the footpad of broiler on different ages and two broiler houses with tunnel ventilation system. In this study, we evaluated the footpad of broiler by infrared thermography, the quality of litter: moisture, pH and temperature, and the environmental conditions (temperature and humidity) of the facility. The statistic analysis was made by completely randomized design to the litter quality using double factorial 2x4 (2 broiler house: dark-house and tunnel and 4 birds' ages: 21, 28, 35 and 42 days old) with 12 repetitions. The same design was used to thermal conditions by double factorial 2x4 (2 broiler

house: dark-house and tunnel and 4 birds' ages: 21, 28, 35 and 42 days old) with 4 repetitions. The statistic analysis of surface temperature of footpad was completely randomized in a double factorial 2x2 (2 broiler house: dark-house and tunnel and 2 sex: male and female) with 15 repetitions. The footpad analysis was calculated by the incidence of lesions on footpad to evaluate the probability, risk ratio and odds ratio using Fisher Exact Test. Tukey test was used to mean comparisons between factors (5% of significance level). Birds with 28 days old reared in dark-house presented higher surface temperatures on footpad of right leg (mean = 31.20 °C) than the birds raised in tunnel systems (mean= 30.24 °C). Likewise, the left leg present superficial temperature of footpad higher in dark-house (31.68 °C) than the tunnel systems (30.11 °C). At 35 days old of birds, the surface temperature mean of surface temperature of bird's footpad reared in the dark-house system presents the lower left cushion (29.48 °C) compared to the birds of the tunnel system (30.56 °C). At 42 days old of birds, the male bird's present footpad surface temperatures (34.52 °C) higher than females (32.49 °C) in the dark-house system. It was significant the mean of right (male = 33.61 °C and female= 32.44 °C) and left footpad surface temperature (male = 33.95 °C and female = 32.80 °C) at 42 days old of birds. There is an association between the incidence of footpad dermatitis and the surface temperature of the footpad. This association features a consequence of injury in facilities with tunnel ventilation system and the male birds

Key Words: footpad dermatitis, odds ratio, risk ratio

P228 Factors associated with incidence of myopathy in broiler pectoralis major muscle of different production systems Nilsa Lima^{*1}, Francieli Montagna², Rodrigo Garcia², Fabiana Caldara², Irenilza Nääs³, Marta Baracho³, Flavia Jacob³, Thayla Curi³ *¹Universidade Estadual de Campinas; ²Federal University of Grande Dourados; ³University of Campinas*

The aim of this research was to estimate the incidence of pectoral myopathy in Pectoralis Major muscle in broilers reared in different commercial strains and facilities types. Data were collected in a broiler slaughterhouse, located in the Center-West region of Brazil. The 5580 broiler breast samples were evaluated mixed (equivalent to 3% of the number of birds slaughtered of each livestock) of the two broiler houses: Dark-house and tunnel system and three commercial strains: Hubbard, Cobb, and Ross. The macroscopic evaluation and classification of degrees of incidence of muscle change the pectoralis major muscle was considered the following classification of breasts: Grade 0: Normal or Absence, Grade 1: Intermediate or Moderate and Grade 2: Severe. The evaluation of the production performance used: Final average weight; food conversion; average daily gain; final weight gain; feed intake; mortality; viability and productive efficiency index. The single-factor variance was used to analysis and comparisons of means by Student's t test. Birds from the dark-house system present higher chances (26%) and risks (13%) to development changes in muscle fibers in the pectoralis than the birds of the tunnel system, indicating that birds exposed to those conditions can increase chances and risks of increased incidence of myopathy. The birds bred in a rearing environment such as in the dark-house had higher feed intake with 10% higher. The occurrence of myopathy pectoral present significant association for birds raised in dark-house with increased chance of risks of muscle change with moderate to severe.

Key Words: chicken meat, myopathy, pectoralis major, lineage, broiler facilities

P229 Carbon footprint of Brazilian broiler meat consumers Raquel Silva^{*1}, Nilsa Lima¹, Thayla Carvalho², Irenilza Nääs¹ *¹State University of Campinas; ²Anhanguera University*

A personal carbon footprint is the emissions caused by an individual's consumption. It is an estimation of how a person lifestyle might contribute to the climate change. The present study aimed to analyze the carbon footprint profile of the Brazilian broiler meat everyday consumer. A total of 222 individuals from the various regions of the countries answered an online questionnaire containing several questions related to the consumer habits

including the daily consumption of broiler meat. To build up the consumer profile the questionnaire included questions related to age, level of education, gender, marital status, the number of children, type of house, wage, car type, and appropriate actions toward sustainability such as recycling. The answers were organized in a database and the software WEKA version 3.6.13 was used to divide the data into three groups. The algorithm applied was the SimpleKmeans using the Euclidian distance to select the groups. The three selected groups (cluster 1- C1, cluster 2- C2, and cluster 3- C3) presented the same quantity of similarities such as 69 (31%), 61 (27%), and 92 (41%) for C1, C2, and C3, respectively. A sum of square errors was 461.30 in five interactions. Five individual from each group were randomly selected, and the collected data was used as input into the WWF online footprint calculator. The mean value of the obtained carbon footprint in tons of carbon per year was calculated for each individual. The profile of C1 had subjects 26 to 35 years old, college education, was mainly female, single and did not have children. The carbon footprint of C1 was 18 ± 3 tons/year. The profile of C2 had individuals older than 45 years, with a college degree, mainly female, married with two or more children. This group had a mean value of carbon footprint of 17 ± 2 tons/year. The third group C3 had subjects with age from 26 to 35 years, mainly female married without children, and had a mean value of carbon footprint of 18 ± 3 tons/year. Although three clusters were identified in the questionnaire answers, the calculated carbon footprint was similar in the groups. The mean value of the carbon footprint for the middle-class groups varies in developed, and developing countries. In the U.K. the average rate of carbon footprint is near 10 ton/year, while in the U.S. Varies from 18 to 25 tons/year, and in Australia is near 19 tons/years. All values are related to the lifestyle of the groups. Results indicate that Brazilian broiler meat consumers, mostly from the middle class have an average carbon footprint ranging from 15 to 21 tons/year.

Key Words: carbon equivalent individual emission, broiler meat consumer, middle class consumer, climate change

P230 Carbon footprint of intensive broiler production in Brazil Nilza Lima^{*1}, Irenilza Nääs¹, Rodrigo Garcia², Flavia Jacob¹, Marta Baracho¹
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The intensive broiler production is a significant economic activity when considering the increase in broiler production and the number of slaughtered birds. However, this commercial segment needs to adjust to the perspectives of low carbon emission economy. There is a lack of information of carbon equivalent emitted in the broiler production supply chain under certain rearing conditions. Therefore this study aimed to estimate the greenhouse gases (GHG) from broilers reared in the dark house system in Brazil and to find the carbon footprint for subsidizing future mitigation. Dark house systems consisted of a house 15 m wide, 150 m long and 3.8 m high, and a floor area of 31500 m² with forced ventilation; exhaust fans (12 with an air flow of 580 m³ s⁻¹), a high-pressure fogging system, and internal built walls painted with a black coating. To evaluate the carbon footprint the total rearing time was considered (1d old to 42d old). Data from 5 similar houses were registered including electricity use, dimensions, and material of the house, the number of reared birds, litter management, the number of flocks in the same litter per year, and feed ration. GHG emissions were estimated using the method developed by the World Resources Institute using emission factors based on the region and the type of animal, according to the recommendations of the IPCC for inventories. Mechanical emissions were approximately 97% of the total emissions. Annual total emissions from mechanical sources added 740 tons of CO₂eq/year. This value is a result of the use of electricity (21 tons of CO₂eq/year) and the technological level of the system (exhaust fans, automatic feeders, and drinkers). Emission from the litter added up 55 tons of CO₂eq/year. Feed represented nearly 75% of all emissions depending on the origin and the type of feed grains for the production of the feed ration. The total estimation of the environmental

impact of broiler production under the dark house system in the center-west of Brazil is 740 tons of CO₂eq/year.

Key Words: environmental impact, greenhouse gases, broiler meat

P231 Enrichment by Access to Swimming Water and Resultant Impact on Performance and Well Being of Meat Type Pekin Ducks Mitchell Hoysock^{*UG1}, Zachary Lowman², James Jurgielewicz², Phillip Clauer¹ ¹The Pennsylvania State University; ²Joe Jurgielewicz & Son

Ducks possess several traits that easily differentiate them from other types of poultry. One of these unique traits is their great affinity for water. Duck production in the U.S. began in Long Island, NY, where ducks were reared in large open lots, with some type of open water access. As duck production in the U.S. has increased, there have been significant advances in management and production including the nipple water line. However, many welfare standards require that waterfowl have enriched housing including access to swimming and or preening water. There are limited studies in the literature that address this issue in Pekin ducks. The current study examines the performance of Pekin ducks provided with a water trough that allows for swimming and preening water compared to standard nipple lines. Ducks with access to a swimming trough were significantly ($p \leq 0.0054$) lighter (7.01lb) than the control (7.42 lb). These birds also had significantly higher foot pad lesion scores (1.17) compared to control (0.54). However, the enriched group had significantly ($p \leq 0.001$) lower nasal scores (0.02 vs 0.27) and though not significant, were also found to have better feather condition scores (1.39) versus controls (1.47), and lower eye scores (0.13 vs 0.19). Based on this trial, enrichment of housing with swimming troughs result in decreased weight gain, while the duck welfare measurements resulted in improved eye score and nasal scores yet, increased foot lesions. Careful decisions must be made in commercial systems to both maximize performance and animal welfare. Enrichment of duck housing with swimming troughs significantly decreases growth rate and increases foot pad lesions yet improves nasal and feather scores. These factors must be considered when designing future commercial facilities for ducks.

Key Words: Pekin duck, Water, Nasal, Lesions

P232 Trailer thermal environment during commercial broiler transportation Yi Liang^{*}, Douglas Aldridge, Kaushik Luthra, Susan Watkins, Karen Christensen, Yvonne Thaxton *University of Arkansas*

Thermal condition during live haul broiler transportation is a critical factor and can affect broiler welfare. The impact of extreme weather conditions and commonly used mitigation measures on the trailer thermal environment in the U.S. are not well understood. Data from 28 trips (approximately 2 to 5 hours in duration each) were collected in winter, summer and mild seasons in Northwest Arkansas and surrounding areas. Temperature and relative humidity at forty-five grid points of five cross sections (also known as rows) of the trailers were monitored during loading, transporting and holding period before birds were processed. Average trailer temperatures at each cross section of each monitoring trip were calculated for different trailer configuration or mitigation measures. About 60% of the thermal loads in trailers fitted with single wind boards experienced temperature between 40 to 60 °F, representing 0 to 10 °F temperature rises above ambient conditions. About 60% of the loads in trailers fitted with double wind boards experienced temperature between 30 to 50 °F, representing 10 to 20 °F temperature rises above ambient. With assistance of fan trailers and various types of water treatments during farm loading in summer, average trailer temperature were below 92 °F for 70% of loads, with the rest between 92 and 96 °F. The cooling strategies were able to maintain trailer temperature during transportation above -4 and 10 °F of ambient temperature. Thermal cores were present in some of the trips monitored.

Key Words: poultry production

P233 Dealing with an inherent weakness in laboratory methods to detect *Salmonella* in feed Nelson Cox^{*1}, Douglas Cosby¹, Mark Berrang¹, Kurt Richardson² ¹USDA, ARS, U.S. National Poultry Research Center; ²Anitox, Incorporated

Human salmonellosis outbreaks have been linked to contamination of animal feeds. Therefore, it is critical to employ sensitive, reliable *Salmonella* detection methods for animal feed and feedstuffs. Research has shown that incubation of mixed feeds and feed ingredients in commonly used pre-enrichment media can reach an acidic pH that may kill or injure *Salmonella* potentially confounding detection. The objective of this study was to confirm pH sensitivity of *Salmonella* and test a new highly buffered medium for culture of feed. Approximately 10⁵ colony forming units (CFU) of *S. Enteritidis* (SE), *S. Heidelberg* (SH), *S. Kentucky* (SK) and *S. Typhimurium* (ST) were individually inoculated into 50 mL of citrate buffer at various pH's (4.0 – 5.0) for 24 h at 37°C. The injury and death observed confirmed that a pH between 4.0 and 5.0 was detrimental to these 4 *Salmonella* serotypes, with % injury ranging from 89.4 to 100% and the % death ranging from 77.5 to 100%. ST was the most sensitive serotype, SH was the most resistant. When a new triple buffered peptone broth (TBP) was compared to lactose broth (LB) and buffered peptone (BP), the TBP performed much better at maintaining an acceptable pH during feed incubation than the two more commonly used pre-enrichment broths. The mean pH of the TBP during pre-enrichment of feed was 6.6 and significantly higher than either BP (5.1) or LB (4.4). When *Salmonella* was inoculated into feed in TBP and LP, it was recovered 24/24 and 2/24, respectively. TBP shows promise as a means to maintain a near neutral pH in feed samples during the pre-enrichment step and may allow the accurate detection of *Salmonella* in these types of samples. An effective pre-enrichment method utilizing an effective buffering system may provide more reliable information regarding feed as a source of contamination in poultry and poultry products which may be overlooked with currently used laboratory procedures.

Key Words: *Salmonella*, feeds, feed ingredients, recovery

P234 Acid tolerance of dry-stressed *Salmonella* Kurt Richardson^{*1}, Nelson Cox², Douglas Cosby², Mark Berrang², Leslie DeRome¹ ¹Anitox Corp; ²USDA-ARS

The pH of *Salmonella* pre-enrichment media becomes acidic (pH 4.0 to 5.0) when feed/ingredient were incubated for 24 hrs. Acidic conditions have been reported to injure or kill *Salmonella*. *Salmonella* present in commercially prepared dry feed can be expected to have been subjected to some degree of dry stress. In this study, non-stressed and stressed cultures of four known feed isolates (*S. Montevideo*, *S. Senftenberg*, *S. Tennessee* and *S. Schwarzengrund*) and four isolates (*S. Typhimurium*, *S. Enteritidis*, *S. Infantis*, and *S. Heidelberg*), economically important in processing plants, were subjected to dry-stress in meat and bone meal. Stress and non-stressed cultures were incubated in pHs ranging from 4.0 to 7.0. Cell injury and death was determined by counting colonies that grew on selective xylose lysine tergitol 4 agar (XLT4) compared to those that grew on non-selective nutrient agar (NA). In the case of cell death in non-stressed *Salmonella*, *S. Typhimurium* was the most acid tolerant and *S. Heidelberg* was the most acid sensitive whereas in stressed *Salmonella*, *S. Senftenberg* was the most acid tolerant and *S. Tennessee* was the most acid sensitive. The pH required to cause cell injury varied among isolates. With some isolates, the pH required for 50% were cell death and 50% cell injury were similar. In other isolates, cell injury occurred at a much higher pH. These findings suggest that the pH of the pre-enrichment media may influence the serotype of *Salmonella* recovered from feed.

Key Words: *Salmonella*, feed, pH

P235 Comparing the environmental impact of broiler and fish production Irenilza Nääs^{*1}, Silvia Bonilla¹, Nilsa Lima² ¹Paulista University; ²State University of Campinas

As the world's demand for food increases, the increasing emissions to land, water, and atmosphere from intensive livestock production is worthy of concern. Poultry and fish from intensive operations are a primary source of global human food consumption. Broiler houses are a source of ammonia emissions function of NH₃ concentration inside the housing depending on flock density, litter, diet and ventilation systems. On the other hand, concerns are expressed about the discharge of wastes, from fish production. This study uses the emergy concept to estimate the role of natural services from a land area to act as a sink for ammonia emissions from a poultry production housing and phosphorous from an aquaculture farm. The environmental work done by the biosphere intending to dilute the considered emissions is accounted regarding emergy and converted to the "support area" concept, the land demand responsible for acting as a buffer. Emergy is defined as the sum of all inputs of energy (directly or indirectly) required for a process to provide a given product, when inputs are expressed in the same form (or type) of energy, such as solar energy. The present study retrieved data from four broiler houses in Brazil. There were 25,200 broilers in each house reared for 42 days until they reach the commercial weight of 2 kg. The tilapia farm had a total of 200 fish cages, 40 of 4 m³ and 60 of 6 m³ each. The pond where the cages are placed covers an area of 30 ha with an average depth of 2.10 m. The lake was fed by a water course which pours a water supply of 150 l/sec in average. Fingerlings are placed into the cages, and after a cycle of approximately 180 days, the fish reach 484 g. The production is 320,000 fishes/year. Ammonia emission values were obtained by onsite measurements. The phosphorous release was estimated according to the conversion factor in biomass and the content of phosphorus in the food. Additional data were retrieved from literature. Assuming that the total emergy required to dilute pollutants is derived from renewable resources, the calculated "support area" will act as a sustainability predictor of long-term sustainability. The found emergy eco-efficiency (kg y/seJ 10-10) for poultry production is 1.3, and for fish, production is 0.0013. Results suggest that poultry production seems to be a thousand times more "eco-efficient" than aquaculture as well as presenting a lower support area. Accounting for the environmental services required to dilute emissions is shown to be a necessary procedure towards the proper evaluation of long-term sustainability and quantification of externalities.

Key Words: emergy analysis, environmental impact, broiler production, aquaculture

P236 Environmental impact of broiler meat and beef consumers Irenilza Nääs^{*1}, Raquel Silva¹, Nilsa Lima¹, Thayla Carvalho² ¹State University of Campinas; ²Anhanguera University

An individual carbon footprint is the sum of all emissions of greenhouse gasses like (carbon equivalent), which were induced by a person activities in a given time frame. Evaluating footprints has been referred to as consumption-based accounting. This study compared the environmental impact of broiler meat and beef consumers in Brazil, using the carbon footprint assessment. A total of 222 subjects from the various regions of the countries answered an online questionnaire containing several questions related to the consumer habits including the daily consumption of either broiler meat or beef. The customer profile included questions related to age, level of education, gender, marital status, the number of children, type of house, wage, car type, and appropriate actions toward sustainability such as recycling. The answers were organized in a database and the software WEKA version 3.6.13 was used to separate the data into three clusters. Mean values were compared using Student T-test. Five individual from each group were randomly selected (15 beef consumer and 15 broiler meat consumer), and the reference data was used as input into the WWF online footprint calculator. The carbon footprint of beef eaters (Mean = 21 tons/year; Standard error mean = 1) was 13% higher (P-value = 0.008) than the broiler meat eaters (Mean = 18 tons/year; Standard error mean = 1). Similar

studies on this topic indicate that beef consumers in all meals presented a carbon footprint 14% higher than those eating broiler meat. Considering similar lifestyle and taking into account just the consumer preference for eating broiler meat every day makes these consumers more sustainable than those eating beef frequently.

Key Words: carbon footprint, meat consumers, sustainability

P237 Types of poultry farms on percentage of condemnation broiler carcass at slaughter Rodrigo Garcia*, Rafael Belintani, Rodrigo Borille, Carla Heloisa Domingues, Irenilza Naas, Rodolpho Marques, João Paulo Bueno, Tassia Maria Bevilaqua, Rosana Bicas, Sarah Sgavioli, Fabiana Caldara *Universidade Federal da Grande Dourados*

Carcass quality problems cause high economic losses to poultry industry worldwide. Overall, poultry carcasses quality observed at slaughterhouse depends predominantly of events that were exposed during fattening period, as well as pre-slaughter step during processing. The aim of the study was to evaluate the influence of type of poultry farms on percentage of condemnations broiler carcasses at slaughterhouses. It was used data from Federal Inspection Service (SIF, Brazil) of 2165 broilers batches, related of slaughters from 2015 of a commercial poultry slaughterhouse in center-west region of Brazil. Types of poultry farms were divided into: conventional - positive pressure ventilation (n = 1931 batches) with 12 birds per square meter, tunnel type - negative pressure ventilation (n = 50 batches) with 13 birds per square meter and dark house - negative pressure ventilation (n = 184 batches) with 14 birds per square meter area. It was analyzed the percentage of convicted birds for each pathology (aerosaculitis, cellulite, dermatosis and ascites) and average weight per bird (kg) at slaughter time. Results were submitted to variance analysis (ANOVA, $P < 0.05$) and in case of significance effect were compared by Tukey test ($P < 0.05$). Results showed that types of poultry farms did not affect the percentage of condemnations for aerosaculitis ($P = 0.062$), dermatosis ($P = 0.218$), ascites ($P = 0.453$) and average weight per bird ($P = 0.083$), however, type of poultry farms presented influence on percentage of condemnations for cellulitis ($P = 0.023$). Tukey test ($P < 0.05$) indicated that conventional system had greater influence ($P < 0.05$) on condemnations for cellulitis (0.91%), when compared to dark house system (0.76%). Type tunnel system did not differ from the others (0.86%). These results indicate that type of poultry farm has little influence on carcass condemnations percentages, being evident just on percentage for cellulite.

