

air quality, surface deposition, animal and human health and regulated by the US EPA in non-attainment areas. Odor is a nuisance issue for commercial farms near housing developments and other urban settings and often a constituent of dust and emissions. At a Penn State research hen house five tree species comprising a vegetative buffer were planted in pot-in-pot containers in five rows downwind of four hen house fans. Both laboratory olfactometry detection threshold (DT) and field olfactometry dilutions-to-threshold (D/T) measurements were made with and without the trees to study the impact of vegetation on odor thresholds. Odor samples for the laboratory olfactometry were secured in Tedlar™ bags and evaluated in 24h time. At a commercial hen complex with six 250,000 hen houses, vegetative buffers with four rows were established downwind of three house's fans (27 tunnel fans each) while the other three houses served as controls. Laboratory olfactometry DT measurements were made at both the Penn State and commercial hen complex with and without trees to study the impact of vegetation on odor thresholds. Six trained odor assessors made laboratory DT determinations, and four odor assessors using the Nasal Ranger™ made field D/T evaluations with and without trees at Penn State. Laboratory DT results for Aug and Sept at the commercial complex averaged 29 and 44 respectively for the houses with and without trees. Measurements made in Aug at the commercial site were significantly less when trees were present ($P=0.10$). Laboratory DT results at the Penn State farm averaged 21 and 39 respectively, with and without trees ($P>0.10$). However, using the Nasal Ranger™, D/T results averaged 4.3 and 9.4 with and without trees ($P=0.01$). Despite low background odor levels at both research and commercial sites, both consistent numerical and statistically significant results suggest vegetation reduces odor.

Key Words: odor, olfactometry, laying hens, detection threshold, vegetation

29 Evaluation of a new poultry house for the presence of *Salmonella* at different sites through the broiler production continuum. J. A. Byrd*, T. C. Crippen, C. L. Sheffield, T. L. Poole, and D. J. Nisbet, USDA-ARS, SPARC, Food and Feed Safety Research Unit, College Station, TX.

Poultry companies continue to produce safe and wholesome products while facing increased regulatory pressure to control foodborne pathogens. Although many risk factors that contribute to *Salmonella* concentrations have been identified, precise identification of the most effective sites for intervention have not been established. The present study evaluates a naïve (new) poultry house with different environmental parameters on *Salmonella* incidence at different points of production.

One broiler house with four consecutive flocks were studied. Preharvest sample points included: tray pads (2/sample point), litter (12/sample point), water (3/sample point), feed (3/sample point) and birds (20/sample point) sampled at days 0, 18, 32, 46, and 62. All samples were evaluated for *Salmonella*. Prior to placement on the farm, *Salmonella* were detected in all water, feed, hatchery (traypads), and in 18% of the litter samples. Water samples were 100% positive for *Salmonella* at Days 1 and 18 in Flocks 1-3. Similarly, *Salmonella* was detected in high levels (60-100%) in Flocks 1 and 3 on Days 1 and 18. However, ceca samples evaluated for *Salmonella* were found under 5% on all days except for Flock 3 which had *Salmonella* 95% (Day 1) and 25% (Day 18). *Campylobacter* was not detected on the farm during the entire study. The data demonstrates the importance of pathogen-free environmental conditions even on naïve farm. Data from this study may help poultry professionals understand how environmental factors may affect food-borne pathogens in poultry and the difficulty that may be encountered in making risk management decisions.

Key Words: new house, environmental, *Salmonella*, poultry

30 Investigation of growth performance and ascites mortality in broiler chickens reared in a greenhouse or a conventional house at a high altitude area. F. Khajali*^{1,2} and M. Faraji¹, ¹Shahrekord University, Shahrekord, Iran, ²University of Arkansas, Fayetteville.