Key Words: aerosaculitis, ascites, cellulitis, dermatitis

P238 Influence of seasons on percentage of condemnation broiler carcass at slaughter Rodrigo Garcia*¹, Rafael Belintani¹, Rodolpho Marques¹, João Bueno¹, Carla Domingues¹, Tassia Bevilaqua¹, Rosana Bicas¹, Irenilza Naas¹, Rodrigo Borille² ¹*Universidade Federal da Grande Dourados*; ²*Universidade Federal de Santa Maria*

The aim of the study was to evaluate the influence of seasons on percentage of condemnation broiler carcasses at slaughterhouses. It was used data from Federal Inspection Service (SIF, Brazil) of 2165 broilers batches, related of slaughters from 2015 of a commercial poultry slaughterhouse in center-west region of Brazil. Seasons were divided in (total N = 2165 batches): summer (N = 555 batches), fall (N = 519 batches), winter (N = 551 batches) and spring (N = 540 batches). It was analyzed the percentage of condemnation birds for each pathology (aerosaculitis, cellulite, dermatosis and ascites) and average weight per bird (kg) at slaughter time. Results were submitted to variance analysis (ANOVA, $P < 0.05$) and in case of significance effect were compared by Tukey test ($P < 0.05$). Results showed that seasons affected ($P < 0.001$) condemnation (%) for aerosaculitis, cellulitis, dermatitis, ascites and average weight. Condemnation for aerosaculitis were higher ($P < 0.05$) in the summer (0.08%) compared to fall (0.05%), spring (0.03%) and winter (0.02%). Cellulite was higher ($P < 0.05$) in the summer (1.34%), followed by fall (1.0%), spring (0.68%) and winter (0.56%), respectively. Condemnation for dermatoses were higher ($P < 0.05$) in the summer (1.11%), followed by fall (0.77%), winter and spring

(0.59 and 0.57%). Ascites syndrome had a higher percentage ($P < 0.05$) in winter and summer (0.10 and 0.10%), followed by fall (0.07%) and spring (0.06%). The highest average weight ($P < 0.05$) appear in autumn (2.84 kg) followed by summer (2.76 kg), winter and spring (2.68 and 2.66 kg respectively). In conclusion, summer appears as the factor that causes most condemnations, even not providing the highest weight gain in birds.

Key Words: aerosaculitis, ascites, cellulitis, dermatitis

P239 A survey of the housing and physical conditions of backyard flocks Richard Blatchford*, Margaret De Luz *University of California, Davis*

Backyard flocks have increased in popularity over the last 5-10 years. While most research has focused on owner attitudes and knowledge, little attention has been given to the housing conditions and the state of the birds themselves. The goal of this study was to document the variation in housing and the physical condition of backyard chickens in Northern California. A total of 300 hens, from 51 flocks representing 9 counties, were assessed using a modified version of the Welfare Quality® assessment protocol for poultry. Housing characteristics, such as floor space, resource availability, ammonia levels, and whether or not hens were allowed to range were collected for each flock. Flock size ranged from 2 to 30 birds, with ages ranging from 14 weeks to 7 years. Overall, hens were in good condition, with little to no incidence of eye and beak abnormalities, vent lesions, respiratory discharge, or toe damage. The most common health-related issues were keel bone damage (56%), comb wounds (38%), external parasites (28%), and foot lesions (21%). Most hens were fully feathered, although 8% of hens had feather loss on the head. All flocks were provided with more than 1 ft² of space per bird within the housing structure. Feeder space ranged from 1.4 to 47.6 cm/bird, and a mix of pan and nipple waterers were observed. The majority of flocks (82%) were provided with individual nest boxes, with the remainder using colony nests. All nests were furnished with substrate. All but 2 flocks were provided with perching within the housing structure for the birds to roost at night, with perch space ranging from 9.5 to 364.3 cm/bird. Seventy one percent of flocks were allowed to range, and there was no detectable ammonia at any flock location. While housing conditions varied widely between flocks, most birds had the appropriate resources available to them, and were in good physical condition. The observance of comb wounds and feather loss on the head suggest backyard flocks may be prone to mild or moderate aggression. The prevalence of keel damage is surprising and more research should be performed to understand the cause of these injuries.

Key Words: backyard chickens, housing, physical condition, welfare

P240 Microbial population analysis of broilers in different flock and embryonic ages from GI, yolk and egg wash via Illumina MiSeq and QIIME pipeline Steven Ricke*¹, Sang In Lee¹, Si Hong Park¹, Kelli Hiatt², Holly Sellers³, Michael Rothrock² ¹*University of Arkansas*; ²*USDA-ARS US National Poultry Research Center*; ³*UGA Poultry Diagnostic & Research Center*

There are several food-safety issues related to broiler egg production, including the introduction/proliferation of zoonotic pathogens during embryonic gastrointestinal (GI) tract development. Little is known about the overall GI bacterial communities, how they change over time, or how their composition could influence zoonotic pathogen survival/transmission. To determine the effects of embryonic age and broiler breeder flock age on developing GI and yolk bacterial communities the GI tracts and yolks were aseptically removed from commercial broiler eggs at 4 times (7-, 15-, 20-days post fertilization, and 1-day post-hatch) from broiler breeder flocks of three different ages (20, 35, and 60 weeks). Egg washes occurred only at the 20-day sampling point (Trial 1). As part of a second study, eggs from the 20-week-old flock were re-sampled at 35 and 60 weeks of age (Trial 2). For all samples. DNA was extracted and 16S microbiomic sequencing analysis (using QIIME) was performed using the Illumina MiSeq platform. In the hatchery trial 1, alpha diversity analysis revealed that younger embryonic

age exhibits highest observed OTUs and decreased approaching hatch. Also, the younger breeder flock exhibited lower average observed OTUs in GI, yolk and egg wash samples and with the observed OTUs increasing as breeder flock age increased. The GI tract samples exhibited the highest observed OTUs, followed by the yolk and egg wash samples, respectively. In the beta diversity analysis, aside from clustering based on sample type (GI, yolk, egg wash), minor clustering was found based on embryonic age groups (7- and 14-day versus 20-day and 1-day post-hatch), but no clustering based on breeder flock age. In the hatchery trial 2, significantly higher observed OTUs were detected in egg wash compared to GI and yolk. Also, older flock age exhibited higher observed OTUs and group 3 of embryonic age exhibited significantly higher observed OTUs compared to other three groups. Beta diversity indicated almost complete clustering by flock age alone and combination of flock age and sample type. In both trials, significant microbial population shifting was frequently observed by embryonic age and flock age.

Key Words: Microbiome, Next Generation Sequencing, Broiler

P241 Evaluation of light intensity on Pharaoh quail growth performance Casey Ritz*, Brian Fairchild, Michael Czarick *The University of Georgia*

Quail are an upland gamebird that are much more active than commercial broiler chickens. Changes in light intensity may alter activity that reduces their body weight gain and subsequent feed conversion ratio. The purpose of this study was two-fold: 1) to compare quail growth parameters of body weight gain, feed consumption and feed conversion ratio under two light intensity regimes, and 2) to evaluate the impact of the light regimes on the rate of sexual maturity as a function of gonad weight. Two light intensity treatments consisted of a high intensity treatment of 20 lux, and a low intensity treatment of 2 lux. All pens were started on full light (20 lux) 24 hours per day for the first 7 days. On Day 8, the light intensity of half the pens was reduced to 2.0 lux for 24 hours per day for the remainder of the study. Pen weights and weekly feed consumption was recorded on Days 0, 7, 14, 21 and 28 for body weight gain and feed conversion calculations. Body weight, feed conversion ratio, and mortality were not significantly different between the light treatments. Under commercial quail housing conditions, low light intensity can be used without concern of performance loss. The low light intensity may reduce the incidence of injury and trauma related mortality. Quail reach sexual maturity at 42 days. Day length was the same within the treatments of this study. However, the males in the high intensity treatment had significantly heavier testes at 28 days of age. No significant differences were noted in female ovary development. The data suggest that light intensity is a strong stimulus for gonad development, particularly in males. These results imply that lower light intensity in meat quail production will not negatively impact quail performance and could delay teste development.

Key Words: Quail, Light, Intensity, growth

P242 Multi-mycotoxin analysis in 829 feed and raw material samples in 2016 Verena Starkl¹, Paula Kovalsky¹, Timothy Jenkins¹, Michael Sulyok² ¹*Biomim Holding GmbH*; ²*Department IFA-Tulln, University of Natural Resources and Life Sciences, Vienna, Austria*

More than 40,000 feed samples including corn, wheat, barley, soy as well as finished feed were analyzed within the Biomim Mycotoxin Survey since 2004. The results presented here include data from samples sourced worldwide from January to September 2016. The samples were analyzed using Liquid Chromatography-Mass Spectrometry/Mass Spectrometry (LC-MS/MS, Spectrum 380®) screening for more than 380 mycotoxins and other secondary metabolites. For practical relevance a cut-off level for all mycotoxins was established at >1 ppb (except aflatoxin at > 0.5 ppb). The aim of this study was to obtain information on the occurrence and contamination level of multiple mycotoxins in feed and raw materials samples from various regions. A total of 829 samples (raw materials like corn and wheat, as well as finished feed) were collected worldwide and screened for

the presence of multiple mycotoxins and other secondary metabolites using Spectrum 380®. Up to 103 different mycotoxins and metabolites were found per sample. Only 4% of all analyzed samples contained less than 10 mycotoxins. On average, 25 different metabolites were detected per sample. 80% of the analyzed samples tested positive for aurofusarin and tryptophol, 76% for moniliformin, 66% for beauvericin, 64% for zearalenone, 55% for fumonisin B₁ (average of positives 528 ppb, 361 ppb, 105 ppb, 25 ppb, 75 ppb and 713 ppb; maximum found ppb, 35,344 ppb, 18,160 ppb, 2,560 ppb, 842 ppb, 6,276 ppb and 20,373 ppb). The sensitivity of mycotoxin analysis and especially of LC-MS/MS increased by 200-fold in the last 10 years leading to the fact that more mycotoxins are found. Performing multi-mycotoxin analysis definitely elucidates the occurrence of mycotoxins but more research is needed to evaluate the practical impact of most of these “new” mycotoxins on animals and human.

Key Words: Multi-mycotoxin analysis, survey

P243 Relationships of eggshell thickness to thermal gradients across the shell at the large and equatorial regions of embryonated broiler hatching eggs Oluwaseun Durojaye*, Edgar Peebles *Mississippi State University*

The possible relationships of eggshell thickness at the large end (LSTH) of the embryonated broiler hatching egg (Ross 708) with the temperature gradients between the interior (air cell; ACT) and exterior surface of the eggshell at the large (STL) and equatorial (STE) regions of the egg were examined. Forty-three eggs were weighed and set on each of 8 levels of a single incubator. Transponders were implanted in 10 eggs per level at 12 d of incubation (DOI), and LSTH of those eggs were measured at 19 DOI. The ACT (transponder telemetry), and STL and STE (infrared thermometry) temperatures were recorded daily at 10:00 AM and 4:00 PM between 12 and 19 DOI. Differences between ACT and STL (Δ TL), and ACT and STE (Δ TE) were calculated. The LSTH and Δ TL of the eggs were negatively correlated at 10:00 AM ($P \leq 0.014$) and 4:00 PM ($P \leq 0.018$) on 17 DOI and at 10:00 AM on 18 DOI ($P \leq 0.016$). In addition, LSTH and Δ TE were negatively correlated ($P \leq 0.022$) at 10:00 AM on 17 DOI. However, across 12 and 19 DOI, LSTH was not significantly correlated with Δ TL ($P = 0.40$) or Δ TE ($P = 0.59$). There was also no significant correlation ($P \leq 0.92$) between LSTH and the mean difference between STE and STL across 12 and 19 DOI. However, across the 12 and 19 DOI period there was a significant positive correlation ($P \leq 0.0001$) between Δ TE and the mean difference between STE and STL. Furthermore, mean STL, STE, and ACT differed significantly ($P \leq 0.0001$). Mean ACT was significantly higher than that of STE and STL, whereas STE was significantly higher than that of STL across the 12 to 19 DOI period. These data suggest that LSTH may not significantly affect heat transfer in embryonated broiler hatching eggs, and that it is important to consider eggshell region when determining eggshell temperature and the role of the eggshell as a thermal barrier.

Key Words: air cell, broiler, eggshell thickness, temperature, transponder

P244 Effects of incubation with a photoperiod on tibia breaking strength in three strains of hens Cassandra Stupart*^{UG}, William Hannah, Janice MacIsaac, Bruce Rathgeber *Dalhousie University*

The provision of a photoperiod during incubation has been shown to positively affect early growth performance in laying hens. The purpose of this experiment was to determine if the normally loss in bone strength late in a production cycle is affected by these incubation conditions. Three strains of laying hens with potential differences in bone integrity were evaluated. Eggs from Lohmann Lite, Lohmann Brown, and a Barred-Plymouth Rock heritage line were incubated under one of four incubation treatments. Treatment 1 eggs were incubated in full darkness for all 21 days, while treatment 2 eggs were incubated with a 12 hours light:12 hours dark (12L:12D) lighting cycle for all 21 days. Treatment 3 eggs were kept in the dark for the first 9 days and then transferred to another incubator with 12L:12D photoperiod. Treatment 4 eggs were incubated for 17 days in the dark and then transferred into a separate incubator with 12L:12D photoperiod. Five

cages per treatment, per strain were selected at random from 92 conventional cages. Selected individuals were culled at 72 weeks of age and tibias were removed and frozen. Following a 24 h thaw, the tibias were deboned and refrozen until 24 h sampling. Each bone was measured for diameter at the centre, overall length and weight. Breaking strength was determined using a TA.XT Plus texture analyzer with a 3 point breaking attachment and 50kg load cell. Data was analyzed using the Proc Mixed procedure of SAS. There were no measurable effects of lighting treatments on bone strength. However, Barred Plymouth Rock hens had higher ($P < 0.05$) breaking strength (34.9kg) compared to Lohmann Lite (25.0 kg) and Lohmann Brown (21.9 kg) laying hens. The lower productivity of dual-purpose hens is likely the reason for higher bone breaking strength compared to high producing commercial laying breeds. The addition of light during photoperiod did not create a difference in bone strength when measured this late in production.

Key Words: Incubation photoperiod, tibia breaking strength, genetic background

P245 Assessing navel closure in newly hatched broiler chicks using thermal imaging Valene MacNeil^{*UG}, Kayla Graham, Xujie Li, Bruce Rathgeber *Dalhousie University*

The visual navel score is an indication of chick quality, which is an important aspect of hatchery success and broiler productivity. It was hypothesized that using an infrared camera to navel score chicks by navel temperature could produce a more accurate method of navel scoring by eliminating human error and bias. 3328 Ross 308 broiler eggs were randomly assigned and equally distributed to 8 trays in each of 8 incubators. Four incubators had a control lighting program of 0L:24D and four were assigned to 12L:12D for the first 17 days. From day 18-21, the lighting treatments consisted of 0L:24D, 12L:12D, 18L:6D and 24L:0D in each of 2 incubators with setter and hatcher treatments arranged in a factorial design. Day old broiler chicks were navel scored visually on a scale of 1-3 based on closure and appearance of the navel. Score of one was a clean and closed navel, two was a navel left open up to 2mm, and a score of three was defined as a navel opening that exceeded 2mm. Once a navel score was established, the temperature of the navel was measured with an infrared camera for 5 chicks from each category per hatching tray if available. Statistical analysis (ANOVA) was performed to determine if the mean temperature for each score (1-3) was different. Score 1 was lowest temperature ($P < 0.0001$) with a mean of 36.7°C. Navel score 2 was different than score 1 and 3 with a mean temperature of 37.1°C ($P < 0.0001$), and navel score 3 was higher than both the other scores with mean of 37.6°C ($P < 0.0001$). The results indicate the use of thermal imaging has the potential as a useful tool for monitoring chick quality that is equivalent to visual scoring methods. A specific temperature range for each navel score of 1 to 3 could be established.

Key Words: Broiler chicks, Navel score, Thermal imaging, Chick quality

P246 Non-invasive methods for measuring stress and lesions attributed to bacterial chondronecrosis with osteomyelitis (BCO) in four and five week old broilers Shawna Weimer*, Andronikos Mauromoustakos, Robert Wideman, Dawn Koltes, Karen Christensen, Yvonne Vizzier-Thaxton *University of Arkansas*

Our long term objective is to non-invasively assess stress and lameness in broilers using infrared thermography (IRT) technology. Drawing blood to evaluate circulating corticosterone (CORT) levels is inherently stressful to the bird. Bacterial chondronecrosis with osteomyelitis (BCO) is a major contributor to broiler lameness. Two experiments were conducted to evaluate the effect of light intensity (5, 10, and 20 lux) and flooring type (litter vs. wire) on stress and the incidence of BCO. The objectives were to determine if CORT levels in feathers and blood are related to IRT eye temperatures (°C). The potential relationships between IRT leg temperatures and the severity of BCO lesions in the proximal femoral head (femoral head necrosis; FHN) and the proximal tibial head (tibial head necrosis; THN) also were evaluated. Day old chicks were placed into environmental pens (N = 6)

with litter flooring. Light intensity treatments began at 1 wk of age. At 4 wk of age, half (N = 50) of the birds in each litter pen (N = 6) were moved to a wire flooring pen (N = 6) with the same light intensity as the source litter pen. At 4 and 5 wk of age five birds were selected randomly from each pen (N=12) and body weight, blood samples, and thermal images of the eye and legs were collected. After humane euthanasia, FHN and THN lesions were macroscopically scored and primary feathers were collected. Serum and primary feather CORT levels were measured using an ELISA. Within each thermal image, anatomical areas of the eye and legs were isolated using the thermal imaging software. No effect of light intensity was detected. Pearson's pairwise correlations were evaluated and a p-value of $P < 0.05$ was considered significant. At 4 and 5 wk of age, leg surface temperatures were higher ($P < 0.0001$) for birds on wire flooring compared to birds on litter. At 4 wk of age, birds with higher serum CORT levels had higher feather CORT ($P < 0.0001$) levels and lower ($P = 0.003$) average eye temperatures. At 5 wk of age, birds with higher cumulative THN and FHN lesion severity had higher ($P = 0.05$) leg temperatures. The results from these studies indicate feather CORT and IRT could be valuable non-invasive tools for measuring broiler stress and lameness.

Key Words: broiler, IRT, non-invasive, stress, BCO

P247 Infrared thermography (IRT) as a non-invasive method for measuring stress in one week old broiler chicks Shawna Weimer*, Andronikos Mauromoustakos, Robert Wideman, Dawn Koltes, Karen Christensen, Yvonne Vizzier-Thaxton *University of Arkansas*

Our long term objective is to non-invasively assess stress in broilers. Infrared thermography (IRT) technology is a versatile method utilized in livestock research. Thermal image analysis can isolate surface temperatures of specific areas on the animal to non-invasively evaluate disease, metabolism, reproductive status, lameness and stress. IRT image analysis of the eye can detect peripheral vasoconstriction associated with the acute stress response, with cooler eyes indicating increased stress. The objective of this study was to determine if thermal image eye temperatures were correlated with circulating levels of corticosterone (CORT) in one wk old broiler chicks. Two replicated experiments were conducted to evaluate the effect of light intensity on broiler stress. Day old chicks were placed in environmental pens (N = 6) with litter flooring. Body weight, blood and thermal images of five chicks from each pen were sampled (N = 30) while all chicks were exposed to the same baseline light intensity. Five different chicks were sampled from each pen (N = 30) 24 h after their first exposure to one of three light intensities: 5 lux, 10 lux, and 20 lux. An image of the eye was taken with a thermal image camera. Blood samples were drawn within 2 min after picking up the bird. Serum CORT levels were measured using an ELISA. Within each thermal image anatomical areas of the eye were isolated using thermal imaging software. Data from both experiments were pooled for statistical analysis and Pearson's pairwise correlations were evaluated for all birds. A p-value of $P < 0.05$ was considered significant. No differences were detected when values obtained at the baseline light intensity were compared with values obtained at subsequent intensities. Birds with higher body weights had lower ($P < 0.001$) serum CORT levels. Maximum eye temperatures were lower ($P = 0.02$) for chicks with higher serum CORT levels. These studies suggest IRT can be used as a noninvasive measure to evaluate stress in broiler chicks.

Key Words: broiler, IRT, corticosterone, stress, welfare

P248 Influence of fan induced photoperiod on selected blood plasma biochemistry, enzyme activities and electrolyte levels of male broilers reared to 63 day of age. Hammed Olanrewaju*, Joseph Purswell, Stephanie Collier, Scott Branton *USDA-ARS, Poultry Research Unit*

Increasing broiler house size and ventilation capacity have resulted in increased light ingress through ventilation system components and may alter the effective photoperiod for broiler chickens and create local increases in light intensity, which may also have impact on broilers' body homeostasis. The objective of this study was to determine the influence of fan induced

photoperiod on selected blood plasma biochemistry, enzyme activities and electrolytes levels of male broilers reared to 63 day of age. A total of 960 male broiler chicks were randomly distributed to 16 environmentally-controlled rooms at 60 chicks/room. Birds were provided a diet formulated to meet or exceed NRC recommendations with feed and water provided *ad libitum*. The lighting program to 35 d was identical for both treatments and the treatments were initiated at 36 d. The two treatments consisted of constant (C) light intensity at 2.5 lx at 16L:8D based on prescriptive intensities in typical heavy broiler lighting programs and a variable (V) light intensity and photoperiod program that was based on field measurements near tunnel fans in a solid walled broiler house. The study was a completely randomized design with room serving as the experimental unit. Blood samples were collected from wing brachial vein of 6 birds per room on day 35 (before initiation of the treatments) and on day 63. Selected blood plasma biochemistry, enzyme activities and electrolyte levels were evaluated using an ACE Axcel clinical analyzer. The results showed that compared with broilers exposed to a constant light intensity of 2.5 lx, broilers exposed to variable lighting to mimic areas near tunnel fans had significantly higher levels of plasma albumin, total protein, uric acid, cholesterol, low density lipoprotein, high density lipoprotein, triglycerides, glucose, sodium, magnesium, and significantly lower enzyme activity of creatine kinase. Overall, enzymatic activity parameters showed higher variability than biochemistry parameters. These results underline the importance of age as a significant contributor of variation in levels of several blood chemistry parameters, especially cardiac and muscle marker proteins.

Key Words: photoperiod, biomarkers, broilers, welfare

P249 Dietary supplementation of Original XPC to reduce stress in heat stressed and non-heat stressed broilers. Paul Price^{*GS1}, Hilary Pavlidis², Don McIntyre², Gregory Archer¹ ¹Texas A&M University; ²Diamond V

Reduction of stress is an important factor in improving poultry welfare especially during periods of heat stress. A study was conducted to evaluate the effects of feeding Original XPC to broilers reared under ambient or heat stress temperatures. Dietary treatments included: T1, control feed (CON), T2, XPC added to the feed at 1.25 kg/MT (XPC), and T3, XPC fed at 2.0 kg/MT (XPC2). Half the birds in each dietary treatment were subjected to either no heat stress (75F constant) or heat stress (95F:75F for 18:6h daily) from 28 to 42d. At the end of the heat stress period, blood was collected from 40 birds/T. Blood was analyzed for plasma corticosterone (CORT), plasma HSP70 (HSP70), and heterophil/lymphocyte ratios (HL). At 42 d, bilateral metatarsal traits were also measured in 40 birds/T to assess physical asymmetry. Hocks and footpads were also scored as a measure of bird welfare. Birds fed either XPC or XPC2 had significantly lower CORT levels than CON (5129 ± 617 and 4660 ± 510 pg/ml vs. 8433 ± 730, respectively, $P < 0.001$). Physical asymmetry scores were also higher ($P < 0.001$) in CON compared to XPC and XPC2 fed broilers (1.50 ± 0.13 vs. 0.54 ± 0.05 and 0.61 ± 0.07, respectively). And HL ratios were significantly greater in CON than for XPC and XPC2 birds (0.81 ± 0.05 mm vs. 0.62 ± 0.05 mm and 0.61 ± 0.05 mm, respectively, $P < 0.01$). No differences were observed between CON broilers and those fed XPC in HSP70 (5.15 ng/ml, $P > 0.05$). However, heat stress did increase ($P < 0.001$) HSP70 (5.65 ± 0.12 vs. 4.78 ± 0.11 ng/ml, for heat stress and non-heat stress, respectively). Feeding XPC did not significantly influence footpad or hock scores since all treatment scores were acceptable. Feeding XPC to broiler chickens improved animal welfare via reduced stress indicators while under heat stress or non-heat stress conditions. These results indicate that XPC may be used as a means to improve the poultry welfare by reducing stress susceptibility.

Key Words: broiler, stress, physical asymmetry, XPC, Heat

P250 Dietary supplementation of Original XPC or AviCare to reduce stress in broilers. Jill Nelson^{*1}, Hilary Pavlidis², Don McIntyre², Gregory Archer¹ ¹Texas A&M University; ²Diamond V

Reducing stress is an important goal in animal production and previous research has demonstrated the ability of Original XPC to reduce the stress response of broilers during a heat stress. A study was conducted to evaluate the effects of feeding Original XPC in the feed or AviCare in the water to broilers exposed to acute stress in addition to normal rearing stressors. Dietary treatments included: T1, control non-stressed (CNS), T2, control stressed (CS), T3, XPC added to the feed at 1.25 kg/MT (XPC), and T4, AviCare added to water at 20oz/379L (AVI). All treatments except T1 received the following stressors: Cocco vaccination at d1, reared on reused litter, heat stress and feed/water withdrawal for 12h on d18. On d19, blood was collected from 60 birds/T. Blood was analyzed for plasma corticosterone (CORT) and heterophil/lymphocyte ratios (HL). At 41 d, CORT and HL were also determined in 24 birds/T and additionally bilateral bone traits were measured in 60 birds/T to assess physical asymmetry (ASYM). Birds fed either XPC or AVI had significantly lower CORT and HL than CS (CORT: 280 ± 46 and 312 ± 37 pg/ml vs. 691 ± 64, respectively, $P < 0.001$; HL: 0.13 ± 0.02 and 0.14 ± 0.02 vs. 0.21 ± 0.03, respectively, $P < 0.001$) on d19. The CNS also had lower CORT (194 ± 30 pg/ml, $P < 0.001$) and HL (0.10 ± 0.01, $P < 0.001$) than the CS on d19. Birds fed either XPC or AVI had significantly lower CORT, HL, and ASYM than both CNS and CS on d41 (CORT: 56 ± 13 and 75 ± 19 pg/ml vs. 234 ± 772 and 252 ± 76 pg/ml, respectively, $P < 0.04$; HL: 0.16 ± 0.02 and 0.16 ± 0.02 vs. 0.25 ± 0.03 and 0.25 ± 0.03, respectively, $P < 0.02$; ASYM: 1.70 ± 0.10 and 1.68 ± 0.09 vs. 2.13 ± 0.14 and 2.06 ± 0.15, respectively, $P < 0.04$). Feeding XPC or AVI to broiler chickens improved animal welfare via reduced stress indicators after acute stress or the effects of normal rearing stress. These results indicate that XPC or AVI may be used as a means to improve the poultry welfare by reducing stress susceptibility.

Key Words: broiler, stress, physical asymmetry, XPC, AviCare

P251 The acidification of litter and its effect on the broilers meat quality. Rodrigo Garcia^{*1}, Claudia Komiyama², Rodrigo Garcia², Nariane Gonçalves¹, Ana Claudia Andrade¹, Ednaldo Andrade¹, Willian Maba¹, Diandra Bet¹, Carlos Junior¹ ¹Universidade Federal de Mato Grosso; ²Universidade Federal da Grande Dourados

The ammonia volatilization in aviaries represents a problem for poultry industry, since it directly affects the broilers well-being and consequently can affect the meat quality. Therefore, this work aimed to evaluate the effect of litter acidification on the broiler meat quality parameters. Four commercial aviaries of positive pressure with 6° reuse litter were used. These aviaries were tested to effects of acidify product (calcium sulfate activated with sulfuric acid and phyllosilicate expanded) applied directly on litter two days before the chicks housing in a concentration of 700 g/m² in the brooding area and 300 g/m² after 14 days of housing in the rest of the aviary. The experimental design was completely randomized with two treatments (with and without acidification), being two aviaries treated with the acidifying and the other two without any treatment (control). At 42 days of age, a total of 92 broilers (23 birds/aviary) were sent to the slaughterhouse where 46 chicken breast boneless were collected per treatment. After 24 hours *post-mortem*, there were evaluated the pH, objective color (L*, a* and b* value), drip loss and cooking loss. The results were analyzed by ANOVA and averages compared by Tukey test (5%) on SISVAR statistical programmer. The results obtained for the drip loss, cooking loss, lightness and redness did not present statistical differences among treatments. For the yellowness, there was statistical difference ($P > 0.0277$), in which the acidified treatment obtained lowest b* value (2.32), in other words, broiler meat was less yellow. Although this difference, both treatments featured low yellow values to be considered a normal meat (3.0 to 7.0). With respect to the pH of meat, there were no statistical differences among treatments, but showed values higher than expected (6.2). The ultimate pH is determinative to the meat quality, and the decrease occurs in function of the metabolic transformation

of the glycogen reserves of lactic acid. When the pH remains higher than normal, this compromised the breaking of the sarcomeres and its surface discharge less light, making the meat darker, and may result in dark, firm and dry meat (DFD). It can be concluded that the litter acidification did not influence in broilers meat quality parameters.

Key Words: chemical conditioner, pH, color

P252 Ammonia volatilization in broiler litter submitted on acidification Rodrigo Garcia^{*1}, Cláudia Komiyama², Rodrigo Garcia², Nariane Gonçalves¹, Juliana Lima¹, Ednaldo Andrade¹, Diandra Bet¹, Fátima Savegnago¹ ¹*Universidade Federal de Mato Grosso*; ²*Universidade Federal da Grande Dourados*

With the increasing in the broiler litter reutilization, there is an increase in the toxic gases concentration, as ammonia, due the deposition and decomposition of the broilers excreta, affecting the bird's welfare. So, the use of the products in the broiler litter that change the pH can contribute to improve the aviaries intern environment. In this context, the aim of this study was to evaluate the effect of acidifying products on the broiler litter reused to reduce the ammonia volatilization. The experiment has been realized in four commercial poultry facilities of positive pressure, testing the use of the acidifying products applied directly on the sixth reused broiler litter. There were arranged in completely randomized design with two treatments (two acidified and two without this product) with subdivided parcels represented by the sampling spots inside in each aviary (12 spots/aviary). The broiler litters samples for the ammonia volatilization and pH analyses were realized with 0, 1, 14, 28 and 42 days of broilers age. In these aviaries, it had been tested the effects of the acidifying product (Sulfate calcium activated with sulfuric acid and expanded phyllosilicate) applied on the broiler litter two days before the chicks placement at the concentration of 700g/m² in the brooding area and 300g/m² after 14 days of the birds placement in the rest of the aviary. The results have been evaluated by the variances analysis and t test by the SISVAR statistics program. The volatile ammonia was lower at 1, 14 and 28 days on the broiler litter that received the acidifying (0.24; 0.25; and 0.66 mg/h, respectively) than control treatment that showed values of 0.64; 0.45 and 0.78 mg/h, respectively. The pH showed a similar behavior, however the significant differences between the acidified and the control aviaries remained since the first day until the 42^o day, in which the acidifying litter presented pH of 7.50; 8.22; 8.31 and 8.41 and the control treatment presents pH of 8.32; 8.68; 8.53 and 8.64, respectively. The acidifying product tested decreased ammonia volatilization in broiler litter, optimizing the broiler litter quality and the broilers welfare.

Key Words: Broiler litter quality, Welfare, Toxic Gases

P253 The influence of reused litter and its effect on the broilers meat quality. Rodrigo Garcia^{*1}, Claudia Komiyama², Rodrigo Garcia², Ana Andrade¹, Nariane Gonçalves¹, Ednaldo Andrade¹, Willian Maba¹, Carlos Junior¹, Diandra Bet¹ ¹*Universidade Federal do Mato Grosso*; ²*Universidade Federal da Grande Dourados*

The reused litter in aviculture is a feasible and desirable from the point of view of sustainable production. Therefore, this work aimed to evaluate the effect of reused litter on the broiler meat quality parameters. Four commercial aviaries of positive pressure with 6^o to 9^o reused litter were tested. The experimental design was completely randomized with four treatments (four consecutive batches) throughout the year. At 42 days of age, a total of 44 broilers (22 birds/aviary) were sent to the slaughterhouse where 44 chicken breasts boneless were collected per treatment in with reused. After 24 hours post-mortem, there were evaluated the pH, objective color (L*, a* and b* value), drip loss (DL) and cooking loss (CL) of breast meat. The results were analyzed by ANOVA and averages compared by Scott-Knot (5%) on SISVAR statistical programmer. There was effect of reused of litter in pH, in which to 7^o and 9^o reused showed better results, followed by the 8^o reused litter (5.79 5.85, 5.91, respectively), these results are considered standard, but the litter of sixth reused presented values higher than expected (6.2). The meat color presented statistical difference, in which

the L* value for the 7^o and 9^o reused showed values within the expected (48.22 and 48.71, respectively) different from 6^o to 8^o reused that showed reduced lightness (45.10 and 46.58, respectively). The redness presented values between 2.99 to 3.99 within the expected (2.5 to 5.5). The yellowness presented values exceeding 3.0 in 7^o, 8^o and 9^o reused and this values are within the expected for normal color (3.0 to 7.0), however, the sixth reused presented value lower than other reused litters (2.86). The DL presented values between 2.66% to 3.37%. For CL, the sixth reused litter presented value lower than expected for normal breast meat (23.95%), this may be due to the high pH of the meat, which changes the hydrophilic sites dynamics of proteins, promoting a strong bonding the water endogenous of the meat. The litter of 6^o reused presented the indexes below the expected. This may be due to environmental effects, once this period presented high temperature and humidity levels. It can be concluded that the reused litter can promote changes in broilers meat quality parameters.

Key Words: drip loss, cooking loss, color

P254 The growth pattern of warm-region chickens under natural prolonged heating conditions Al-Amira El-Kashef^{*UG}, Doaa Higazy, Essam El-Gendy *Faculty of Agriculture, Cairo University*

The purpose of this research was to evaluate the growth performance of native Egyptian chickens (warm-region chickens) under natural prolonged severe heating conditions. Two genetic lines were used; line CE1 that has been selected 15 generations for high 6-week BW and line CE2 that is randomly bred over generations and serves as the genetic control of line CE1. The birds of both lines have been raised intermingled from hatch to 18 wks of age under natural heat stress conditions. The maximum temperature ranged from 32 to 44°C with an average of 39°C, and the minimum temperature ranged from 23°C to 31°C, with an average of 28°C. The maximum humidity ranged from 60-100%RH, and the average of daily maximum humidity was 89%RH. The minimum humidity ranged 44-65%RH, with an average of 58%RH. The maximum temperature-humidity index (THI) ranged from 22.4°C to 34.8°C with an average of 28.8°C and the minimum THI ranged from 10°C to 27.8°C with an average of 18.6°C. Biweekly BW, body weight gain (BWG), daily body weight gain (DBWG) and growth rate (GR) was obtained for all birds, and the data were statistically analyzed for the effect of genetic line on growth under heating conditions.

The results indicated that line CE1 was significantly ($P \leq 0.05$) heavier than line CE2 in all age comparisons. Line CE1 weighed 36 g at hatch and increased to 1469 g at 18 weeks of age, whereas line CE2 weighed 34 and 1161 g at both ages. Similar significant ($P \leq 0.05$) line differences were also obtained in BWG and DBWG. Line CE1 gained 53 g during 0-2 wks, and the gain increased gradually to 327 g during 4-6 wks and then declined to 164 g during 8-10 wks of age, whereas the control line CE2 gained 45, 203 and 121 g during the corresponding ages. Although all birds showed retarded growth during the growing period, line CE1 grew in a rate significantly ($P \leq 0.05$) faster than line CE2 during most of the growing period. In both lines, GR increased to reach its maximal rate by week 4, and then gradually declined. The inflection point was between 4-6 wks of age in both lines. By 10 wks of age, mortality was increased vastly with similar rates in both lines. These results explain the growth patterns of different genetic lines under natural prolonged severe heating conditions, where birds were grown in a retarded growth patterns and the differences were due to the normal genetic variation in growth, the genetic basis of heat tolerance and the genetic selection.

Key Words: Growth pattern, heat stress conditions, warm-region chickens

P255 Effects of post-hatch holding time before placement on broiler body temperature during grow-out Edgar Peebles^{*1}, Tiago Oliveira², Antonio Bertechini², Elizabeth Kim³, Opeyemi Olojede¹, Sharon Womack¹, Patrick Gerard⁴ ¹Mississippi State University; ²Department of Animal Science, Federal University of Lavras; ³USDA-ARS; ⁴Clemson University

The effect of post-hatch (poh) holding time treatment (HT) on daily grow-out broiler body temperature (bt) was determined. The hatching eggs from a Ross 708 breeder flock at 32 wk of age were incubated under standard commercial conditions. At 21 d of incubation, hatched chicks were randomly allocated to 2 poh HT. A 0 h HT (0HT) group had immediate access to water and feed, and a 24 h HT (24HT) group contained birds that were kept in transport baskets in their pens without access to feed and water for 24 h before being released. Approximately 15 birds were placed in each of 27 replicate pens belonging to each HT, and approximately 2 birds in each pen had a temperature transponder (IPTT-300; Bio Medic Data Systems Inc., Seaford, DE) inserted s.c. in the neck region. All birds were brooded under standard commercial conditions, and had ad libitum access to feed and water after their respective HT. Bird bt was determined daily beginning at 1 d and ending on 39 d poh. There was a significant ($P \leq 0.0001$) effect due to bird age. There was also an interaction between bird age and HT that approached significance ($P \leq 0.07$). A general increase in bt occurred during the poh period. At 1 d poh, bt was $40.69 \pm 0.070^\circ\text{C}$, and at 39 d was $41.46 \pm 0.068^\circ\text{C}$. In the 24HT, bt at 19 d was greater ($P \leq 0.003$), and at 38 d was lower ($P \leq 0.003$), in comparison to that in the 0HT. Chick bt at 19 d in the 0HT and 24HT were 40.66 and $40.96 \pm 0.086^\circ\text{C}$, respectively, and at 38 d in the 0HT and 24HT were 41.56 and $41.24 \pm 0.086^\circ\text{C}$, respectively. Under standard brooding conditions, a general increase in bt occurs in Ross 708 broilers, however, these birds do not exhibit a consistently significant bt response to a 24HT (without access to feed and water) before placement.

Key Words: body temperature, broiler, feed and water restriction, holding time, posthatch

P256 Cytology of H/L ratio - the calculus of stress Paul Cotter^{*}, Kathleen Cotter *Cotter Laboratory*

The purpose of this poster is to show how cytology affects the H/L stress calculus. Heterophil lymphocyte ratios (H/L) were computed from 143 blood films of commercial hens. Housing was in aviaries (AV, N = 47) commercial cages (CC, N = 48) or enriched cages (EN, N = 48) and blood was drawn at 77 wk. Leukograms (standard differential counts, SDC) were established by sorting 200 – 400 cells as small (Ls) and medium lymphocytes (Lm) heterophils H (classic HC, variant HV, typical HT) monocytes (Mn) basophils (Ba) and eosinophils (Eo). Three methods calculated H/L ratios: 1 classic heterophils / small lymphocytes (HC/Ls) “the theory”, 2 all heterophils / small lymphocytes (HC + HV + HT) / (Ls) aka “H/L 1”, 3 all heterophils / all lymphocytes (HC + HV + HT) / (Ls + Lm) aka “H/L 2”. Methods 2 and 3 are “the practice”. Low H/L’s by method 1 ranged from 0.001 - 0.015, H/L’s are highest by method 2 (0.31 – 0.45) and were (0.27 – 0.36) by method 3. TWBC’s estimated from SDC slides were ~ 27K for CC and EN cages and ~ 57K for AV. The major H/L difference (method 1 vs. 2 & 3) is explained by variation of heterophil cytology. Relatively few HC’s (< 1%) compared with 12% HV and 18% HT accounted for most of the differences. Lymphocyte cytology had a minor effect because Lm’s were ~ 10% and included some reactive cells. Remarkably H/L’s computed by methods 2 and 3 were in a range suggesting the absence of disease and stress in spite of a high frequency of atypical cells in hemograms. The results emphasize the necessity of giving priority to cytology and the need to integrate the H/L with cellularity (TWBC).

Key Words: heterophil lymphocyte ratio, hemogram, cytology, cellularity

Metabolism & Nutrition

P257 Performance and meat quality of Cobb MX x 500 male and female broilers as affected by amino acid density Barbara de Almeida Mallmann^{*GS1}, Xiao Sun², Casey Owens¹, Samuel Rochell¹, Justina Caldas³, Michael Kidd¹ ¹University of Arkansas; ²Nanjing Agricultural University; ³Cobb-Vantress

An experiment was conducted to determine the effects of dietary amino acid (AA) density on growth performance, processing yield, and woody breast scores of male and female broilers processed at different ages. A total of 864 Cobb Mx x 500 broilers (432 male, 432 female) were distributed by sex to 72 floor pens (12 birds per pen) at 1 d of age. Chicks were allotted to 4 experimental treatments consisting of a factorial arrangement of sex (male and female) and 2 levels of dietary AA. Experimental diets were phase-fed and formulated to contain 1.28, 1.12, and 0.96% digestible Lys in the starter, grower, and finisher diets, respectively. A moderate AA density (MAA) was formulated with digestible AA ratios relative to Lys set at 75, 66, 73, 64, 100 and 17% for TSAA, Thr, Val, Ile, Arg, and Trp, respectively. In the high AA density (HAA) diet, AA to Lys ratios were formulated to be the same for TSAA and Thr but increased to 77, 67, 105, and 18% for Val, Ile, Arg, and Trp, respectively. At 28, 35, and 42 d of age, all birds from 6 replicate pens of each treatment were weighed and processed for determination of body weight gain (BWG), feed intake (FI), feed conversion ratio (FCR), and processing yields. *Pectoralis major* muscles were visually scored for woody breast at 42 d. Male broilers had greater ($P < 0.05$) FI and BWG than females throughout the trial. Males broilers also had lower FCR than females at 28 and 35 d, but 42 d FCR was not affected by sex. Birds fed HAA diets had a lower FCR ($P < 0.05$) than those fed MAA diets at 35 d, independent of sex, but no other effects of diet or diet x sex interactions were observed on growth performance. Abdominal fat pad yield was higher ($P < 0.05$) for females than for males at 28 and 35 d. At 42

d, an interaction was observed whereby abdominal fat pad yield was higher ($P < 0.05$) for females fed the MAA diet compared with those fed the HAA diet, but diet did not affect ($P > 0.05$) abdominal fat pad yield of male broilers. At 28 d, feeding the HAA diet increased *Pectoralis minor* yield of male broilers, but decreased that of female birds, resulting in a gender x diet interaction ($P < 0.05$). At 35 and 42 d, *P. minor* yield was greater ($P < 0.05$) for females than for males, with no influence of diet. Incidence of moderate and severe woody breast scores was higher ($P < 0.05$) for males than for females at 42 d. In summary, increasing formulation minimums for AA to Lys ratios beyond TSAA and Thr did not consistently improve broiler live performance or carcass characteristics.