In the present study, a greenhouse was constructed to meet the birds environmental needs and welfare and the response of broiler chickens (Ross 308) in terms of growth performance, physiological variables and mortality from ascites grown in the greenhouse were studied in relation to a conventional house with similar conditions. Four hundred day-old chicks were randomly distributed among 8 groups and placed either in the greenhouse (4 groups) or the conventional house (4 groups). The experiment was conducted in floor pens in both houses from 2 to 42d in a completely randomized design. Results showed that the birds in the greenhouse ate significantly ($P<0.05$) more feed than those reared in the conventional house in the growing (21-42d) and throughout the trial (2-42d). Differences between the houses were not significant for body weight gain and feed conversion ratio in different periods of the experiment. FCR throughout the trial was 1.78 and 1.81 for the birds housed in the conventional house and the greenhouse, respectively. Mortality from ascites was 9.5 and 12% in birds housed in the conventional house and the greenhouse, respectively. There were no significant differences with respect to hematocrit and serum nitric oxide concentration between the houses.

Key Words: greenhouse, broiler, ascites

Immunology I

31 Susceptibility of commercial broiler chickens that differ in innate immune responsiveness to coccidial infection. M. H. Kogut*¹, C. L. Swaggerty¹, I. Y. Pevzner², and J. R. Nerren¹, ¹USDA-ARS, College Station, TX, ²Cobb-Vantress, Inc., Siloam Springs, AR.

Traditionally, genetic selection of poultry based on immunity/disease resistance has centered on inherent resistance to a specific infectious agent. Given the ability of the innate immune system to recognize a variety of pathogens, we hypothesize that innate immunity could be a more useful marker when genetically selecting chickens for disease

resistance. We have identified two lines of broiler chickens divergent in their innate response (line A = highly efficient and line B = low efficiency). We have shown that this functional efficiency of the innate response can be genetically transferred to progeny, is sex-associated, and genetically influenced by the sire. Furthermore, we have shown that increased in vitro innate immune function corresponds with increased in vivo resistance to infections by Gram-positive and Gram-negative bacteria. Coccidiosis remains one of the most common and most expensive diseases of poultry worldwide. The objective of the current study was

to determine if the previously reported differences in susceptibility to bacterial infections between the lines A and B translates to an increase in resistance or susceptibility to infection with *Eimeria tenella*. Two-week old broilers from lines A and B were randomized by weight into 4 treatment groups: uninfected controls or those challenged orally with either 15, 30, or 45 x 10³ sporulated oocysts of *E. tenella* (PSU strain). Six days later all birds were sacrificed, weighed, and the ceca from each chicken lesion scored. Line A chickens had significantly greater weight gains and significantly lower cecal lesion scores when compared to challenge dose-matched line B chickens. These results are further proof that the differential in vitro innate immune function between line A and B chickens corresponds with increased in vivo resistance to not only bacterial infections, but also parasitic protozoan infections.

Key Words: innate immunity, *Eimeria tenella*, disease resistance

32 Immunomodulatory effects of a commercially available probiotic on coccidiosis vaccination in broilers. K. Stringfellow*¹, D. Caldwell¹, J. Lee¹, A. Klein¹, S. Pohl¹, M. Mohl², R. Beltran², G. Schatzmayr², S. Fitz-Coy³, C. Broussard³, and M. Farnell¹, ¹Texas AgriLife Research, College Station, TX, ²BiomIn GmbH, Herzogenburg, Austria, ³Intervet/Schering-Plough Animal Health, Summit, NJ.

Probiotics in poultry diets enhance gut health as well as stimulate both innate and adaptive immunity. The hypothesis of this study was that probiotic administration would modulate the immune response against coccidiosis vaccination and subsequent clinical *Eimeria* challenge in broilers. This trial consisted of a negative control, probiotic alone, vaccine alone, and probiotic with vaccine combined experimental groups. Probiotic was administered through the drinking water and coccidiosis vaccination was performed on day-of-hatch by spray application. All birds were challenged with field-strain *Eimeria* oocysts by litter application on day 14 and oral gavage on day 35. Blood was collected on days 14, 21, 28, 35, and 42. Heterophil and mononuclear cells were each assayed for oxidative burst and lymphocyte proliferation. On days 14 and 28, heterophil oxidative burst was increased (P<.05) in probiotic with vaccine combination broilers relative to controls. Heterophil oxidative burst was also increased (P<.05) in vaccine alone and probiotic alone broilers on day 35. Monocyte oxidative burst was increased (P<.05) in the probiotic with vaccine combination broilers on all days except day 42 as compared to controls. On day 21, an increase (P<.05) in monocyte oxidative burst was observed in vaccine alone broilers. An increase (P<.05) in monocyte oxidative burst was seen in all groups on day 35. Lymphocyte proliferation was greater (P<.05) on days 14 and 42 in probiotic alone broilers and in all groups on day 21, when compared to controls. Increases (P<.05) in lymphocyte proliferation were also seen in probiotic with vaccine combination broilers on day 14. These data suggest that probiotic administration has the potential to modulate immune responsiveness in broilers to coccidiosis vaccination and subsequent clinical *Eimeria* challenge.