Key Words: Amino acids, ideal ratios, performance, processing yields, woody breast

P258 Arginine requirement for male turkeys from seven to twenty-one days old. Joao Ferreira^{*GS}, Jeff Firman *University of Missouri*

Arginine is the sixth most limiting amino acid in a corn-soybean meal based diet. The knowledge of the arginine requirement and other less limiting amino acids is important in order to reduce the crude protein and, consequently, to reduce feed cost. The objective of the study was to establish the digestible requirement of arginine for male turkeys from 7 to 21 d. A total of 312 7-d-old toms were randomly allocated into battery cages in a temperature controlled room with feed and water provided ad libitum. There were thirteen treatments with six replicates and four birds per replicate. Dietary treatments comprised of 0.70, 0.81, 0.92, 1.03, 1.14, 1.25, 1.36, 1.47, 1.58, 1.69, 1.80, or 1.91% of digestible arginine in the diet, and a positive control diet with arginine meeting NRC (1994) requirement. The NLIN procedure of SAS was used to estimate the breakpoint of the average feed intake (AFI), final average body weight (FABW), average weight gain

(AWG), and feed conversion (FC). Growth performance variables were not different between positive control versus treated groups. The digestible arginine requirement for FABW and ADW were similar with breakpoint at 0.99% ($P < 0.05$). The FC reached the breakpoint at 1.13% of digestible arginine ($P < 0.05$). The digestible arginine requirement for AFI was 1.57% ($P < 0.05$). These results suggest that the requirement of digestible arginine is less than the requirements indicated by the NRC in a corn-soybean meal based diet with coefficient of digestibility 85% resulting in 1.36% of digestible arginine.

Key Words: turkey, arginine, digestible amino acids, requirement, low protein

P259 Effects of herbal Methioren on growth performance, egg production and egg quality in laying hens Fernanda Castro^{*1}, Paula Sedlacek¹, Shivi Maini², Mohan Ji Saxena², Ravikanth Kotagiri², Woo Kyun Kim¹ ¹University of Georgia; ²Ayurvet Limited

Methionine (Met) is the first limiting amino acid for poultry fed corn/soybean meal diets. The most common source of Met in poultry diets is DL-Met obtained from petrol-derived products. However, with the rising price of these products and demand for the production of organic animal protein, the development of organic sources of this amino acid has increased. Therefore, the aim of the study was to evaluate the effects of herbal Methioren on feed efficiency, egg production and egg quality in laying hens. A total of 180 laying hens (Hyline W36) were allocated in individual cages, distributed in a completely randomized design, with five treatments, six repetitions and six hens per repetition. The treatments were T1 – 100% of DL-Met; T2 – 100% herbal-Met; T3 – Negative control (low Met diet: -0.20%); T4 – 50% DL-Met and 50% herbal Met; and T5 – 67% DL-Met and 33% herbal Met. Egg production, egg quality (Haugh unit, egg weight, shell thickness, shell break strength, and specific gravity), feed intake, body weight and feed conversion were measured daily, biweekly and monthly, respectively, from 19 to 40 weeks of age. The means were subjected to ANOVA and, when significant, means were compared by Duncan test. Statements of significance were based on $p \leq 0.05$. For the overall period, egg production, specific gravity, Haugh units, shell thickness and body weight were not different between the treatments ($p > 0.05$). Egg weight and shell weight were significantly lower for T2 and T3 when compared to the other treatments, ($p < 0.0001$ and $p = 0.0003$, respectively), whereas there was no significant difference among T1, T4 and T5. For feed intake, T2 showed the highest value, T3 had higher feed intake when compared to T1 ($p = 0.0006$), whereas there was no difference among T1, T3, T4 and T5. T2 and T3 presented higher feed conversion ratio when compared to T1, T4 and T5 ($p < 0.0001$). In conclusion, the results show that use of 50% or 33% of herbal methionine maintained comparable performance characteristics as well as egg production and quality to 100% DL-Met during the egg production period.

Key Words: Methionine, Laying Hen, Growth performance, Egg quality

P260 Methionine maintenance requirement estimations for 8 to 16 day old broilers Joel Montgomery^{*UG}, Katie Hilton, Michael Schlumbohm, Garrett Mullenix, Justina Caldas, Judith England, Craig Coon *University of Arkansas*

The purpose of this study was to determine maintenance of digestible methionine (dig met) for 8 to 16d Cobb 500 broilers. Eight hundred and four day-old male broiler chicks were placed in 12 floor pens and fed a common starter diet from 0 to 8d. The starter diet was formulated to meet Cobb 2015 recommendations. At 8d all chicks were weighed and the average body weight (BW) and SD (standard deviation) was determined. Four hundred and thirty two chicks were selected within 1 SD of the average BW and placed in 72 digestibility cages (6 birds/cage). Birds were fed 4 semi-purified test diets (12 reps per diet, 18 reps x 6 birds = 108 birds per diet) from 8d to 16d. Diets were formulated to contain 0, 5, 10 or 15% of the Cobb 2015 recommended level for dig met. All other amino acids, including cystine, were formulated to 15% of the recommended level to maintain the

recommended ratio to digestible lysine (dAA:dlys). At 8d, 20 chicks were selected for initial body composition determination. At 12, 14 and 16d, 20 birds per treatment were selected within 1 SD of the average treatment BW. Selected birds were euthanized by CO₂ inhalation and body composition was determined by DEXA scanning (dual energy X-ray absorptiometry) using the GE Lunar Prodigy with small animal software. Data was analyzed using JMP Pro 13 (SAS Institute, 2016). Day 8-14 birds fed 0% dig met had significantly ($p < 0.0001$) less body protein than birds fed 5, 10, and 15% dig met diets. However, at 16d, birds fed 0% and 5% dig met diets had significantly less ($p < 0.0001$) body protein than broilers fed 10% and 15% dig met. Linear regression ($p < 0.0001$, $R^2 = 0.90$) indicated daily digestible methionine requirement for broilers 8-16d is 300.5mg per day/kg BW.

Key Words: Maintenance, Methionine, Amino acid, Broiler, Body composition

P261 What are the best lysine and methionine+cystine levels to improve breast meat quality of broilers at 21 days old? Carla Heloisa Domingues^{*1}, Karina Duarte², Elaine Santos², Thays Quadros², Diana Castiblanco², Sarah Sgavioli², Rodrigo Garcia¹, Otto Junqueira² ¹Universidade Federal da Grande Dourados; ²Universidade Estadual Paulista

Nutritional recommendations for broiler diets are designed to maximize growth during rearing period. However, amino acid requirements may vary according to the ultimate goal of production. In Brazil, a large number of poultry companies has Arab Emirates as main market to export “Griller Chicken” and one of the main requirements of this market is meat quality. The aim of this study was to evaluate different levels of digestible lysine and methionine+cystine on meat quality of pectoral muscle (*Pectoralis major*) of broilers at 21 days old. A total of 3,200 one-day-old male Cobb x Cobb 500 chicks were used, distributed in a completely randomized design in a factorial arrangement 2X5 (two digestible lysine levels - 1.253 and 1.378% X five digestible methionine+cystine levels - 0.812, 0.860, 0.902, 0.947 and 0.992%) and eight replicates of 40 birds each. At 21 days of age, 480 birds were culled to the achievement of sampling pectoral muscle, which were submitted to analysis of the following parameters of meat quality: Color (L^* = lightness, a^* = redness, and b^* = yellowness), cook loss, shear force and pH values. There was no interaction ($P > 0.05$) of digestible lysine and methionine + cystine levels for any of the variables. There was an effect ($P < 0.05$) of digestible lysine levels on the meat color and shear force occurring highest rate of redness for birds that received the level of 1.253% digestible lysine when compared to those fed with diets containing 1.378% digestible lysine, while the opposite occurred with the shear force. The levels of digestible methionine + cystine did not influence ($P > 0.05$) the redness, yellowness, pH and cook loss of breast meat, however, there was a quadratic effect ($P < 0.05$) for lightness ($Y = 291.39 - 520.82x + 280.54x^2$, $R^2 = 0.94$), indicating 0.928% as the highest level of digestible methionine + cystine for this variable. It was observed a decreasing linear effect ($P < 0.05$) for shear force ($Y = 11.786 - 9.7403x$, $R^2 = 0.88$), with increased levels of digestible methionine + cystine feed. In conclusion, the results of this study suggest that diets with 1.253 and 1.378% digestible lysine levels improve redness and shear force respectively and 0.928% digestible methionine + cystine level improve the lightness.

Key Words: digestible amino acid, pectoral muscle, pH, shear force

P262 Effect of pullulanase present in sorghum grains on nutrients digestibility Bernardo Iglesias^{*1}, Jorge Azcona¹, María Charrière¹, Pedro Pardo² ¹INTA - EEA Pergamino; ²Advanta Semillas S.A.I.C., Investigación Sorgo

Pullulanase is a debranching enzyme naturally present in plants like sorghum. Two experiments (exp.) were conducted to evaluate the effect of this enzyme on true metabolizable energy (TME) of different sorghum grains. Also amino acid digestibility (AA dig) was determined in one of the exp. The treatments result from a 2x2 factorial arrangement of 2 levels of tannins (low, LT and high, HT) and 2 levels of pullulanase (with, AP and with-

out, WP). Tannin content was determined by Folin Dennis technic, pullulanase activity by enzymatic method using Azurine-crosslinked-pullulan as substrate, and TME and AA dig using adult roosters (Sibbald method). Data were analyzed by ANOVA and Duncan's multiple range test. TME: An interaction tannin x pullulanase was observed in both exp. thus data is reported within each level of tannin. The pullulanase has greater improvement in TME on HT sorghum than LT sorghum. Exp.1: Sorghum LT-WP had 3858 kcal/kg and LT-AP had 3988 ($P \leq 0.05$), while Sorghum HT-WP had 3454 kcal/kg and HT-AP had 3835 kcal/kg ($P \leq 0.05$). Exp.2: Sorghum LT-WP had 3951 kcal/kg and LT-AP had 4143 ($P \leq 0.05$), while Sorghum HT-WP had 3539 kcal/kg and HT-AP had 4006 kcal/kg ($P \leq 0.05$). In both experiments LT-WP and HT-AP did not differ ($P > 0.05$). Met+Cis dig: Sorghum LT-WP had 84.4% and LT-AP had 92.7% ($P \leq 0.05$), while Sorghum HT-WP had 36.2% and HT-AP had 89.1% ($P \leq 0.05$). Lis dig: Sorghum LT-WP had 81.8% and LT-AP had 91.7% ($P \leq 0.05$), while Sorghum HT-WP had 58.1% and HT-AP had 87.5% ($P \leq 0.05$). Average AA dig: Sorghum LT-WP had 84.4% and LT-AP had 92.7% ($P \leq 0.05$), while Sorghum HT-WP had 36.2% and HT-AP had 89.1% ($P \leq 0.05$). AA dig of HT-AP was higher than LT-WP ($P \leq 0.05$). In conclusion, sorghum grains with natural pullulanase activity had better energy and amino acids utilization, being this effect greater in HT sorghums than LT sorghums. The nutrients digestibility of HT-WP sorghums was similar to that of LT-AP.

Key Words: Poultry, Digestibility, Tannins, Energy, Amino acids

P263 Dose response of commercial phytases in broilers fed corn-SBM-animal byproducts based diets low in non-phytate phosphorus Sandra Rodrigues^{*1}, Ricardo Gonzalez-Esquerri¹, Raquel Araujo¹, Rafael Nascimento², Cristiane Araujo², Lúcio Araujo² ¹Novus International Inc.; ²Universidade de São Paulo

An 18d trial was conducted to evaluate the efficacy of different dosages of commercial phytases in broilers fed corn-SBM-meat and bone meal-poultry byproduct meal-feather meal based mash diets low in non-phytate phosphorus (npp). A total of 2,260 Cobb-500 d-old male chicks were randomly assigned to 13 treatments with 8 or 9 replicates of 20 broilers each. Treatments 1 to 4 consisted of 0.23% (negative control, NC), 0.28%, 0.33% and 0.38% (positive control, PC) npp diets, respectively. Treatments 5 to 13 consisted of NC plus 250, 500 or 1000 FTU/kg diet of phytase A, B or C, respectively. All diets were formulated to contain 0.74% Ca using limestone. Main ingredients plus Ca and P sources were analyzed before formulations. Nutritional levels were 25kcal and 5% AAs lower than Rostagno et al. (2011) for all diets. Performance from 1-18d, tibia ash percentage and P equivalence at 18d were analyzed using 1-way ANOVA and Tukey test at $P \leq 0.05$. Regression analysis were carried out considering treatments 1 to 4 in order to calculate phosphorus equivalence for treatments supplemented with phytases. Body weight gain (BWG) was higher for PC but not different from 0.33% npp, phytase A (250, 500 and 1000FTU) and phytase B at 500 and 1000FTU. Phytase C was not different from NC at any level. Feed intake (FI) was higher for PC, phytase A at 250 and 1000FTU and phytase B at 1000FTU than 0.23 and 0.28% npp. Livability and FCR did not present differences ($P > 0.05$). However, tibia ash (%) was higher for PC and phytase A at 250 and 1000FTU; without significant difference ($P > 0.05$) from 0.33% npp, phytase A at 500FTU and phytase B 1000FTU. Phytase C at 250 and 1000FTU was not different from NC for this parameter. BWG and tibia ash (%) presented linear improvement with graded levels of npp. Feeding phytase A at any level or phytase B at 1000 FTU resulted in higher P equivalence values when considered BWG or tibia ash. In summary, body weight gain and tibia ash percentage data indicates that phytase A and B are more efficient than phytase C; and in general, phytase A had a solid response requiring lower dosages to reach the 1000 FTU's performance levels of Phytase B and C.

Key Words: animal byproduct, broiler, phytase, dose response

P264 Measurement of uronic acid content in non-starch polysaccharide assays using microtiter plate reader spectrophotometer Pramir Maharjan^{*}, Maria Cortes, Katie Hilton, Craig Coon *University of Arkansas*

Pectin levels in non-starch polysaccharides (NSP) in feed ingredient is mostly contributed by the galacturonic acid. Measurement of uronic acid in the form of galacturonic acid in NSP assays are generally performed by using single-read spectrophotometers equipped with cuvettes. This method is tedious in handling samples especially in large numbers as the results of this assay are time dependent (due to color change) and involve relocating of strong acidic sample solutions to a cuvette prior to reading. This report describes the adjustment in methods involved in determining the pectic galacturonic acid content using microtiter plate reader compared to the spectrophotometer that uses cuvettes. First, non-cellulosic NSP fractions were separated out after starch removal process from the sample feeds (400 mg). 125 ul of the NSP fraction were used for the uronic acid assay, and were diluted to 1000 ul. The solution mixture was then treated with 125 ul of 2 % NaCl followed by acid hydrolysis (2ml of 18.4 M H_2SO_4) of pectic material in the solution for 10 min at 70 °C dry heat. The reaction mixture was then treated with 125 ul 3,5 dimethylphenol (DMP) solution, and was allowed to stand for 10 min before it was read for absorbances at 400 nm and 450 nm using spectrophotometer that uses 1 cm wide cuvette. Similar lab procedures were followed for uronic acid assay using microtiter plate reader, whereas this time only 250 ul of the sample solution was used and transferred to 96 well micro titer plate before absorbances were read. The difference in absorbance reads between 400 nm and 450 nm (to avoid interferences from neutral sugar components present in the sample) was used to calculate uronic acid content for both of the techniques using standard curves of known concentration of galacturonic acid produced separately for each of the techniques. 16 individual samples were analyzed for uronic acid content using both techniques. The results from each of the techniques were compared for each individual sample. Based on the results, the uronic acid assay using microtiter plate was found to be more sensitive ($P < 0.05$) for galacturonic acid detection than the spectrophotometer technique that used cuvette. The microtiter plate reader technique also seemed to be more convenient and safer while handling large numbers of samples.

Key Words: uronic acid, galacturonic acid, NSP, microtiter plate reader

P265 Effectiveness of feed additives to improve shell quality in older laying hens. Josephine Foley^{*GS}, Kathryn Hanford, Sheila Purdum *University of Nebraska - Lincoln*

In recent years, the poultry industry has experienced an onslaught of issues associated with H5N2, also known as Avian Influenza. Due to the outbreak of Avian Influenza, many laying hen facilities have been keeping hens in production much longer than their normal production period. As the hen ages, shell quality deteriorates leading to increased numbers of broken eggs which take a toll on the industry economically. For this reason, it is important to test products that may improve shell quality and bone health. This study sought to investigate the effectiveness of 3 different feed additives on shell strength and bone health in older white Leghorn hens. A total of 270 Bovan White laying hens were housed in 45 cages for a total of 24 weeks (6 months) from 58 weeks to 82 weeks of age. Each cage was assigned to one of five treatment groups with 9 replicate cages in a randomized complete block design. Group 1 was assigned as the control group, group 2 was supplemented with LayerMax Shell Add Pack, Group 3 was supplemented with EXPMCFA, Group 4 was supplemented with Fortishell for 24 weeks, and Group 5 was supplemented with Fortishell for 10 weeks, fed the control diet for 6 weeks, and fed Fortishell for another 8 weeks. Egg production, feed consumption, and mortality were recorded daily. Egg weights were measured and recorded biweekly. Eggshell strength and shell percent were measured biweekly, and Haugh Unit was measured monthly. This study found a higher percent egg production in Group 3 ($p=0.001$), supplemented with EXPMCFA, and the lowest percent production in the control group. A higher feed intake was calculated at a gram/hen/day rate in Groups 4 and 5

($p=0.0007$). The control group showed a markedly lower feed intake overall. A larger egg weight was noted for Groups 2 and 5 ($p=0.0012$), and the lowest average weight was measured in the control group. Finally, a higher egg shell breaking strength was found in Group 5 ($p=0.12$). Based on these results, this study found that certain supplements did successfully improve egg shell integrity in older laying hens compared to a control.

Key Words: Laying hen, Feed additives, Egg production

P266 Effects of a mannan oligosaccharide product on live performance and small intestine morphology in pekin ducks Jungwoo Park^{*GS}, Muhammad Hashim, Hector Leyva-Jimenez, Micky Clary, John Carey *Texas A&M University*

Two experiments were conducted to investigate the effect of a Mannan-Oligosaccharide (MOS) product on duck live performance, jejunum, and ileum. The 5 experimental treatments were; Control (CON), and MOS at 250 g/ton (T1), 500 g/ton (T2), 1 kg/ton (T3) and 2 kg/ton (T4). Mixed sex ducklings were housed in battery cages, 5 birds per unit, 9 replicates for a total of 45 ducks per treatment. Body weights, feed consumption, feed conversion ratio were evaluated at 7, 14 and 21d. The jejunum and ileum length, weight, index, and viscosity were evaluated at 21d. Body weight at 7d was not significantly different among the treatments in experiment 1. T1 and T4 had significantly higher body weights than T2 at 14d and 21d. Body weights in experiment 2 at 14d and 21d were not significantly different among the treatments. T3 had significantly higher body weight than T1 at 7d. Experiment 1 feed consumption at 7d and 14d were not significantly different among the treatments. T2 and T3 consumed significantly less feed than CON at 21d. Experiment 2 feed consumption at 14d and 21d were not significantly different among the treatments. T1 and T2 consumed significantly less feed than the T4 at 7d. Experiment 1 feed conversion at 7d and 21d were not significantly different among the treatments. T1 had significantly better feed conversion than the T3 at 14d. Experiment 2 T2 and T3 had significantly better feed conversion than the T1 and T4 at 7d. T3 had significantly better feed conversion than CON at 14d and CON, T1, and T2 at 21d. Jejunum length and weight were not significantly impacted by treatments in either experiment. Experiment 1 ileum length was not significantly impacted by treatments, but T3 had significantly heavier ileum than CON and T1. Experiment 2 ileum length and weight were not significantly impacted by treatments. Experiment 1 T3 had significantly greater ileum index than CON, T1, and T4. Experiment 1 jejunum viscosity was not significantly different among the treatments, but T2 and T3 had significantly lower ileum viscosity than CON. Both jejunum and ileum viscosity were not impacted by treatment in experiment 2. These experiments demonstrate 1 kg/ton of MOS could be beneficial regarding live performance and ileum morphology of ducklings.

Key Words: Mannan-oligosaccharide, Pekin duck, duck nutrition, live production, histology

P267 Evaluation of a Bacillus based DFM on male broiler growth performance as compared to antibiotic growth promotor Christopher Eagleson^{*GS1}, Rocky Latham¹, Cody Flores¹, Omar Gutierrez², Jason Lee¹ *¹Texas A&M University; ²Huvepharma Inc.*

The current environment of increasing production levels of broilers reared without antibiotics provides a need to identify potential replacements. Direct fed microbial (DFM) products have shown promise as a potential alternative to sub-therapeutic antibiotics. This experiment evaluated the impact of *Bacillus*-based DFM on male broiler growth performance in comparison to a known antibiotic growth promoter, bacitracin methylene disalicylate (BMD). Three dietary treatments were fed in a randomized complete block design with 10 replications of 40 Cobb 500 males/pen for a total of 1200 broilers placed on built-up litter for a 42 day evaluation period. The dietary treatments included: a non-medicated control comprised of a standard corn/soy diet with 5% DDGS inclusion and phytase, control with bacitracin methylene disalicylate (BMD) included at 50 g/ton, and control supplemented with DFM. On day of placement, all birds were spray vaccinated

with a commercially available coccidiosis vaccine in a commercial spray cabinet and allowed to preen 1 hr prior to randomization and placement. Three dietary phases were fed throughout the duration of the trial: starter (d 0-14, crumble), grower (d 14-28, pellet), and finisher (d 28-42, pellet). Body weight (BW) and feed consumption measurements were taken at the conclusion of each dietary phase and were used to calculate body weight gain (BWG), feed intake (FI), and mortality-corrected feed conversion ratio (FCR). The control diet fed broilers yielded the lowest BW through the duration of the experiment being significantly less than the BMD and DFM fed broiler on d 14, 28, and 42. The reduction in BW was a result of reduced FI in the control birds compared to the other two treatment groups. Additionally, FCR was increased in control fed broilers during the starter phase and cumulatively from d 1 to 28 as compared to the DFM and BMD fed broilers. The DFM fed broilers had significantly heavier body weight as compared to the BMD fed broilers on day 14 and 28. These data confirm that *Bacillus* based DFM products can potentially serve as an alternative to commonly used antibiotic without sacrificing performance.

Key Words: DFM, Broiler, Antibiotic Growth Promoter, Performance

P268 Evaluation of a direct fed microbial (DFM) compared to antibiotic growth promoters in male broiler growth parameters Kyle Smith^{*GS1}, Rocky Latham¹, Kyle Brown¹, Nathan Augspurger², Blyn Brown², Mike King³, Sona Son³, Jason Lee¹ *¹Texas A&M University; ²JBS United, Inc.; ³Microbial Discovery Group*

The objective of the current study was to evaluate the effectiveness of a *Bacillus*-based DFM on male broiler growth performance. Three dietary treatments were fed in a randomized complete block design with 10 replications of 40 Cobb 500 males/pen for a total of 1200 broilers placed on built-up litter for a 41 day evaluation period. The dietary treatments included: a non-medicated control comprised of a standard corn/soy diet with 5% DDGS, 2.5% meat and bone meal with the inclusion of phytase, control with bacitracin methylene disalicylate (BMD) included at 50 g/ton, and control supplemented with DFM. On day of placement, all birds were vaccinated with a commercially available coccidiosis vaccine in a commercial spray cabinet and allowed to preen 1 hr prior to randomization and placement. Broilers were placed on built-up litter from 4 previous flocks. Three dietary phases were fed throughout the duration of the trial: starter (d 0-14, crumble), grower (d 14-28, pellet), and finisher (d 28-41, pellet). Body weight (BW) and feed consumption measurements were taken at the conclusion of each dietary phase and were used to calculate body weight gain (BWG), feed consumption (FC), and mortality-corrected feed conversion ratio (FCR). Broilers fed both the BMD and DFM maintained an increased ($P<0.05$) BW compared to the NC throughout the experiment; additionally, during the starter and grower phases, the DFM inclusion had increased ($P<0.05$) BW compared to the BMD treatment. FC was increased ($P<0.05$) with the inclusion of DFM and BMD throughout the trial compared to the NC while during the starter and cumulatively through d 28, the DFM treatment increased ($P<0.05$) FC compared to the BMD. During the starter phase, FCR was reduced ($P<0.05$) with both BMD and DFM compared to the control. Both BMD and DFM yielded lower weight adjusted FCR values ($P<0.05$) compared to the NC when using 27 grams of BW equal to 1 point of FCR (0.01). Throughout the trial, the inclusion of DFM was either similar to or had improved performance compared to the BMD treatment. These data support the idea that *Bacillus*-based DFM inclusion in broiler diets can deliver similar growth performance levels as antibiotic growth promoters and can be considered as a potential alternative as the poultry industry moves to meeting consumer demands of antibiotic free production.

Key Words: Broiler, Direct Fed Microbial, Antibiotic Growth Promoter, Performance

P269 Evaluation of Direct-Fed Microorganism and functional feed ingredient co-administration on the gastrointestinal microbiota of broiler chickens Timothy Broderick*^{GS1}, Jason Lee¹, Omar Gutierrez²
¹Texas A&M University; ²Huvepharma, Inc

Administration of Direct-Fed Microorganisms (DFM) and functional feed ingredients, including dietary prebiotics and botanical extracts, has been demonstrated to improve growth performance, animal health, and microbial food safety in poultry and is thought to be a potentially important component of antibiotic free poultry production. In this study, we investigated the co-administration of Direct-Fed *Bacillus licheniformis* with proprietary functional ingredient blends containing dietary prebiotics and botanical extracts in broiler chickens over a 42 day growth period. Five treatment groups were fed experimental rations comprised of an untreated control, an antibiotic-treated control (bacitracin methylene disalicylate), Direct-Fed *B. licheniformis*, and Direct-Fed *B. licheniformis* co-administered with one of two proprietary blends of functional feed ingredients. Culturing of gastrointestinal microbiota determined administration of functional ingredients decreased counts of *C. perfringens* ($P = 0.018$) as compared to the untreated control and increased counts of *Lactobacillus* spp. ($P = 0.036$) as compared to the antibiotic-treated control. DFM and functional ingredient administration was not observed to have a significant effect on *Campylobacter jejuni*, total Enterobacteriaceae, or *Enterococcus* spp., overall. Correlation analysis revealed significant associations between populations of *Lactobacillus* spp. and *C. jejuni*. Positive associations were observed between counts of *C. jejuni* in the cecum with *Lactobacillus* spp. in the ileum ($r = 0.375$, $P = 0.012$) and in the cecum ($r = 0.455$, $P = 0.001$) at Day 21, while a positive association was observed at Day 42 between *Campylobacter* in the cecum and *Lactobacillus* ($r = 0.556$, $P = 0.000$) in the ileum. Our results suggest co-administration of Direct-Fed *B. licheniformis* and functional feed ingredients can be used to reduce *Clostridium perfringens* and promote *Lactobacillus* spp. in the gastrointestinal tract of broilers.

Key Words: *Bacillus licheniformis*, DFM, *Clostridium perfringens*, *Lactobacillus*

P270 Comparison the effect of antibiotic, probiotic, prebiotic, phytobiotic and Bacillus subtilis on broiler performance Monese Hamidi*¹, Shaban Rahimi¹, Nahid Mojmami² ¹Tarbiat Modares University; ²Razavi vaccine and serum Production Research Institute

In this study, the effects of antibiotic (oxytetracycline), probiotics (type 1 and type 2), Bactocell, prebiotic (Diamond V Original XPCTM), phytobiotic (licorice extract with thyme), phytobiotic plus probiotic type 2, and *Bacillus subtilis* on broiler performance were evaluated. Experiment was performed in a completely randomized design with 7 treatments, 4 replicates and 14 chicks in each pen. The experimental diets were fed from day one until day 42. Feed intake, weight gain and feed conversion ratio were measured on a weekly basis. Statistical analysis of the data showed significant effect of treatments on FI, WG and FCR ($P \leq 0.05$). Administration of probiotics, phytobiotic, and *Bacillus subtilis* to the diet resulted in reduce of FI and FCR compared to the antibiotic and control groups ($P \leq 0.05$). Higher weight gain was seen in probiotic and phytobiotic treatments compared to prebiotic group ($P \leq 0.05$). In conclusion, using probiotic, phytobiotic and *Bacillus subtilis* in broiler diets improve growth performance of these birds; therefore, can be considered as antibiotic alternatives in poultry production.

Key Words: antibiotic, *Bacillus subtilis*, broiler

P271 Intestinal mucosal development and meat quality in broiler chicks fed diets containing Ginkgo biloba leaves or fermented garlic, singly or in combination Sang Lee*¹, Hashemi Mahmood¹, Yu Thaw¹, Da Hye Kim¹, Moungh Cheul Keum¹, Byoung Ki An¹, Kyung Woo Lee¹, Yong Suk Lee², Youn Geun Jeong² ¹Konkuk University; ²eagleview inc.

A study was carried out to evaluate the effect of solvent-extracted *Ginkgo biloba* leaves (GK) and fermented garlic (FG), singly or in combination, on

growth performance, intestinal morphometry, meat quality, and antioxidant capacity of broilers. A total of 600 day-old broiler chicks were randomly assigned to four treatments, each with six replicates of 25 chicks and were fed on an experimental diet containing 2,000 mg/kg of GK, 2,000 mg/kg of FG, or 1,000 mg/kg of FG plus 1,000 mg/kg of GK (FGK) for 35 days. Data were analyzed using one-way analysis of variance (ANOVA) and treatment means were separated via Duncan's multiple range test. Either FG or GK, singly or in combination, had no effect on average daily gain, average daily feed intake and feed:gain ratio in broiler chicks. Dietary GK reduced ($P < 0.05$) the cooking loss of thigh meats compared with the control group. Chicks fed the GK or FG-added diet had higher ($P < 0.05$) pH of breast meat compared with those on the control diet. Dietary FGK or FG decreased ($P < 0.05$) malondialdehyde content in thigh meat compared with the control group. At day 14, the villus surface area of duodenum was increased ($P < 0.05$) in the GK-fed chickens compared with those on the control diet. However, the GK-induced increase in villus surface area was not noted in jejunum or ileum, or in later days. Collectively, it seems that dietary FG enhanced *in vivo* antioxidant property as manifested by its lowering effect on malondialdehyde contents in chicken meats. Furthermore, dietary GK improved gut function and meat quality in broiler chickens.

Key Words: *Ginkgo biloba* leaves, fermented garlic, growth performance, meat quality, antioxidant capacity

P272 Dietary calcium-butyrate versus citri Dietary calcium-butyrate versus citric acid improves eggshell quality of laying hens in the late stage of production Moungh Keum*, Da Kim, Sang Lee, Kyoung Lee, Byoung an Konkuk university

An experiment was conducted to determine the effects of two different organic acids on egg production, eggshell quality and eggshell ultrastructure, and tibia characteristics in old laying hens. A total of 216 commercial hens (Hy-Line Brown) aged 60 weeks were randomly assigned to 3 treatments with 8 replicate of 9 birds each. A corn-soybean meal basal diet was used as the control diet, (CONT). To formulate the experimental diets, the CONT diet was mixed with citric acid (CIT) and ca-butyrate (CaBU). The experiment lasted 8 weeks. All data were analyzed using the ANOVA procedure of SAS. Dietary treatments did not affect egg production, feed intake, egg mass, feed conversion ratio and cracked eggs. Egg weights were low ($P < 0.01$) in CaBU groups compared with the CONT. Eggshell strength was increased ($P < 0.01$) in CaBU groups compared with the CONT and CIT. Feeding a diet containing CaBU increased ($P < 0.05$) relative eggshell weight compared with the CONT. Finally, dietary treatments failed ($P > 0.05$) to affect eggshell and yolk colors, Haugh unit, eggshell thickness, eggshell ultrastructure (i.e., palisade or mammillary layer), or tibia characteristics including tibia breaking strength and tibia length. It is concluded that dietary CaBU versus citric acid was considered effective organic acid in improving eggshell quality of laying hens in the late stage of production.

Key Words: Ca-butyrate, citric acid, eggshell quality, aged laying hens

P273 Effect of Amasil NA on growth performance and Salmonella Typhimurium colonization in broilers Pratima Acharya Adhikari*¹, Joshua Jendza², Douglas Cosby³, Nelson Cox³, Woo Kyun Kim⁴ ¹University of Georgia; ²BASF Corporation; ³United States Department of Agriculture, U.S. National Poultry Research Center; ⁴Department of Poultry Science, University of Georgia

The effect of Amasil NA (feed grade sodium formate) on growth performance and *Salmonella* Typhimurium (ST) was investigated in a 42-d experiment. There were five treatments: a negative control diet without ST challenge (NC), positive control diet with ST challenge (PC), PC + 0.3% of Amasil NA, PC + 0.6% of Amasil NA and PC + 0.9% of Amasil NA. A total of 800 d-old Cobb chicks were distributed into four groups of 200 in each, comprising four replicates per treatment. Chickens were individually challenged with 10^7 cfu/ml of nalidixic acid resistant ST (ST^{NAR}) on d-4 post-hatch. Growth performance was measured at d 14, 28 and 42 and 10

chicks per pen were euthanized to sample ceca at 9, 24 and 38 days post-infection (dpi). The FCR in the PC + 0.3%, 0.6% and 0.9% Amasil NA fed birds was similar to the NC in the grower phase. The body weight and body weight gain were not affected either in the starter or grower phases. However, in the finisher phase, body weight gain in Amasil NA group was better than the PC and similar to NC group. There was a significant effect ($P < 0.05$) of Amasil NA on the colonization of cecal ST. Supplementation of highest level, 0.9% of Amasil NA showed better result in all days post challenge. At 9 dpi, cecal ST^{NAR} was $3.28 \log_{10}$ in PC that was reduced to $2.65 \log_{10}$ at 0.3%, $1.40 \log_{10}$ at 0.6% and $0.84 \log_{10}$ in 0.9% Amasil NA. At 24, dpi, cecal recovery was 0.81, 0.99, 0.53 and $0.33 \log_{10}$ in PC, 0.3%, 0.6% and 0.9% Amasil NA, respectively. Similarly, at 38 dpi, cecal recovery of ST^{NAR} was 0.26, 0.11, 0.33 and $0 \log_{10}$ in PC, 0.3%, 0.6% and 0.9%, respectively. The results show that Amasil NA can be one of the dietary strategies to control infection caused by *Salmonella*.

Key Words: acidification, broilers, performance, *Salmonella*

P274 Effects of prebiotics and probiotics on the performance and bacterial colonization of broiler chickens Alaeldein Abudabos*, Hamad Al-Batshan *King Saud University*

A study was undertaken to evaluate the effects of Neoxyval (antimicrobial growth promoter (AGP)), TechnoMos (prebiotic), GalliPro (probiotic) and a mixture of TechnoMos and GalliPro (symbiotic) on growth performance, carcass yield, histomorphology and intestinal bacterial counts in broilers (0 d to 42 d). Two hundred day-old Ross (308) broilers were allocated to five experimental treatments: T1 = control (CONT), T2 = T1 + Neoxyval, T3 = T1 + GalliPro, T4 = T1 + TechnoMos and T5 = T1 + GalliPro + TechnoMos. The results revealed that birds that received T2, T4 and T3 gained more weight and converted feed more efficiently than those in T1 and T5 ($P < 0.01$). Longer ileal villi ($492.9 \mu m$) were recorded in birds that received T4 compared with T1 ($424.7 \mu m$) and T2 ($439.9 \mu m$) ($P < 0.05$). Conversely, jejunal villi length and width were not influenced by treatment. T3 eliminated *Clostridium perfringens* from the ileum ($P < 0.05$), but not from the caecum. Generally, birds that received T3 and T5 performed similar to the AGP group, T2. The results from this study indicated that the probiotic (T3) and prebiotic (T4) used in this trial could serve as alternatives to AGP (T2). Enhancement in the performance of broilers could be explained partially by improvement in intestinal morphology and microbial balance associated with modulation of intestinal microflora and inhibition of pathogens.

Key Words: Antimicrobial growth promoters (AGPs), broiler performance, prebiotic, probiotic, symbiotic

P275 The effect of phytogenic feed additives to substitute in-feed antibiotics on growth traits and blood biochemical parameters in broiler chicks challenged with *Salmonella typhimurium* Alaeldein Abudabos* *King Saud University*

There is a growing concern over the use of antibiotics due to the increased resistance of pathogens in broiler. The present study was designed to find the comparative effect of an antibiotic, and some phytogenic on performance traits, blood biochemical parameters, and antioxidant status during starter phase exposed to *Salmonella typhimurium* challenge. A total of 560-day-old broiler chicks (Ross 308) were randomly allocated to seven treatments (eight replicates). Control (basal diet); T1, infected with *Salmonella enterica* subsp. *typhimurium*; T2, infected + avilamycin at the rate of 0.2 g/kg; T3, infected + essential oil of thymol; T4, infected + phytogenic; T5, infected + anti-*Salmonella* organic acid; and T6, infected + essential oils of thyme, anise, and other components. Body weight gain and feed conversion ratio (FCR) were significantly ($P < 0.05$) high in the T2 and T5 at the end of the first and the second week and similar to T4. During the second week, European production efficiency factor (EPEF) was also significantly ($P < 0.05$) high in T2, T4 and T5. Blood albumin increased significantly ($P < 0.05$) in birds of T2 in the first week, while during the second week, blood glucose and triglyceride concentration decreased significantly ($P < 0.05$) in T5. Blood ALT concentration decreased significantly

($P < 0.05$) in T6 compared to other treatments in the second week. Total antioxidant capacity (at the end of the second week) and thiobarbituric acid reactive substances (TBARS) did not change significantly. From the results of the present study, it was concluded that different feed additives could be substituted with antibiotics in the feed of broiler exposed to *S. typhimurium* challenge.

Key Words: Antibiotic, Broiler, *Salmonella*, Phytogenic, Essential oil

P276 Study by flow cytometry of the bacteriostatic effect of a commercial blend of essential oils at sub-inhibitory concentrations against *E. coli* Sylvain Kerros*¹, Claire Girard², Karine Fayolle², Françoise Leriche², Thibaut Chabrilat¹ ¹*Phytosynthese*; ²*VetAgro Sup*

The evolution of antibiotic resistance is a crucial challenge. Phytogenic additives are an alternative to antibiotics use in animal feed, but their mode of action remains unclear. This work investigates the action of a commercial mixture of essential oils used at growth inhibitory concentration (GIC) and sub-inhibitory concentrations (sub-GIC, GIC dilutions) on both growth and physiological state of an *E. coli* reference strain.

E. coli has been exposed to 4 different inhibitory concentrations (GIC, GIC/2, GIC/4 and GIC/8) of the essential oils blend in triplicate. A growth monitoring by optical density allowed measuring the growth data (lag time and maximal optical density) for each dilution and a negative control.

A second experience using flow cytometry with propidium iodine as a viability marker with red fluorescence intensity has been achieved. The objective was to evaluate the membrane alteration caused by dilutions of essential oils mixture and colistin antibiotic (positive control).

A growth delay and a decrease of the maximum bacterial load are observed at sub-inhibitory concentrations of the essential oils mixture, compared to the control. A statistical analysis of variance through a F-test was used on the specific variable growth delay (measured of the lag time in hours in triplicate) depending on the level of three sub-inhibitory concentrations (GIC/2, GIC/4 and GIC/8). F-test result with a F ratio > 10.92 with (2,6) degrees of freedom and p-value of 0.01% proved significantly that growth delay is sub-GIC dependent.

This growth delay affected by the essential oils mixture may be partially explained by an alteration of membrane permeability observed at several dilutions tested (GIC, GIC/2, GIC/4). However, a simple linear regression analysis showed a significant difference in the dose dependent kinetics between essential oils blend ($R^2=0.80$) and antibiotic ($R^2=0.98$) actions.

In this study, we demonstrate the bacteriostatic mode of action of the essential oils mixture at sub-GIC and a loss in the bacteria viability through membrane permeabilization. A further work could investigate other mode of action by evaluating effects on intracellular pH, membrane potential and enzymatic activity.