Key Words: *Eimeria*, probiotic, vaccine, immune, heterophil

33 Influence of probiotic administration, coccidiosis vaccination, *Eimeria* challenge, or ionophorous coccidiostat administration on gut morphology in broilers. S. L. Dunn*¹, D. J. Caldwell¹, J. T. Lee¹, K. D. Stringfellow¹, A. E. Klein¹, R. Droleskey², M. Mohl³, R. Beltran³, G. Schatzmayr³, S. Fitz-Coy⁴, C. Broussard⁴, and M. B. Farnell¹, ¹Texas AgriLife Research, College Station, TX, ²SPARC-USDA, College Station,

TX, ³BiomIn GmbH, Herzogenburg, Austria, ⁴Intervet/Schering-Plough Animal Health, Summit, NJ.

Probiotics are beneficial bacteria that can stimulate avian mucosal immune function. We hypothesized that stimulating the innate immune system with probiotics would improve the adaptive immune response to coccidiosis vaccination, and possibly improve gut health. The current study investigated the effects of a probiotic, a live oocyst coccidiosis vaccine, or an ionophorous coccidiostat on the intestinal morphology of broilers. On day-of-hatch, straight-run broilers were placed into floor pens with built up litter. Experimental groups consisted of negative control, probiotic alone, vaccine alone, probiotic with vaccine, coccidiostat alone, and coccidiostat with probiotic. Birds were challenged with *Eimeria* oocysts via day 14 litter application and day 36 oral challenge. On days 6, 22, 36, and 43, samples of duodenum were collected and stored in neutral buffered formalin, then prepared for morphological evaluation. On day 6, intestinal villi heights of the vaccinated alone group were significantly higher when compared to the negative control. On day 22, intestinal villi heights were increased in the coccidiostat alone and in the coccidiostat with probiotic groups. On days 36 and 43, there were no differences in any groups when compared to the negative control. These data suggest that probiotics and vaccination may benefit villus height initially. On the other hand, the coccidiostat seem to prevent normal exposure of the avian immune system to invasive coccidia for the development of immunity because, once coccidiostat was removed from the ration, villi heights were reduced (p≤.05), indicating the prevalence of infection. Further investigation is necessary to explore the effects of ionophores on immune function.

Key Words: gut morphology, probiotic, coccidiosis, vaccine, ionophore

34 Flow cytometric analysis of the binding of agonistic anti-chicken CD40 mAb to primary chicken B-cells and macrophages. C-H. Chen*¹, D. Abi-Ghanem¹, L. Njongmeta³, J. Bray³, W. Mwangi³, S. D. Waghela³, N. Ing², and L. R. Berghman^{1,3}, ¹Texas A&M University, Poultry Science Department, College Station, ²Texas A&M University, Animal Science Department, College Station, ³Texas A&M University, Veterinary Pathobiology Department, College Station.

Purpose: CD154, a member of the TNF superfamily, which is transiently expressed on activated TH cells, has several essential immune functions. The interaction between CD40 and CD154 mediates specific T-cell help to B-cells in response to T-cell dependent antigens; it also provides signals crucial for affinity maturation and generation of class-switched memory B-cells. Agonistic anti-CD40 monoclonal antibodies (mAbs) successfully mimic the actions of CD154 on antigen presenting cells, leading to enhanced antibody production and isotype switching of B-cells. Biological effects of the anti-chicken CD40 (cCD40) mAbs we produced include induction of nitric oxide (NO) synthesis in chicken HD11 macrophages and enhancement of cell proliferation in chicken DT40 B-cells. In the present study, we describe the interaction of the agonistic anti-cCD40 mAb 2C5 with the extracellular domain of CD40 on both primary chicken B-cells and macrophages.