Key Words: essential oils, sub-inhibitory concentration, growth inhibition, flow cytometry, membrane permeability

P277 Using nutritional strategies to improve egg shell and bone quality of layers for a single lay cycle Tuoying Ao*, Aidan Connolly, Marquisha Paul, Anthony Pescatore, Lizza Macalintal, Mike Ford, Karl Dawson *Alltech-University of Kentucky Nutrition Research Alliance*

A single lay cycle management program involving continuous production of laying hens to 85-90 weeks of age has been adopted by the egg industry due to animal welfare concerns and economics related to molting practices and regulations regarding *Salmonella* monitoring in the environment. However, a single lay cycle with an extended lay period faces many challenges such as osteomalacia of layers, poor egg shell quality and layer fatigue. The objective of this trial was to investigate the effect of using nutritional strategies (Poultry Advantage Pak, De-odorase®, Alltech Inc.) on production performance, egg shell quality and bone quality of laying hens. A 2 x 2 factorial treatment structure with two supplemental levels of Poultry Advantage Pak or De-odorase® in a corn-soy based diet was used.

Two hundred eighty eight Hy-Line Brown layers at 60 weeks of production were randomly assigned to each of four dietary treatments with six replicate units of 12 layers. The layers were raised in layer cages using two birds per cage (25 x 41 cm) and photo-stimulated with 16L: 8D. Feed and water were provided ad libitum. Dietary treatments continued through 80 wk of production. No effects of dietary treatments on egg production, feed conversion ratio and body weight were detected. Dietary De-odorase® increased ($P<0.05$) feed intake (106 vs. 109 g/hen/d). The percentage of bad shell eggs including shell-less eggs, soft-shelled eggs, cracks, corrugated eggs and wrinkled eggs etc. was reduced ($P<0.05$) by dietary Poultry Advantage Pak or De-odorase® or both. The values were 4.15, 1.10, 1.58 and 1.57% for hens fed control, + Poultry Advantage Pak, + De-odorase® and + both. Dietary Poultry Advantage Pak increased ($P<0.05$) tibia bone ash content (63.5 vs. 66.0%). The results indicate that dietary Poultry Advantage Pak and De-odorase® can be used to improve egg shell and bone quality of layers for a single lay cycle.

Key Words: layer, a single lay cycle, performance, shell quality, bone quality

P278 Spores from the probiotic strain *Bacillus subtilis* DSM 32315 remain viable after pelleting and long term storage and are able to germinate in poultry intestinal conditions. Rose Whelan^{*1}, Kiran Doranalli¹, Ines Ochrombel¹, Judith Ringel¹, Markus Wiltafsky¹, Kirsi Vienola², Teemu Rinttilä², Juha Apajalahti² ¹*Evonik Nutrition & Care GmbH*; ²*Alimetrix Ltd.*

A unique strain of *Bacillus subtilis* DSM 32315 was identified as a potential probiotic for poultry as it was shown to inhibit the growth of pathogens and express secondary metabolites with hypothesized effects on gut health. In order to verify the potential of *B. subtilis* DSM 32315 as a probiotic for in feed applications, the ability of *B. subtilis* DSM 32315 spores to remain viable after pelleting and feed storage was tested. Additionally, *B. subtilis* DSM 32315 spores were germinated in digesta from broiler birds.

Spores of the *B. subtilis* DSM 32315 strain were mixed in poultry feed. Total spores were counted after mixing in the mash feed ($n=10$). Feed was then pelleted at 85°C and spores were counted ($n=5$) to check the recovery. The coefficient of variation (1.6%) for spore counts between samples showed good mixing of the product. More importantly, there was no loss of spores after pelleting of the feed. In a test to measure the storage stability of spores in pelleted feed, spores were counted in 3 replicate feed samples taken directly after pelleting at 85°C as well as after 2, 4, 8 and 12 weeks of storage at 40°C and 80% humidity. No significant loss of spores was observed for any of the time periods investigated.

Finally, a germination study was conducted to investigate if *B. subtilis* DSM 32315 spores are able to germinate in the intestinal conditions. Digesta was collected from the proximal intestine, ileum and cecum of broiler birds. *B. subtilis* DSM 32315 spores were then incubated in digesta samples in conditions mimicking the intestinal sections. A qPCR-based method indicated that the total *Bacillus* in each digesta section increased within the first 4h incubation. Culture-based quantification indicated that there was a concomitant increase in vegetative cell count and drop in spore count. This suggests that *B. subtilis* DSM 32315 spores are germinating in conditions of the broiler intestine.

These studies verify the application of *B. subtilis* DSM 32315 spores as a probiotic in poultry feed by providing evidence that these spores can withstand feed production and storage to then germinate in the digesta of broiler birds.

Key Words: Probiotic, Bacillus, Spore, Germination, Viability

P279 The effect of *Bacillus* sp. in broilers to control *Clostridium perfringens* induced necrotic enteritis Sean Griffin^{*1}, Greg Mathis³, Charles Hofacre², Brett Lumpkins³ ¹*Osprey Biotechnics*; ²*The University of Georgia, Poultry Diagnostic Center*; ³*Southern Poultry Research, Inc.*

Objective: To determine the effectiveness of using the Microlife® L *Bacillus licheniformis* and Microlife® S *Bacillus subtilis* direct fed microbials in feed to reduce negative effects of a toxigenic *C. perfringens* on broiler chickens in a necrotic enteritis (NE) challenge model (Hofacre 1998).

Materials & Methods: 1,200 day-of-hatch male Ross x Ross chicks were randomly allocated to 4 treatment groups, with 6 replicates per treatment, 50 chicks per replicate. All received vegetarian, non-medicated, non-enzyme commercial-type broiler starter DOT 0-21 (crumbles), grower 21-29, finisher 29-43. Pelleting of rations was 80°C. Groups included No Additive, and those supplemented with Microlife L *Bacillus licheniformis* at 3 x 10⁵ cfu/g, Microlife S *Bacillus subtilis* at 3 x 10⁵ cfu/g and BMD® 50g/ton feed for the entire 43 Day trial period. All birds received a coccidia challenge at DOT 0 by spray application with the coccidia vaccine, Advent®. *C. perfringens* was evenly mixed into the feed on DOT 19, 20, 21 at ~1x10⁸ cfu/ml/bird.

Results: The results showed that Microlife L *B. licheniformis*, improved adjusted feed conversion significantly by 6.6 points (3.7%) compared to No Additive and significantly equal to BMD ($P<0.05$). NE Lesion Scores for Microlife L were numerically equal to BMD 50g/ton at 0.37 in this pen trial. NE lesion improvement was also evident in a 28 Day Battery Trial entitled Comparative efficacy of DFM's for the control of necrotic enteritis caused by *C. perfringens* in broiler chickens, G. Mathis et al, 2014. In this trial, Microlife L NE Lesion Scores were significantly lower than BMD, Competitor probiotic, and No Additive ($P<0.05$).

Conclusion: Both Microlife *Bacillus* probiotics improved feed conversion significantly by day 29 and this effect persisted until DOT 43 end of trial ($P<0.05$). Both Microlife *Bacillus* direct fed microbials improved feed conversion and NE symptoms were similar in birds given the direct fed microbials or the antibiotic BMD.

Key Words: Bacillus licheniformis, Necrotic Enteritis, Clostridium perfringens, probiotic, Direct Fed Microbial

P280 Effect of Herb Mate inclusion in broilers' diet on carcass yield and chemical composition of breast and thigh meat Rodrigo Garcia^{*1}, Sarah Sgavioli¹, Carla Domingues¹, Gabriela Andrela¹, Irenilza Naas¹, Beatriz Roriz¹, Bruna Barreto¹, Claudia Cardoso², Paulo Rodrigues³, Tassia Bevilacqua¹, Rosana Bicas¹, Rodrigo Borille⁴ ¹*Universidade Federal da Grande Dourados*; ²*Universidade Estadual de Mato Grosso do Sul*; ³*Universidade de São Paulo*; ⁴*Universidade Federal de Santa Maria*

Food originated from animals that received inclusion of certain phyto-genic additives in diet generally show improvement in meat quality, due to antioxidant and fat-soluble characteristics, favoring oxidative stability of muscle tissues and oxidation processes in the body. The aim of this study was to evaluate the effect of herb mate (*Ilex paraguariensis*) in broilers' diet on carcass yield and chemical composition of breast and thigh. A total of 800 broilers (males) of Cobb 500 strain were used, divided into 32 boxes of 25 birds each, raised until 42 days. Four treatments were determined by levels of herb mate inclusion in diet (0.0, 0.2, 0.4, 0.6), distributed in a completely randomized design. It was evaluated hot and cold carcass yield, pH of breast and thigh meat, as well as dry matter (%), crude protein (%) and ether extract (%). Data were submitted to variance analysis (ANOVA, $P<0.05$) and in case of significance effect regression analyzes were performed. Results showed that there was an increase ($P<0.05$) of hot carcass yield and ether extract content in broilers thigh meat, with the increasing of herb mate levels in diet. Remaining variables had no significance effect ($P>0.05$) with herb mate inclusion in diet. In conclusion, the addition of herb

mate in broilers diet influences hot carcass yield and ether extract content of broiler thigh meat.

Key Words: carcass yield, fatty acids, phytogetic additives

P281 Effects of the dietary supplementation with a Schizochytrium sp algae on laying hen performance and egg yolk fatty acid composition

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A study was conducted to evaluate the effects of the dietary supplementation of a natural source of docosahexaenoic acid (DHA; C22:6n-3 from *Schizochytrium* sp. algae, SA) on laying hen performance parameters and egg yolk fatty acid profile. Sixty 27-week-old Babcock Brown hens were divided into four experimental groups that received graded levels of SA supplementation on a corn-soybean diet as follows: 0, 0.5%, 1.0% and 1.5%. The experiment was conducted for 90 days. Production parameters were monitored daily and analyzed weekly. Serum activity of lactate dehydrogenase (LDH), aspartate aminotransferase (AST) and amylase were tested at days 7, 42 and 84 from 10 hens per experimental group. Egg yolk fatty acid (FA) profile was determined daily from days 1 to 8 and then weekly until day 89. The results showed that yolk fat DHA levels increased in a dose-response fashion with the inclusion level of SA and reached at plateau at day 8 of the experiment. Egg fat DHA average of all measurements from 8d was 0.88, 1.87, 2.49 and 2.94% ($P < 0.05$) with SA supplementation of 0, 0.5, 1.0 and 1.5%, respectively. Arachidonic acid (AA), a major n-6 fatty acid, was significantly reduced by dietary DHA. It was expressed under function $Y = 2,2557 - 0,2962X$ ($Y = AA$; $X = DHA$; $r^2 = 0.99$). Further, the n-6/n-3 FA ratio in yolk fat was reduced from 13.3 in the control group to 6.7 (SA 0.5%), 5.4 (SA 1.0%), and 4.5 (SA 1.5%) ($P < 0.01$). Egg production, egg weight and egg yolk pigmentation which were all significantly lower in the group receiving 1.5% SA compared with the control ($P < 0.01$). No significant differences in the serum activity of LDH, AST or amylase were observed at any sampling time. It was concluded that the dietary supplementation of 1.0% SA is able to increase egg yolk DHA content and decrease the n-6/n-3 ratio without affecting performance parameters.

Key Words: Schizochytrium spp., DHA, Egg yolk, gas chromatography, Omega-3

P282 Inclusion of Herb Mate in diet change fatty acid profile of broiler meat

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Several studies have shown that herb mate (*Ilex paraguariensis*) extracts have antioxidant effects, protecting low density lipoproteins in human plasma from oxidation, and preventing lipid peroxidation of rat liver microsomes. The aim of this study was to evaluate the effect of herb mate in broilers' diet on levels of four polyunsaturated fatty acids of broiler meat. A total of 800 broilers (males) of Cobb 500 strain were used, divided into 32 boxes of 25 birds each, raised until 42 days. Four treatments were determined by levels of herb mate inclusion in diet (0.0, 0.2, 0.4, 0.6), distributed in a completely randomized design. In laboratory four polyunsaturated fatty acids (linoleic acid, α -linolenic, arachidonic and eicosapentaenoic) contents were determined from chicken thigh meat. Data were submitted to variance analysis (ANOVA, $P < 0.05$) and in case of significance effect regression analyzes were performed. Results showed significant increase ($P < 0.001$) in all evaluated fatty acids (linoleic, α -linolenic, arachidonic and eicosapentaenoic) levels of chicken thigh, with increasing of herb mate inclusion levels in diet. It was concluded that herb mate influences the profile of polyunsaturated fatty acid of broiler thigh meat.

Key Words: fatty acids, lipid profile, phytogetic additives

P283 Inhibition of Campylobacter jejuni by Original XPC™ in an anaerobic mixed fecal in vitro culture system. Peter Rubinelli*, Si Hong Park¹, Hillary Pavlidis², Donald McIntyre², Steven Ricke¹ ¹University of Arkansas; ²Diamond V

Campylobacter continues to be a primary food safety issue in commercial poultry. Therefore, methods are needed to rapidly evaluate the inhibitory activity of prebiotic and prebiotic-like materials on *Campylobacter*. This study was designed to test the hypothesis that the functional metabolites in Diamond V Original XPC™ can inhibit *Campylobacter* under anaerobic conditions in the presence of non-sterile chicken feed and chicken fecal matter. Fresh fecal samples were collected from the cages of four 5 week-old broiler chickens. Working in an anaerobic chamber, a 0.1 g portion of each fecal sample was added to 300 ml ADS. Then 20 ml of the fecal slurries was added to 0.25 g chicken feed with and without 0.2 g Original XPC (XPC), for a final concentration of 1% XPC (w/v). The slurries were incubated for 24 h under anaerobic atm, 42 C, 150 RPM mixing. Subsequently, a marker strain of *Campylobacter jejuni* was introduced at 1×10^7 CFU/ml, and at 0, 24, and 48 h a portion of the slurry was removed, dilution plated onto selective CEFEX medium, and incubated under microaerophilic atm for 48 h. Colonies were then counted to determine any effect of XPC on the survival of the *Campylobacter*. Two separate trials were conducted. Both trials contained the non-sterile chicken feed and the marker strain *C. jejuni*, with and without XPC. The first additionally contained the 1:3000 dilution of fecal matter, while the second contained only the non-sterile chicken feed + *C. jejuni* marker strain with and without XPC. In Experiment 1, the mean log CFU/ml for *C. jejuni* in the Feed Only treatment was 3.02, while for the Feed + XPC treatment it was less than 1 (below the limit of detection). In Experiment 2, the mean log CFU/ml for *C. jejuni* in the Feed Only treatment was 2.87, while in the Feed + XPC treatment it was again less than 1 (undetectable). These results indicate that Original XPC has a reproducible inhibitory effect on *C. jejuni* in an *in vitro* anaerobic culture system. The results further indicate that fecal matter was not required for the inhibitory effect. Further studies are needed to evaluate the requirement for the non-sterile chicken feed, which may supply microorganisms that contribute to the reduction of *C. jejuni* in conjunction with XPC.

Key Words: Campylobacter, XPC, prebiotic, prebiotic-like, in vitro

P284 Study on effects of Probiotic with herbal oil in growth performance and carcass traits of Japanese Quail sagar Paudel*, Bhesh Bhandari, Damodar Neupane, Ajit Jha, Mukesh karki, Niraj Baskota, Deepak Adhikari *Nepal Agricultural Research Council*

The aim of the present study was to investigate the effect of dietary supplementation with commercially available a Probiotic and Herbal Oil (HO) on growth performance and carcass traits of Japanese quail. Eight hundred one day-old quails chicks were randomly divided into four treatment groups of 200 birds (probiotic at four levels). Each treatment group was further sub-divided into four replicates of 50 birds (25 male and 25 female) per replicate. Feed were formulated based on Probiotic levels (Treatment 1 with 40mg herbal oil with Probiotic 1gram/kg, Treatment 2 with 50mg HO and Probiotic 2g/kg, Treatment 3 with 55 mg HO and Probiotic 3g/kg and treatment 4 Probiotic 3g/kg). There were significant effects of dietary herbal oil and Probiotic levels on body weight gain, feed intake, carcass yield ($P < 0.05$). At day 42, birds fed the diet in treatment 1 showed the highest body weight gain (175g, 169g, 165g and 160g) highest feed intake (450g, 438g, 445g and 420g) highest feed conversion ratio (3.5, 3.9, 4.1 and 4.1) and highest carcass yield (95g, 90g, 93g and 89g) ($P < 0.05$). This was followed by chicks on the diet containing treatment 2, treatment 3 and treatment 4 in decreasing order. The feed intakes at days 21 and 42 were significantly different between the treatments. There were no significant differences of the quails at 42 days of age in terms of sensory evaluation. It was concluded that the supplementation of the 40 gram herbal oil with Probiotic 1gram/kg to quails diet had beneficial effects on body weight gain, feed intake feed conversion ratio and carcass yield.

Key Words: probiotic, quail, feed intake

P285 Effects of lysophospholipid product (Lipidol™) on growth performance in broilers fed with a commercial or re-formulated energy diet Byoungyun Jung^{*1}, Ernesto González², Carlos Coello², José Menocal² ¹EasyBio Inc; ²Carval Group

A study was conducted to evaluate the effects of supplementing different levels of lysophospholipid product (Lipidol™) to commercial or re-formulated energy diet on growth performances in broilers. A total of 2,400 1-day old cobb-500 birds were randomly allocated to 6 treatments with 8 replicates each with 50 birds. The experiment arranged a 2 × 3 factorial design. Factors were energy level (commercial or 100kcal/kg metabolism energy reduced) and Lipidol™ level (0, 0.05%, or 0.1%) of diets. Three diet phases were fed throughout the trial: starter (d 0–10), grower (d 11–24), and finisher (d 25–42). Body weight (BW) and feed intake (FI) were measured and feed conversion ratio (FCR) was calculated at the end of each phase. The birds fed with commercial energy diets had higher BW at 42 days of age ($p < 0.01$) and lower FCR value in all phases ($p < 0.01$) as compared to the birds fed with a re-formulated energy diet (100kcal/MT reduced energy). The additive effects of Lipidol™ were observed with a higher level of BW at 0.1% during the grower period and at 0.05% during the finisher period ($p < 0.01$) as compared to the non-Lipidol™ group. The addition of 60.05% Lipidol™ to the commercial diet significantly increased BW at d 42 as compared to the commercial diet. There was no difference on BW between the birds fed with a commercial diet and the birds fed with a re-formulated diet plus 0.05% Lipidol™. The supplementary effects of Lipidol™ at 0.05% and 0.1% were observed with a significantly improved FCR at d 10 and 24 as compared to the non-Lipidol™ group. The birds fed with the commercial diet plus 0.05% or 0.1% Lipidol™ had better FCR than the birds fed with commercial diet at d 10 and 24. There was no difference on FCR between the birds with fed a commercial diet and the birds fed with a re-formulated diet plus 0.1% Lipidol™ at d10 and 24. In conclusion, the addition of 0.05% Lipidol™ to the commercial diet had a positive effect on growth performance and adding 0.1% Lipidol™ alleviated the negative effects on the growth performance resulted from feeding 100kcal/MT reduced energy diet to birds.

Key Words: Broilers, Lysophospholipid, re-formulated diet, performance

P286 Commercial organic acid blend improves broiler gut health and performance David Harrington^{*1}, Leon Broom¹, Augustine Owusu-Asiedu¹, Aikaterini Konstanti¹, Ilias Giannenas² ¹Anpario PLC; ²Aristotle University of Thessaloniki

Use of organic acids (OAs) has become common in animal nutrition as OAs are demonstrated to have favourable effects. For example, *in-vivo*, OAs have been shown to influence the intestinal microbiota, including reduction of *E.coli* and *Salmonella spp.* numbers, while promoting populations of lactobacilli. Furthermore, they have also shown to have positive effects on intestinal morphology, digestibility and the immune system, culminating in improved animal performance (Broom, 2015). This study examined the effect of an organic acid blend (OAB) (Anpario, UK), containing both formic and propionic acids and their salts on a mixed silicate carrier, on the performance and intestinal microbiota of broiler chickens. A total of 480 Ross 308 one-day-old broilers were split into 2 groups (8 reps/group, 30 birds/rep), control (C) and OAB (2kg/ton), and were reared from days 1–42. Feed and drinking water were provided *ad-libitum*. Body weight gain (BWG) was measured and FCR was determined during the trial period. Components of the ileal and caecal microbiota were enumerated by quantitative qPCR, with the ratio of *Lactobacillus spp.* (Ls) to *Clostridium spp.* (Cs) or *E.coli* (Ec) used to assess shifts in their relative populations. The data were analysed by ANOVA and significance between groups was declared at $P \leq 0.05$. OAB supplemented broilers showed higher BWG (OAB: 2512.9g vs C: 2364.2g; $P < 0.05$) and better FCR (OAB: 1.34 vs C: 1.73; $P < 0.001$). OAB supplementation was also associated with a relative increase in Ls compared to Cs in the ileal ($P < 0.01$) and caecal ($P < 0.05$) microbiota, as well as a relative increase of Ls compared to Ec in the caeca ($P < 0.05$). In conclusion, OAB supplementation promoted favourable shifts

in the relative populations of key intestinal bacteria and improved broiler growth performance.

Reference: L.J. Broom. 2015. Organic acids for improving intestinal health of poultry. World's Poultry Science Journal, 71, 630–642

Key Words: Organic acid, Gut health, Microbiota, Broilers

P287 Impact of incubation time and addition of original-XPC on the microbiota in an in vitro broiler cecal bioassay Steven Ricke^{*1}, Sang In Lee¹, Si Hong Park¹, Stephanie Roto¹, Peter Rubinelli¹, Hilary Pavlidis², Don McIntyre² ¹University of Arkansas; ²Diamond V

The functional metabolites of Diamond V Original XPC™ have been recognized for their ability to improve food safety by reducing *Salmonella* prevalence, numbers, virulence and antibiotic resistance in commercial broilers and turkeys. Previously, we observed an effect of XPC on both *Salmonella* survival and the cecal microbiome of *in vitro* cecal incubations from broilers at 14, 28 and 42d. In both trials, cecal contents of broilers had been collected and diluted to generate a cecal slurry followed by an addition of 1% of Original XPC (XPC) in feed to one group for comparison with cecal slurry only (CO), and feed with slurry (NC) groups. As a follow-up to this study, we have now analyzed the microbiome recovered from aliquots of samples that had been previously collected at 0, 6, 12, 24, and 48 h of the corresponding *in vitro* incubations. In Trial 1, NC, CO and XPC groups exhibited similar pattern of taxonomic abundance. However, *Bacteroidetes* were observed at high abundance in a CO group at 24 and 48 h. There were no significant differences in the alpha diversity based on day, hour and treatment. In the beta diversity analysis, each group was clustered as a function of sampling time. Also, the CO group exhibited its own detectable clustering compared to NC and XPC groups. In Trial 2, both XPC and NC groups exhibited the highest *Firmicute* level at 0 h but the level of *Bacteroidetes* dominated after 6 h incubation. The complexity of alpha diversity did not change as a function of incubation time except from the 0 h sample in trial 2. Beta diversity analysis exhibited clustering by treatments including NC and XPC groups as a function of incubation time (6, 12, 24 and 48 h). According to both trials, microbial populations were not affected by *Salmonella* inoculation after 6 h incubation, and NC and XPC groups exhibited similar diversity.

Key Words: Prebiotic, Microbiome, Next Generation Sequencing

P288 Evaluation of medium chain fatty acids alone or in combination with plant extracts and prebiotics on tom turkey performance. Nicholas Evans^{*1}, T Karnezos¹, Ron Dvorak¹, Michael Sims² ¹PMI Nutritional Additives; ²Viginia Diversified Research Corporation

A turkey performance trial was conducted to evaluate a medium chain fatty acid product (MF) and a MF product combined with plant extracts and prebiotics (MF+). Day-of-hatch tom turkeys were randomly assigned to floor pens (30/pen) containing fresh pine shavings. Birds were provided diets (12 replicates/treatment) containing either no additives (NC), bacitracin methylene disalicylate (BMD®), MF or MF+. At 72 days, birds in the MF and MF+ groups had significantly ($p \leq 0.05$) higher body weights than the NC group. The MF group had a significantly lower ($p \leq 0.05$) body weight compared to the BMD® group, but the MF+ group was not significantly different from the BMD® group. The feed conversion ratio (FCR) and mortality adjusted feed conversion ratio (MAFCR) were not significantly different ($p > 0.05$) for the MF and MF+ groups compared to the BMD® or NC groups; however, both parameters (FCR and MAFCR) were significantly ($p \leq 0.05$) improved for the BMD® group compared to the NC group. These data indicate that diets supplemented with MF or MF+ can have a positive effect on bird performance when compared to non-supplemented diets. Additionally, MF+ supplemented diets can also result in similar bird performance (body weight, FCR, MAFCR) when compared to BMD® supplemented diets.

Key Words: turkeys, medium chain fatty acids, plant extracts, prebiotics, performance

P289 Performance of broilers fed diets supplemented with lysophospholipids (Lipidol™) versus an antibiotic growth promotant program in a 42d performance trial. Theodore Karnezos^{*1}, Ronald Dvorak¹, Curtis Novak², Mahmoud Masadeh², Michael Sims³, Byoungyun Jung⁴ ¹PMI Nutritional Additives; ²Purina Animal Nutrition; ³Virginia Diversified Research; ⁴Easybio

A 42-day, 30 birds/pen, 3 treatments, 10 replications (30 pens), floor pen study was conducted to compare the performance and feed conversion of straight-run Cobb 500 broiler chicks, vaccinated with Coccivac®, and fed diets supplemented with a lysophospholipid product (Lipidol™) (LIP) versus a Virginiamycin (20 g/ton in all feeds) antibiotic growth promotant (PC) and untreated control (NC). On day 14, the body weights were significantly ($p \leq 0.05$) greater for broilers on the diet containing PC than those on the LIP, while LIP was similar to the NC group. On day 28, the body weights for PC were significantly ($p \leq 0.05$) greater than the NC, and similar ($p > 0.05$) to the LIP treatment. By day 42, the body weights were similar ($p > 0.05$) across the treatments. On day 14 and 28, the mortality adjusted feed conversion (MAFC) of all treatments were similar ($p > 0.05$). However, by day 42 MAFC of the LIP group was significantly ($p \leq 0.10$) more efficient than the NC and similar ($p > 0.05$) to the PC group. Mortality at day 14, 28 and 42 was similar across the groups. The results from the trial indicate that LIP supplemented broilers had similar ($p > 0.05$) 42d body weights, mortality adjusted feed conversion, and mortality as the PC group. These data suggest that LIP supplementation improves broiler performance by increased feed conversion.

Key Words: Broilers, Lysophospholipids, Lipidol™, FCR, Virginiamycin

P290 Grape pomace flour influence yolk pigmentation of quail eggs Hébron Fróes^{*1}, Iânglio Jácome¹, Rafael Tavares¹, Mateus Martinelli¹, Rodrigo Garcia², Carla Heloisa Domingues², Rodrigo Borille², Tassia Bevilacqua², Rosana Bicas² ¹Universidade Federal de Santa Maria; ²Universidade Federal da Grande Dourados

The aim of the study was to evaluate the use of grape pomace flour on the performance and egg quality of quail during the laying phase. One hundred ninety-two (192), 42-day-old European quails (*Coturnix coturnix*) were distributed in a completely randomized design with four treatments (0, 2, 4, and 6% grape pomace flour inclusion) and six replications of eight birds each. For the quail performance parameters, egg weight (g), average feed intake (g/bird), total feed intake (g/bird), egg production (%), feed conversion (kg/dozen) were evaluated, while for egg quality, the evaluated characteristics were: Haugh Unit, albumen weight (g), yolk weight (g), shell thickness (mm), specific gravity (g/cm³), and yolk pigmentation. Statistical analyses were performed using ANOVA procedure, and in case of significant effect ($P < 0.05$), polynomial regression analysis was performed. There was no effect ($P > 0.05$) between the grape pomace flour levels for egg production, feed intake and feed conversion, but there was a decreasing linear effect ($EW = 11.99 - 0.9357x$; $R^2 = 32.64\%$) among the treatments for egg weight. For the egg quality parameters, there was no effect ($P > 0.05$) for Haugh Unit and thickness of the shell. There was a decreasing linear effect for the weight of the albumen ($AW = 6.862 - 1.096x$; $R^2 = 50\%$), and specific gravity ($SG = 1.074 - 3.805x$; $R^2 = 41.73\%$) and a quadratic effect for the yolk weight ($YW = 3.752 + 2.320x - 3.111x^2$; $R^2 = 33.87\%$) and yolk pigmentation ($YP = 3.317 - 2.331x + 14.70x^2$; $R^2 = 88.92\%$). The inclusion of grape pomace flour in quail diets influenced the pigmentation of egg yolk, proving the efficiency of the by-product as a pigmentation additive.

Key Words: additives, egg production, egg quality, Haugh Unit

P292 Effect of multi-strain Bacillus probiotic on performance parameters of broiler chickens. Bradley Schrader^{*GS}, Elle Chadwick, Laci MacKay, James Krehling, Ken Macklin Auburn University

Bacillus amyloliquefaciens (BA) is a gram-positive, spore-forming bacterium capable of producing enzymes and antimicrobial compounds which can aide in nutrient absorption and metabolism, immunological functions,

and help prevent pathogenic colonization within the gastrointestinal tract (GIT) of animals. The purpose of this study was to examine the effect of a BA probiotic mixture on production, and microbiome composition in the GIT of broilers. One-day-old broiler chicks (120) were randomly assigned to one of three treatments: An industry comparable, broiler basal diet (CON); A basal diet supplemented with 60g/ton feed salinomycin (SAL); and a basal diet supplemented with a mixture of four BA strains at 1×10^7 CFU/g feed (PRO); each treatment had 5 replicates with 8 birds per replicate. Chicks were reared in Petersime cages for 21d, with feed and body weights (BW) being collected on d0, 7, 14 and 21. Data was adjusted for mortality, then used to calculate average daily feed intake (ADFI), BW, average daily gain (ADG), and feed conversion ratio (FCR). Two sample t-test and GLM were conducted to determine if statistical significance was reached when comparing performance data among treatments ($P < 0.1$). No significant differences in BW were seen throughout the trial among treatments. FCR of the CON group between d14-21 was significantly lower compared to SAL treated birds ($P < 0.1$). The FCR was not statistically different among all treatments for the remainder of the trial. CON had a significantly higher ADFI and ADG compared to PRO treated birds ($P < 0.1$ and $P < 0.05$, respectively). Previous studies have demonstrated that broilers reared in cages are exposed to fewer immunological challenges compared to broilers raised on litter, which may in part explain why the SAL and PRO treatments did not outperform the CON group in this study. Variations in performance were observed between the five PRO pens, suggesting more replications are needed. Microbiome samples are still being analyzed, so these results will not be included here. Additional trials evaluating the efficiency of this BA probiotic with a higher number of replicates per treatment should be carried out to validate the results of this study.

Key Words: Probiotic, Bacillus, Performance

P293 Effects of dietary microalgae and zinc source on the bone characteristics and uniformity of broiler breeder pullets Marquisha Paul^{*GS}, Anthony Pescatore, Tuoying Ao, Michael Ford, Karl Dawson Alltech-University of Kentucky Nutrition Research Alliance

Zinc (Zn) is a trace element and essential nutrient for growth and skeletal development. Omega-3 fatty acids are also essential nutrients and are known to play an important role in bone tissue development. Bioplex® Zn (Alltech, Inc.) is a Zn proteinate that has been shown to be more bio-available to chickens compared to inorganic sources of Zn. FORPLUS™ (Alltech, Inc.) is an unextracted, whole-cell microalgae (*Aurantiochytrium limacinum* CCA 4087/2) that contains 64% fat and 16% Docosahexaenoic acid (DHA). The purpose of this study was to investigate the effects of 2 dietary levels of FORPLUS™ (0% vs. 2%) and 2 dietary Zn sources (ZnO vs. Bioplex® Zn) on bone characteristics and uniformity of broiler breeder pullets. Using a randomized complete block design with a 2x2 factorial trt structure, a total of 440, one-day old Cobb500™ broiler breeder pullets were randomly assigned to 1 of the 4 dietary trt: 1) Corn-soybean meal diet + 40 mg Zn/kg diet as ZnO, 2) Diet 1 + 2% FORPLUS™, 3) Corn-soybean meal diet + 40 mg Zn/kg diet as Bioplex® Zn, 4) Diet 3 + 2% FORPLUS™. Pullets were given *ad libitum* access to feed and water during the first 3 wk after placement, then switched to a restricted feeding regimen to control growth as per the Cobb® breeder management guide. Each dietary trt consisted of 5 rep floor pens (22 pullets/pen), with location within the room serving as the blocking factor. Bone samples were collected at 3 and 6 wk of age to evaluate bone characteristics including bone ash % and bone length. At 20 wk of age, individual BW of pullets was measured to calculate uniformity. At 3 wk of age, no interaction effect of FORPLUS™ level and Zn source on bone characteristics was observed. Compared to pullets provided diets with 0% FORPLUS™, those fed diets with 2% FORPLUS™ had greater ($P < 0.05$) femur ash % (53.1 vs. 54.5%) and femur length (48.9 vs. 50.0 mm). At 6 wk of age, an interaction effect ($P < 0.05$) of FORPLUS™ level and Zn source on femur ash % was detected. The pullets fed the diet containing 2% FORPLUS™ with ZnO had greater ($P < 0.05$) femur ash % than those fed 0% FORPLUS™ with ZnO. Significant effects of FORPLUS™ level or Zn source on BW of pullets were observed at 20 wk of

age. Pullets fed 2% FORPLUS™ had greater ($P<0.05$) BW (2189 vs. 2132 g) compared to pullets fed 0% FORPLUS™. Pullets fed Bioplex® Zn had greater ($P<0.05$) BW (2192 vs. 2129 g) compared to those fed ZnO. At 20 wk of age, an interaction effect of FORPLUS™ level and Zn source on pullet uniformity was observed. Pullets fed diets containing ZnO with FORPLUS™ had greater ($P<0.05$) uniformity than pullets fed ZnO diets without FORPLUS™. Based on these results, dietary FORPLUS™ positively impacted broiler breeder bone characteristics and pre-lay uniformity.

Key Words: Microalgae, Zinc, Broiler breeder, Bone characteristics, Uniformity

P294 Impacts of dietary vitamin D on immune-related activities of *Salmonella enteritidis* vaccinated-laying hens Matthew Warren^{*1}, Jinlei Wen², Kimberly Livingston¹, Michael Persia² ¹North Carolina State University; ²Virginia Tech

Increased supplementation of cholecalciferol (vitamin D₃) in diets of egg producing chickens has been shown to increase the amount of vitamin D₃ deposited in the egg. Various experiments have reported increases in skeletal health, egg shell quality, and altered immune response with supplementation with vitamin D or its metabolites. *Salmonella enteritidis* (SE) is a foodborne pathogen that infects birds and can be passed to eggs and ultimately transmitted to consumers. The data reported examined the effects of vitamin D supplementation on SE antibody production in vaccinated pullets over time. In total, 520 day old Hy-line W-36 chicks were housed in A-frame pullet cages in an environmentally controlled room at Virginia Tech. Chicks were randomly allocated to one of six dietary treatments consisting of a control diet without additional vitamin D supplementation (1,475 IU provided via a commercial premix; T1), the same control diet was supplemented with 6,667 (T2); 16,667 (T3); 33,333 (T4); or 66,667 (T5) IU of vitamin D₃/kg diet, and the final diet was the control diet supplemented with 62.5 mg/ton finished feed of 25-hydroxyvitamin D₃ (T6). All birds remained on the same experimental diets over the entire pullet phase. Birds were weighed at 6, 12, 15, and 17 w of age for growth performance and vaccinated subcutaneously with 0.25 mL dose of AviPro 109 SE4 (Lohmann Animal Health) at 13 w of age. Blood was collected from eight random birds per treatment at 0, 10, and 28 days-post-vaccination (DPV). Plasma was used for SE antibody titers (IDEXX). Relative antibody titers were determined by comparing dietary treatment groups to the control treatment. Differences were determined with PROC GLM with SAS 9.4 to compare effects of treatment and time on antibody production levels. BW did not differ among treatments until 17 w of age where T5 had significantly lower BW T1 (1163.55 g v 1241.38 g; $P<0.001$). Antibody titers for SE were increased at both 10 and 28 DPV ($P<0.001$ and $P<0.0001$); but dietary treatment had no effect on antibody titer levels ($P=0.39$). In conclusion, excessive cholecalciferol supplementation does reduce pullet body weight but not until 17 w of age. However, the additional supplementation did not potentiate the antibody response to SE vaccination.

Key Words: Vitamin D, immunity, antibodies, blood plasma

P295 Does pelleting affect transfer of DHA to eggs when heterotrophically-grown microalgae are added to layer diets? Colm Moran^{*1}, Douglas Currie², Anne Knox² ¹Alltech Inc; ²Roslin Nutrition Ltd

Higher docosahexaenoic acid (DHA) content of eggs offers consumers a nutritionally-enhanced food while adding another revenue stream for poultry producers. Microalgae are high in omega-3 long-chain fatty acids including DHA. Further, heterotrophically grown algae are a sustainable source of LCFA and their existence inside whole algae cells potentially offers a degree of protection not available in extracted algae or fish oils. This study was conducted to determine whether pelleting layer feed altered transfer of dietary DHA to eggs. A total of 384 ISA Brown layers at 20 weeks of age were randomly allocated to 3 test diets in 96 cages. Each treatment was replicated 32 times with 4 birds per cage. Three isonutritive dietary treatments consisted of (1) unsupplemented (Control) mash feed, (2) mash + algae or (3) pelleted feed + algae. Treated diets contained

1% microalgae (unextracted *Aurantiochytrium limacinum* CCAP 4087/2; ForPLUS™, Alltech Inc.). The algae were heterotrophically grown using an unique process on a fresh water, low sodium media. Calculated DHA content for treated diets was 0.16 mg/kg. Diets were based on wheat/soy and formulated to meet or exceed nutritive requirements for growth and egg production. DHA content of egg yolks pooled by cage was measured at 0, 2, 4, 6, and 8 weeks. Extraction, methylation and quantitation of fatty acids followed the AOAC 966.06 and AOCS Ce 2c-11 methods. Data were analyzed as a randomized complete block design with all data subjected to ANOVA. Significant differences among LS means were noted at p-values $\leq 0.05\%$. Treatments did not affect egg weights, egg production, or physical properties of the egg and shell. DHA content of eggs from hens fed treated diets had risen markedly after 2 wks on test diets with mash diets higher in DHA content than pelleted feed (433.2, 821.3 and 732.4 for control, mash/algae and pelleted/algae diets, respectively, $P<0.001$). At week 4 the differences among treatments remained, with pelleted feed higher in DHA than in mash. At weeks 6 and 8, DHA in eggs from treated hens remained significantly higher than that of controls (wk 8: 403.9, 752.7, and 787.1 for control, mash/algae and pelleted/algae diets, $P<0.001$), however no differences between mash and pelleted feeds were noted. It was concluded that pelleting did not affect transfer of DHA to the egg.

Key Words: algae, fatty acids, egg

P296 Changes in egg DHA content over 24 weeks in layers fed diets containing 0, 0.25, 0.5 or 1% heterotrophically-grown algae Colm Moran^{*1}, Douglas Currie², Anne Knox² ¹Alltech Inc.; ²Roslin Nutrition Ltd

Egg fatty acid (FA) profiles are known to be responsive to FA content in layer diets. Given consumer interest in omega-3 fatty acids (FA), there is a need to know how diet FA sources affect egg composition over time. This study evaluated the changes in egg docosahexaenoic acid (DHA) content over a 24 wk period when hens were fed diets containing 0, 0.25, 0.5 and 1% algae (unextracted *Aurantiochytrium limacinum* CCAP 4087/2 algae, FORPLUS™, Alltech Inc) that contained 67% fat and 16% DHA. Algae were heterotrophically grown in an unique process on a fresh water, low sodium media. Inclusion levels provided 0, 420.75, 841.5 and 1683.0 mg DHA/kg feed. Each of the four treatments were fed to 24 replicate cages of 4 birds to provide 96 commercial ISA brown layers (22 weeks of age) per treatment for a period of 168 days. Isonutritive diets were provided in a coarse mash form and formulated to meet or exceed NRC (1994) requirements for growth and egg production. Data provided each 4 wks included egg performance and quality. Fatty acid analysis including DHA content of the pooled egg yolks from each pen ($n=4$) was measured at 0, 4, 12 and 24 wks. Egg production, feed intake and FCE were unaffected by diet. Means for soft shelled and dirty eggs were also unaffected. Cracked egg numbers differed only in week 4-8 when birds given control or 1% algae were higher ($P=0.04$). Palmitic acid and DHA increased linearly with algae level, which matches the profile of the algae. DHA means were 0.01, 0.40, 0.83 and 1.71 for control, 0.25, 0.5 and 1% algae, respectively ($P<0.001$). It was concluded that FORPLUS™ algae addition increased egg DHA in a dose dependent manner with 0.05% algae sufficient to double DHA concentration.

Key Words: algae, fatty acids, egg composition

P297 Effects of various levels of low-fat distiller's dried grains with solubles on intestinal developments of broilers from 28 to 54 days of age Na Dong^{*}, Na Dong, Xi Wang, Wei Zhai *Mississippi State University*

This study evaluated the effects of low fat corn distiller's dried grains with solubles (LF-DDGS) in broiler diets from 28 to 54 d of age on the development of their small intestinal tract. A total of 256 male Ross × Ross 708 chicks were randomly divided into 4 groups. Birds of each group were subdivided into 8 replicates of 8 birds each. The experimental diets contained LF-DDGS at levels of 0, 8, 16 and 24%. The contents of apparent metabolic energy and apparent ileal digestible amino acids of the LF-DDGS were determined by using 40 other male Ross × Ross 708 broilers before formulating the experimental diets. Duodenum, jejunum, and ileum sam-

ples were collected from 1 chick per pen and processed individually at 53 d for histological analysis. Villus height, villus width, muscle thickness, crypt depth, and goblet cell size were measured. Villus length to crypt depth ratio and goblet cell density were calculated. Data were analyzed using one-way ANOVA and partial correlation using PROC GLM of SAS 9.4. Dietary treatments did not affect duodenum and jejunum villus height, villus width, muscle thickness, crypt depth, villus length to crypt depth ratio, goblet cell size, or goblet cell density at d 54. As compared to 0 and 24% LF-DDGS inclusion diets, birds fed 8% LF-DDGS exhibited greater ileum villus width, however, dietary treatments did not affect other ileum structure measurements. In a companion study, feeding birds 8% LF-DDGS diet did not affect BW gain as compared to the control diet. Feeding broilers LF-DDGS at more than 16% in the diets was found to lower BW as compared to the control (0% LF-DDGS) diet. However, various DDGS inclusions tested in the current trial did not impair intestine villus or crypt structure. In addition, partial correlation analysis further confirmed that BW gain of broilers was not associated with intestine villus and crypt structure. In conclusion, up to 8% LF-DDGS can be included in male broiler diet from d 28 to 54 without adverse effects on small intestine development.