Experimental design: The monoclonal anti-cCD40 antibody 2C5 was purified by protein A affinity chromatography, isotyped, and then labeled with R-phycoerythrin. Primary chicken B lymphocytes and mononuclear cells were purified from chicken spleen by use of Histopaque®-1077. Primary chicken macrophage cells were collected from differentiated mononuclear cells cultured in vitro. Viable B lymphocytes and macrophages were stained with labeled mAb 2C5 and then analyzed by

flow cytometry. Chicken DT40 B-cells and HD11 macrophages were similarly stained and analyzed.

Results: Immunoglobulin isotyping assay showed that the anti-cCD40 mAb 2C5 is IgG1. Flow cytometric analysis showed that 2C5 recognizes CD40 on primary chicken B lymphocytes and macrophages, as well as on chicken DT40 and HD11 cell lines.

Conclusion: We have previously shown that mAb 2C5 stimulates proliferation of chicken DT40 cells and NO production by chicken HD11 cells. In this abstract, we report that anti-cCD40 mAb 2C5 is agonistic and can be used to further study the T-cell dependent B-cell activation pathway in chickens.

Key Words: chicken CD40, monoclonal antibodies, flow cytometry, primary chicken B-cells, primary chicken macrophages

35 Immunization of turkeys with live attenuated *Salmonella* vectors expressing CD154. K. M. O'Meara*¹, C. J. Kremer¹, S. L. Layton², B. M. Hargis², and K. Cole¹, ¹The Ohio State University, Columbus, ²University of Arkansas, Fayetteville.

Food-borne illness is a worldwide public health concern and an estimated 1.4 million cases are due to human *Salmonella* infection each year. Even though the organism has been isolated from most food animals, poultry has been identified as the clearest link to human *Salmonellosis*. Therefore, there is a need to find an effective vaccine that protects poultry against multiple *Salmonella* serotypes. Using the Red recombinase system in combination with overlapping extension PCR, several novel attenuated *Salmonella enteritidis* strains (Δ SE) that express variations of a potential immune-enhancing CD154 peptide sequence on the outer membrane protein (lamB) in association with an M2e epitope were developed. The three CD154 peptide sequences evaluated in this study correspond to those naturally occurring in turkey, human and chicken species. Poults were challenged with 10^6 – 10^8 cfu/poult via oral gavage at day-of-hatch and again at 21 d post-hatch with saline or a recombinant *Salmonella* strain (Δ SE–M2e, Δ SE–M2e–TurkeyCD154, Δ SE–M2e–HumanCD154, Δ SE–M2e–ChickenCD154). Liver/spleen and cecal tonsils were aseptically removed at d 7 and weekly through d 42 post-hatch for detection of Δ SE strain recovery, and blood samples were obtained for determination of M2e-specific antibody response. There were no differences observed in M2e-specific antibody response due to the simultaneous expression of CD154. The vaccine candidate strains harboring a CD154 peptide sequence demonstrated faster clearance from the flock when compared to the vaccine candidate strain that does not express a CD154 sequence. However, there were no differences observed between the vaccine candidate strains expressing a CD154 peptide sequence. These data suggest that these *Salmonella*-vectored vaccines expressing a CD154 peptide sequence are able to invade the liver and spleen, thereby stimulating an immune response.

Key Words: *Salmonella*, CD154, colonization, immune response

36 Cloning and functional characterization of avian interleukin-19. S. Kim*¹, K. B. Miska², A. P. McElroy¹, M. C. Jenkins², R. H. Fetterer², and R. A. Dalloul¹, ¹Virginia Polytechnic Institute and State University, Blacksburg, ²Animal and Natural Resources Institute, Beltsville, MD.