Key Words: broiler, crypt, intestine, low-fat distiller's dried grains with solubles, villus

P298 Optimization modeling with spreadsheets: Finding simplicity in complexity Manoel Garcia-Neto*, Rodrigo Terra Celidonio, Roberto Carlos Freitas, Thainá Landim Barros, Rodrigo Pereira Cassiano *UNESP - Univ Estadual Paulista, FMVA, DAPSA*

Models curve analysis can find simplicity in complexity, because can explain and represent many challenges to the real world. The modelling process can find issue investigated, with simplification, defining the essence of complex systems. The model to be used needs to answer a specific question, contributing to performance, to save money or time, and applied to give a fuller understanding of the processes. The Practical Program for Optimization-PPO may be downloaded free from <https://goo.gl/80rJHo>. The PPO workbook used the NT models (Narushin-Takma models) for accurate prediction with a minimum of mathematical complexity. The PPO has been prepared to optimization of cumulative egg or broiler body weight, by maximizing profit from the one day of age until the end of the poultry production. The cumulative egg or broiler body weight, the food utilization, the mortality and the egg or the broiler price are economically analyzed. Furthermore, the PPO workbook is useful because it summarizes the information (production, food consumption, mortality) with advantage of the prediction and estimation of change the profit during the full life cycle of poultry (laying hens or broiler chickens), with application in bio-economic studies for predicting the optimum profit age.

Key Words: Broiler chickens, Laying hens, Modeling, Optimization

P299 A workbook to estimate parameters for models Manoel Garcia-Neto*, Sílvia Helena Perri, Thainá Landim Barros, Rodrigo Pereira Cassiano, Max José Faria-Junior *UNESP - Univ Estadual Paulista, FMVA, DAPSA*

A variety sigmoidal of growth models have been used to predict relationships between data and new observations, commonly used in many fields like agriculture, biology, economics and engineering. This relevant and commonly S-shaped include Gompertz, Logistic (3 and 4 parameters), von Bertalanffy and Richards. The Richards model seems to be more flexible shape and is probably the most robust and realistic function to description the animal growth, because involve four parameters, but presents more difficulties to adjust and requires sophisticated statistical software. An Excel workbook PPM (Practical program for Modeling) may be downloaded free from <https://goo.gl/5je0GV> has been prepared to fit several known models such as: Broken-line (linear and quadratic), Saturation kinetics, Logistics (3 and 4 parameters), Compartmental, New compartmental, RNB (Model 1 and 2), Gompertz, Orskov, Nelson-Siegel, Nelson-Siegel-Svensson, Ducatti, Gaussian, Narushin-Takma, Oscillatory and, finally, detaching

the Richards model. The Richards model is a general form of Brody, von Bertalanffy, Logistic and Gompertz. In practice, with proper understanding of the parameters of the growth curve, like Richards curve, it will be found the asymptotic maximum value, the point of inflexion of the curve, the maximum growth rate, the average growth rate, the age at maximum rate of growth and the weight at inflection point. The use of this workbook consists of three distinct parts: First, copy data in cell "Input and Output". Second, view the data and estimate the value until the predicted line is close to the observed points. Finally, the solver feature of Excel will attempt to minimize the sum of squared errors, by changing of the parameter values, with the goodness-of-fit of the curves and statistical significance of the estimated parameters.

Key Words: Modeling, Richards model

P300 Intra-amnion delivery of mannose or mannose-based oligosaccharides in fertile broiler eggs at 18d of incubation Lizza Macalintal*, Anthony Pescatore, Tuoying Ao, Rijin Xiao, Mike Ford, Ronan Power, Karl Dawson *Alltech-University of Kentucky Poultry Nutrition Research Alliance*

The beneficial effects of mannan-oligosaccharides (MOS) for animal growth and well being has been widely reported. However, these reports center on MOS used as a dietary feed supplement. The goal of the current study was to investigate the effect of mannose or mannose-based oligosaccharides (Alltech Inc) when administered *in ovo* via intra-amnion delivery in 18d-old of incubation (DOI) fertile broiler eggs. Forty fertile eggs were randomly allocated to two treatment groups; D-mannose or mannose polymer with 0.1, 0.5, 1.0, 2.5 and 5.0mM concentrations were injected at a rate of 0.6ml/egg via the amnion of 18DOI fertile eggs. Saline-sham-injected and non-injected eggs were included as control eggs. A total of 480 Cobb 500® day-old fertile broiler eggs were set at standard incubation protocols and at 10 and 18DOI, all eggs were candled to ensure embryo viability, any infertile eggs or eggs with dead embryos were discarded. On d18 of incubation fertile eggs were processed for *in ovo* injection. Following disinfection, drilling of injection site on the egg shell surface and sealing of the injection site; test compounds were administered. Hatchability of fertile eggs injected with D-mannose or mannose polymer at concentrations varying from 0.1-5.0mM resulted in hatchability that ranged from 80-97%, whereas the control eggs were 82.50 and 87.50% respectively. These egg injections did not result in any chick abnormalities nor did it negatively affect hatchability. To our knowledge this is the first time that a mannose or mannose-based oligosaccharide has been used for *in ovo* nutrient delivery and can be successfully injected into the amnion of 18DOI fertile broiler eggs without negatively affecting hatchability and without the aid of an automated egg injection machine.

Key Words: *in ovo*, intra-amnion, mannan oligosaccharide, eggs, hatchability

P301 Exploring the novel approach of probiotic delivery into the gut of pre-hatch chicks Lizza Macalintal*, Anthony Pescatore, Tuoying Ao, Phyllis Glenney, Mike Ford, Karl Dawson *Alltech-University of Kentucky Poultry Nutrition Research Alliance*

Probiotics or direct fed microbials have been proven beneficial to the host animal by creating a more favorable gut microenvironment. Since the goal is to promote healthy gut development prior to hatch, *in ovo* administration is considered a useful approach. A study was conducted to investigate the effect of delivering probiotics via *in ovo* administration on the hatchability of fertile eggs. Thirty eggs were allocated for the following lactic acid bacteria (LABs): *Lactobacillus acidophilus* (LA), *Lactobacillus plantarum* (LP) and *Pediococcus acidilactici* (PA) using 10³ or 10⁶ colony forming units (cfu) injected at a volume of either 50 or 100ul/egg. MRS broth injected and non-injected eggs were included as controls. A total of 420 Cobb500® d0 fertile broiler eggs were set at standard incubation protocols and at 10 and 18 days of incubation (DOI), all eggs were candled to ensure viability of embryos. Any infertile eggs or dead embryos were discarded.

On d18, fertile eggs were processed for injection. Following disinfection, drilling of injection site on the egg shell surface and sealing of the injection site, test LAB were injected into the amnion. On d21, percent hatch, mortality and all unhatched eggs were broken and the embryos examined. *In ovo* administration of fertile eggs with 50 or 100ul per egg LA, LP or PA at concentrations of 10^3 or 10^6 cfu had no negative effect on hatchability. The average hatchability was 81%. Abnormalities were not observed in any of the hatched or unhatched embryos. The results from this study indicated that *in ovo* injection of LAB administered via intra-amnion delivery can be a useful tool to introduce probiotics into the gut of pre-hatch chicks without causing detrimental effects on hatchability or chick development.

Key Words: in ovo, intra-amnion, probiotics, lactic acid bacteria, hatchability

P302 Evaluation of nutrient composition and correlations between nutrients and color characteristics of corn grains Ahmet Pekel^{*1}, Ahmet Pekel¹, Ali Calik², Eren Kuter³, Özcan Cengiz³, Güvenç İnan⁴ ¹*Istanbul University, Faculty of Veterinary Medicine;* ²*Ankara University, Faculty of Veterinary Medicine;* ³*Adnan Menderes University, Faculty of Veterinary Medicine;* ⁴*Optima Nutritional Products Inc*

A study was carried out to determine the nutrient composition and color characteristics of corn grains (n=54) collected from different feed mills located in Turkey during the summer of 2016 and also to evaluate the correlations between nutrient content and color characteristics. The samples were analyzed by wet chemical procedures for DM, crude protein (CP), ether extract (EE), and crude ash and by near-infrared reflectance spectroscopy for acid detergent fiber (ADF) and neutral detergent fiber (NDF), respectively. Color [CIE lightness (L*), redness (a*), and yellowness (b*)] characteristics of the samples were measured in triplicates with a chroma meter. The correlations between nutrients and between color and nutrients were determined using the proc corr procedure in SAS. The average CP, EE, crude ash, ADF and NDF of corn samples studied were 7.55, 3.19, 1.06, 2.09, and 8.35%, respectively. Highest coefficient of variation (CV=14.55) were observed for EE among the nutrients tested in corn samples. Among tested color characteristics, a* value was the highest variable (CV=39.35). The values for L* were found to be inversely correlated ($P < 0.05$) to the EE levels of corn. Negative correlations ($P < 0.05$) were found between b* value and DM, and crude ash levels of corn. Positive correlations also were found between fat content and b* values ($P < 0.01$) and between a* and NDF content ($P < 0.05$) of the corn samples. Corn crude ash level was positively correlated with CP ($P < 0.001$) and ADF levels ($P < 0.05$), respectively. As the a* of the corn samples increased, L* value decreased ($r = -0.583$, $P < 0.001$). In conclusion, since EE level was inversely correlated with L* and positively correlated with b* value, in practice looking for corn with relatively low L* value (lighter) and high b* (more yellow) value may have potential for selecting high fat corn grains for animals such as poultry.

Key Words: color characteristics, corn, correlations, nutrient composition

P304 Using Protease and Xylanase Enzymes as Single or Combined Supplementation to Corn-Soybean Meal Broiler Diets. Nessor Selim*, Hemat Abdel Magied, Heba Habib, Amany Waly, Ahmed Fadl, Sayed Shalash *Animal Production Research Institute (APRI), Agricultural Research Center (ARC)*

Two experiments (EXP1 & 2) were conducted to study the effect of adding xylanase (X), protease (P) or their combination (XP) to corn-soybean meal broiler diets on growth performance and carcass quality. In both EXP1 & 2, day-old Arbor Acres broiler chicks were subjected to three phases feeding program (1-40 d of age). The supplementation rates were 16000 U of X/kg diet (Econase XT25) and 300000U of P/kg diet (CIBENZA® DP100). In EXP1, 160 chicks randomly allocated to 4 treatments. Chicks fed on corn-soybean meal standard diet (STD) without or with supplemental X, P or XP. Diets of STD contained 3000, 3100 and 3200 kcal of metabolizable energy (ME)/kg and 23, 21 and 19 % crude protein (CP) during starter, grower and finisher periods, respectively. In EXP2, 400 chicks were al-

located to (2x5 factorial design) 10 treatments. Chicks were fed one of 5 formulas of reduced levels of CP and ME from values of STD of each feeding phase without or with XP supplementation. The formulas (F) were: F1, (STD); F2, was lower 10 % CP and 100 kcal ME; F3, was lower 10 % CP and 150 kcal ME; F4, was lower 15 % CP and 100 kcal ME; F5, was lower 15 % CP and 150 kcal ME. All diets contained the same total lysine/CP and methionine+cystine/CP of STD of certain phase. Parameters of growth performance, carcass traits, and meat quality were carried out for both EXP 1 & 2, and feeding cost was calculated for EXP2. Results of EXP1 showed significant improvement of FCR due to adding X, P or XP and the best value obtained by using XP (1.55) and P (1.58). Using XP increased dressing (6.18%) and reduced meat contents of malondialdehyde (MDA) and low-density lipoprotein (LDL). Results of main effects of EXP2 showed improvement of FCR (13.2%), dressing (3.8%), and meat quality due to supplemental XP. Using F2, F3, F4 or F5 resulted in gradual adverse effect on growth and meat drip loss, while meat contents of LDL and MDA decreased. Among treatments, supplementing F2 with XP improved growth performance, carcass traits, meat quality, and showed the highest saving of feeding cost/kg of body weight (9.1%) compared with STD value. These results recommended adding XP combination to lower 10% of CP and 100 kcal ME/kg broiler diet to reduce feeding cost and improve growth performance, carcass traits and meat quality.

Key Words: Broiler, xylanase, protease, growth performance, meat quality

P305 Evaluation of multiple copper supplements and concentrations on male broiler performance and bile antimicrobial activity Hunter Walters^{*GSI}, Austin Jasek¹, Pat Welch², Craig Coufal¹, Jason Lee¹ ¹*Texas A&M University;* ²*Novus International*

The objective of the current study was to evaluate the impact of multiple copper supplements on male broiler growth performance and potential bile antimicrobial activity in corn-soy diets. A total of 2560 broilers were assigned randomly to 4 dietary treatments consisting of 16 replicates of 40 Cobb 500 broilers. The experiment was a 2x2 factorial (source x inclusion) design included two sources of copper (copper methionine hydroxyl analogue chelate (CMHAC) and copper chloride (CC)). Birds were fed a starter (d1-14), grower (d14-28), and finisher (d28-38). Average body weight (BW), body weight gain (BWG), mortality adjusted feed conversion ratio (FCR), feed consumption (FC) and mortality (%) were determined on days 14, 28, and 38. On day 38, 4 birds were randomly selected from alternating blocks (32 pens total) for collection of bile to evaluate any potential antimicrobial activity associated with varying copper source and level. Data was analyzed via a 2 x 2 factorial ANOVA with main effect means deemed significantly different a $P \leq 0.05$. On d 28 and 38, broilers fed diets containing 120 ppm Cu significantly increased BW compared to the 30 ppm, additionally; BWG during the finisher phase was improved with the higher inclusion rate of copper. An impact of copper source was also observed as CMHAC fed broilers exhibited an elevated BW at day 28 ($P=0.018$) and 38 ($P=0.031$) compared to CC. This was associated with an increase ($P=0.028$) in BWG during the grower phase of production. Differences in BW and BWG were associated with a higher rate of FC as 120 ppm fed broilers consumed elevated ($P=0.005$) levels of feed as compared to 30 ppm and the CMHAC fed broilers consumed an elevated ($P=0.027$) level of feed compared to CC. Differences in FCR were observed only during the finisher phase of production as higher levels of copper decreased (0.043) FCR and the CMHAC fed broilers exhibited a lower FCR compared to CC. The bile collected from at the conclusion of the experiment did not result in any zone of inhibition when applied to plates of *Salmonella* Typhimurium, *Staphylococcus aureus* or *Clostridium perfringens*. These data suggest that copper level and source can impact broiler growth performance.

Key Words: copper, broiler, performance

P306 Broilers performance supplemented with organic or inorganic minerals Iane Almeida*¹, Ibiara Almeida Paz¹, Jose Roberto Sartori¹, Grace Baldo¹, Alba Fireman², Edivaldo Garcia¹, Andrea Molino¹, Bruno Gilli¹, Ana Carolina Rocha¹, Ricardo Santos¹ ¹UNESP - FMVZ; ²Zinpro Animal Nutrition

The aim of this study was evaluated the performance of broilers supplemented with organic or inorganic minerals and combination between them. For this, were used 2835 male chicks one day old of the Cobb 500 strain, equally distributed in the treatments. The experimental design was a randomized blocks with five treatments (T1: control, T2: 40 ppm of Zn, 80 ppm Mn and 10 ppm inorganic Cu + 40 ppm Zn organic between 1-42 days; T3: 80 ppm Mn and 10 ppm inorganic Cu + 40 ppm Zn Organic from 1 to 42 days; T4: 40 ppm Zn, 40 ppm of Mn and 7 ppm Cu organic between 1 and 21 days and 40 ppm Zn, 80 ppm of Mn and 10ppm inorganic Cu + organic Zn 40ppm between 22 to 42 days; T5 = 40 ppm Zn, 40 ppm of Mn and 7 ppm Cu organic between 1 and 21 days and 80 ppm Mn and 10ppm inorganic Cu + 40 ppm Zn organic between 22 to 42 days) and 9 repetitions with 63 birds. The Performance was evaluated by feed intake, weight gain, feed conversion ratio, viability and production efficiency factor in phase 1 to 42 days. The data were analyzed using the statistical program SAS 9.2. There was difference for weight gain ($p=0.0084$), feed conversion ratio ($p=0.0260$) and viability ($p=0.0330$). The T1 (control treatment) exhibit higher weight gain (2762 kg) and better feed conversion ratio (1.91), however in the T5 there was inverse result, the weight gain was less (2589 kg) and the feed conversion ratio was worse (2.06). The viability was better for broilers chickens in T3 (98.41) and worse for broilers chickens in T5 (95.24). The feed conversion ratio was affect by diet and broilers fed with only organic minerals exhibited the worse production efficiency factor. In general, the characteristics evaluated were a little influenced by supplementation or not supplementation with organic minerals in feed, as well as the elements combination. (FAPESP PROC 2016/04613-5)

Key Words: zinc, cooper, animal production, manganese

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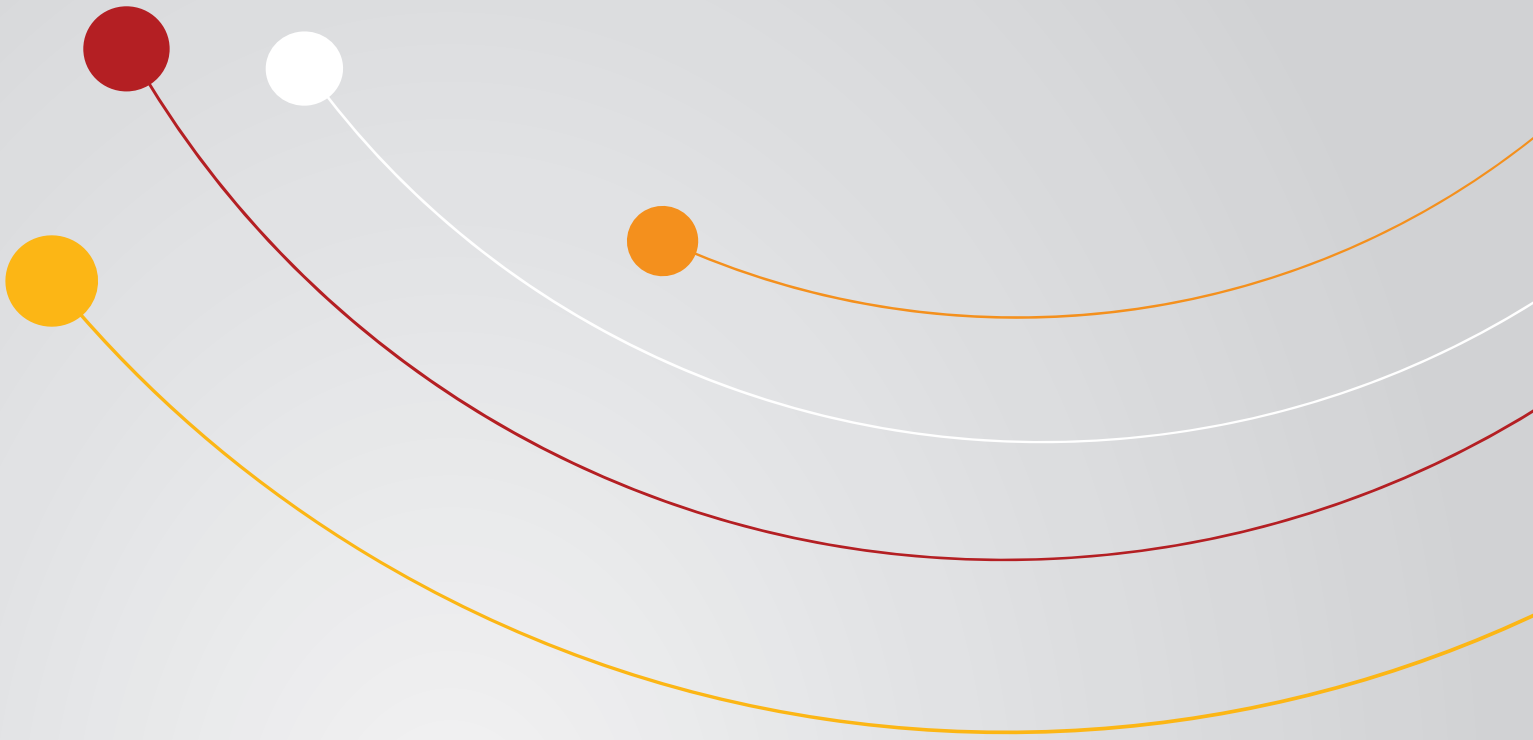
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