An interleukin (IL)-10 family member, IL-19, is a recently discovered T helper type-2 (Th2) cytokine of mammals. As best characterized so far,

IL-19 alters the balance of Th1 and Th2 cells in favor of the Th2 type. Existence of the avian IL-19 gene has been indicated, but no research has reported its functional characterization. The full-length avian IL-19 gene, located on chromosome 26, was amplified from LPS-stimulated chicken monocytes, and cloned into either a prokaryotic (pET28a) or a eukaryotic (pcDNA3.1) expression vector. The confirmed avian IL-19 nucleotide sequence has 47% homology with human and murine IL-19, with a predicted protein sequence of 176 amino acids. Analysis of avian IL-19 amino acid sequence showed conserved and structurally relevant 6 cysteine residues like in mammals, but not the N-glycosylation residue. The bacterially expressed avian recombinant IL-19 (rIL-19) was purified by Ni⁺-resin column and the endotoxin removed. Using purified avian rIL-19, expression of Th2 cytokines was measured in splenocytes using quantitative real-time PCR (qRT-PCR). Isolated splenocytes were cultured in the presence or absence of rIL-19 for 6 and 12 hours. Total RNA was extracted, cDNA prepared, and qRT-PCR performed to assess the levels of Th2 cytokine transcripts. In the presence of rIL-19, expression levels of IL-4 and IL-13, as well as IL-10, were significantly increased in both 6- and 12-hour treatments. This was confirmed by treating splenocytes with supernatants from IL-19 transfected cells. Also, avian monocytes incubated with rIL-19 manifested increased expression of IL-1 β , IL-6, IL-10, and IL-19. This study represents the first report for the cloning, expression, and functional characterization of avian IL-19. Taken together, avian IL-19 function seems to be conserved and similar to that of mammals and may play an important role in responses to extracellular poultry pathogens.

Key Words: IL-19, avian immunity, Th2, real-time PCR

37 Expression of innate immunity genes during *Eimeria praecox* infection in broilers. L. H. Stuard*¹, K. B. Miska², M. C. Jenkins², R. H. Fetterer², and R. A. Dalloul¹, ¹Virginia Polytechnic Institute and State University, Blacksburg, ²Animal Parasitic Diseases Laboratory, USDA/ARS, Beltsville, MD.

Intestinal colonization of avian species by *Eimeria* parasites results in the enteric disease, coccidiosis. Compared to infection by *E. maxima* alone, the simultaneous presence of *E. maxima* and *E. praecox* in the gut has a positive impact on weight gain and feed efficiency. A study was carried out to assess the immunological effects of *E. praecox* infection on the gut of infected broilers. Birds were orally gavaged with 10,000 *E. praecox* oocysts at 2 weeks of age and intestinal sections were sampled consecutively on days 1 through 7 post-infection. Intestinal expression of innate immune gene transcripts was analyzed by real-time PCR. Since *E. praecox* and *E. maxima* infect the duodenum and jejunum, respectively, research was focused on the proximal sections of the small intestine. Analysis of relative gene expression revealed a decrease ($P < 0.05$) in Toll-like receptor (TLR)-15 in the jejunum of infected birds on day 2 post-infection. On day 3, cathelicidin antimicrobial peptide was downregulated in the jejunum of infected broilers. Expression of liver-expressed antimicrobial peptide 2 (LEAP-2) in infected birds was also significantly lower than the control in the duodenum on days 3 through 6, and in the jejunum on day 4. Interestingly, there was also a difference ($P < 0.05$) in the expression of LEAP-2 between the two intestinal sections of both infected and control birds on all 7 days. TLRs participate in innate immunity by acting as pathogen recognition receptors that control the expression of cytokines and chemokines. TLR-15 is an avian-specific TLR suspected to play a role in the defense against bacterial infections. The observed downregulation of TLR-15 suggests that *E. praecox* infection may have a unique effect on this particular TLR, resulting in a compromised innate immune system. Antimicrobial

peptides act as immunomodulators by affecting the membrane permeability of a variety of target cells. While the upregulation of chicken cathelicidin and LEAP-2 has been observed in response to bacterial infections, the results of this study imply that these peptides may react differently to parasitic infections, specifically *E. praecox*.

Key Words: *Eimeria*, innate immunity, broiler, LEAP-2, TLRs

38 Characterization of turkey iNOS and development of assays to study its role in poult enteritis. R. R. Meyerhoff*, R. A. Ali, and M. D. Koci, *North Carolina State University, Raleigh*.

Acute viral enteritis is one of the leading causes of morbidity and mortality in both animals and humans. However, despite its prevalence, our understanding of the mucosal immune response to these enteric pathogens is limited. In turkey production, viral enteritis causes significant financial losses due to decreased growth and feed conversion, increased veterinary care, and in extreme cases increased mortality. In spite of the known impact on poultry production, very few treatment and control strategies have been developed. In an effort to further characterize this host-pathogen interaction, our laboratory has developed a model of acute viral disease mediated by turkey astrovirus type-2 (TAsV-2). In previous studies, we demonstrated that TAsV-2 infection induces severe watery diarrhea and growth depression. However, these clinical signs are associated with only mild histological changes. Although there was no sign/evidence of inflammation or immune response to infection, RNA expression analysis suggests an increase in the expression of constituents of the innate immune system, specifically inducible nitric oxide synthase (iNOS). Subsequent studies suggest that expression of iNOS and its virucidal product (NO) can inhibit TAsV-2 replication. To further understand the role iNOS plays in the anti-TAsV-2 response, we sequenced the full length turkey iNOS (tkiNOS) cDNA, compared it to known iNOS genes, and produced goat-anti-tkiNOS peptide anti-sera. The results of this work are the first, to our knowledge, to describe the full cDNA sequence of the tkiNOS gene and develop tkiNOS specific reagents. These new reagents and assays will play a key role in our ability to determine the effect of iNOS and NO on TAsV-2-mediated enteritis as well as other enteric infections.

Key Words: turkey astrovirus, inducible nitric oxide synthase

39 The effects of the DFM Primalac® on energy repartitioning to the immune system of broilers. R. Qiu*, J. Croom, R. Ali, and M. D. Koci, *North Carolina State University, Department of Poultry Science, Raleigh*.

Direct fed microbials (DFMs) are used in poultry production to as an alternative to the subtherapeutic use of antibiotics. The mechanisms by which they improve animal performance are still unknown. In previous studies the DFM Primalac® reduced ileal respiration without an attendant change in whole-body energy expenditure in broilers. This suggests that energy may be repartitioned between different organ systems within the body following DFM supplementation. To determine if DFM supplementation affects energy metabolism of different organs and tissues, day-old male broilers were allocated to two treatment groups: control starter diet (CON; CP =23%), or CON plus Primalac® (0.3% w/w; PRIM). To assess energy metabolism, body weight, feed consumption, whole-body energy expenditure, organ mass, tissue respiration rates, peripheral blood leukocytes (PBL), and ATP levels were measured at different time points. PRIM caused no difference (P>0.1)

in whole body energy expenditure or bodyweight gain between treatments but did decrease ileal O₂ respiration (P<0.05). Analysis of other tissues demonstrated no changes in the mass or respiration rate of breast muscle, liver or spleen with PRIM (P>0.05). In contrast, bursa weight and the respiration rate of thymus were increased (P<0.05). PRIM treated animals also demonstrated an increase in the ATP level of PBL and an increased rate of ATP usage (p<0.01). This suggests that PRIM treatment increased energy consumption by the immune system. To determine if this increased energy utilization corresponds with an altered immune response, broilers were challenged with sheep red blood cells (SRBC) and assayed for differences in their humoral response. PRIM treated birds demonstrated a faster kinetics in their anti-SRBC IgG and were found to have more total sIgA as compared to controls. Collectively, these data suggests that PRIM supplementation increased energy partitioning to the immune system and enhanced immune response to SRBC challenge. Further investigation is needed to more completely describe the role of PRIM and DFM in the repartitioning of energy to the immune system.

Key Words: DFM, probiotics, immune function, energy metabolism, broiler

40 Effect of chromium sources on immune responses of heat stressed broiler chicks. M. Shivazad*¹, M. Toghyani², and S. H. Zarkesh³, ¹*University of Tehran, College of Agriculture, Karaj, Iran*, ²*Islamic Azad University of Khorasgan, Isfahan, Iran*, ³*University of Isfahan, Isfahan, Iran*.

The present study investigated the effect of different levels of organic and inorganic chromium (Cr) on immunity of heat-stressed broiler chicks. Four hundred and twenty day-old male broilers (Ross 308) were reared in heat stress condition(s) for 42 d. Seven dietary treatments consisted of the basal diet supplemented with 0 (control), 500, 1000 and 1500 micro gram of Cr/kg of diet in the form of Cr nicotinate (contain 12.25% Cr) and Cr chloride (contain 18% Cr) respectively, as organic and inorganic sources. Antibody titers against Newcastle and Influenza virus at 18 and 30d, heterophil to lymphocyte ratios, albumin to globulin ratios and concentration of immunoglobulin G in serum were measured at 21 and 42 d. On day 42, thymus, spleen and bursa of Fabricius were collected, weighed and expressed as a percentage of live body weight. Antibody titers against Newcastle and Influenza virus were elevated at 30d of age in broiler chicks fed supplemental Cr, especially organic Cr. Heterophil to lymphocyte ratios decreased in broiler chicks fed 1000 micro gram of organic or inorganic Cr/kg diet at 21 d. Concentration of immunoglobulin G in serum was increased by organic and inorganic Cr supplementation. Albumin to globulin ratios and weights of lymphoid organs were not affected by supplemental Cr. The results suggest that organic and inorganic Cr supplementation improves some immune responses of heat-stressed broiler chicks.

Key Words: broiler, organic and inorganic Cr, heat stress, immune response

41 Humoral immune response in breeding hens and protective immunity provided by administration of purified *Salmonella gallinarum* porins. G. V. Gomez-Verduzco¹, G. Tellez*², A. L. Quintana¹, A. Isibasi³, and V. Ortiz-Navarrete⁴, ¹*Departamento de Producción Animal:Aves, FMVZ, UNAM, Mexico City, Mexico*, ²*University of Arkansas, Department of Poultry Science, Fayetteville*, ³*Unidad de Investigación Médica en Inmunoquímica del Hospital de Especialidades*

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The current studies were undertaken to assess the ability of humoral immune response in breeding hens and the protective immunity provided by administration of purified *Salmonella gallinarum* (SG) porins to the progeny. Two hundred and ten broiler breeder hens, 53 weeks old, were divided into three groups and subcutaneously immunized via multiple sites at 0 and 10 days with either: a) 10 µg SG porins; b) 30 µg of SG porins; or c) control, inoculated with phosphate buffer solution (PBS) without porins. Seven days after the second immunization, the levels of SG-specific antibodies were determined in the serum and fertile eggs collected from hens using an enzyme linked immunosorbent assay. Furthermore, fertile eggs were collected again from hens in all treatments and incubated for 21 days. On day of hatch, chicks were placed in groups of 30 birds per group and gavaged with 20, 100 and 500 LD₅₀ % of SG. Results indicated that purified SG porins induced the production of IgY class antibodies detected in the serum and eggs of SG porin-immunized hens ($P < 0.05$). In addition, SG porins cross-reacted with porins of *Salmonella typhi*. Compared to control unimmunized hens, the progeny of immunized hens were protected by 53 to 70% fold against challenges of 20 – 500 LD₅₀ % of SG ($P < 0.001$). These results suggest that porins of SG as well as those of other *Salmonella* species participate in the induction of protective immunity, and modulation of humoral immune response is one of the mechanisms involved.

Key Words: *Salmonella gallinarum*, porins, immunity, chickens

42 Effect of dietary *Cinnamomum cassia* and *Curcuma longa* on *Eimeria tenella* infection in broiler chickens. S-H. Lee*¹, S. Jang¹, D. Kim¹, M. Park¹, C. Ionescu², D. Bravo², and H. Lillehoj¹, ¹Animal and Natural Resources Institute, Agricultural Research Service-U.S. Department of Agriculture, Beltsville, MD, ²Pancosma S.A., Geneva, Switzerland.

The protective effect of dietary cinnamaldehyde (*Cinnamomum cassia*) and turmeric (*Curcuma longa*) on avian coccidiosis was evaluated in young broilers. One-day-old broiler chickens were continuously fed with a standard diet alone or standard diets supplemented with cinnamaldehyde or turmeric extracts for 3 weeks. Body weight gains, fecal oocyst shedding, antibody titers, splenocytes proliferation, and pro-inflammatory cytokine production were measured as parameters of protective immunity following infection with *E. tenella* at 14 day of age. There was no toxicity associated with feeding these two plant extracts. Chickens fed turmeric-supplemented diet showed significantly increased body weight gain and shed significantly reduced fecal oocysts compared with birds fed the standard diet alone or the cinnamaldehyde-supplemented diet following challenge infection with *E. tenella*. Both groups fed cinnamaldehyde- or turmeric-supplemented diet showed significantly improved splenocytes proliferation compared with control birds. Chickens fed cinnamaldehyde-supplemented diet produced higher serum antibody titers compared to the groups fed the standard diet or turmeric-supplemented diet. Finally, the levels of local cytokine transcripts of IL-1β and IL-15 were consistently higher in the turmeric-fed group compared to the groups fed the standard diet alone or cinnamaldehyde-supplemented diet. This study provides first immunological evidence that dietary supplementation of cinnamaldehyde and turmeric enhance local innate immunity and turmeric induces higher protective immunity against *E. tenella* infection.

Key Words: broiler, *Eimeria tenella*, *Curcuma longa*, dietary supplement, cytokine

Metabolism and Nutrition I: Vitamins and Minerals

43 Effects of different dietary copper sources at pharmacological levels on laying hen performance, egg yolk cholesterol and blood parameters. A. Y. Pekel* and M. Alp, *Istanbul University, Faculty of Veterinary Medicine, Istanbul, Turkey.*

An experiment was conducted using a total of 120, 16-wk-old, Lohmann Brown hens to compare three different supplemental dietary copper (Cu) sources at prophylactic levels (250 mg/kg) on hen performance, egg yolk cholesterol and blood parameters. Layers were randomly allocated to four dietary treatments with ten replications of three birds each per treatment. Layers were fed diets containing 0 (Control) or 250 ppm Cu from copper sulfate (Cu-sulfate), copper proteinate (Cu-proteinate) or Copper lysine (Cu-lysine) for 24 wk. There were no differences among copper sources for live weight, egg specific gravity, yolk cholesterol, plasma total cholesterol, high-density lipoprotein cholesterol (HDL), triglycerides and glutathione (GSH). Supplementation with 250 ppm Cu-sulfate improved egg production and feed conversion ratio but decreased egg weight ($P < 0.05$) and feed intake ($P < 0.01$) compared with other diets. Supplementation with Cu-proteinate resulted in decreased feed intake ($P < 0.01$) and improved feed efficiency ($P < 0.05$) but egg production and egg weight were not changed as compared with control. Cracked egg ratio of layers given Cu-proteinate was higher ($P < 0.01$) than those of birds fed other diets. Birds fed the Cu-lysine diet had lower egg shell thickness ($P < 0.001$) and lower egg shell weight ($P < 0.05$). Egg shell

thickness of layers given Cu-sulfate was also lower than control ($P < 0.001$). Copper content of the eggs and excreta were significantly ($P < 0.001$) increased regardless of copper source compared with birds fed the control diet. The results of this trial do not confirm previous findings that copper alters lipid metabolism resulting in reduced egg yolk cholesterol. However, the addition of 250 ppm copper from Cu-sulfate might be beneficial in improving the layer performance more so than Cu-lysine and Cu-proteinate.

Key Words: copper, layer, performance, cholesterol, egg quality

44 Selenium enrichment of table eggs. D. C. Bennett* and K. M. Cheng, *University of British Columbia, Vancouver, BC, Canada.*

Selenium (Se) is an essential micronutrient with a recommended dietary allowance for human adults of 55 µg/d. However, there is evidence that greater dietary intakes may have possible health benefits, including a reduction in the risk of cancer. Several studies have shown the feasibility of enriching eggs using organic sources of Se, and that Se-enriched eggs are an effective way to supplement human diets. However, few studies have examined the response of egg Se concentration to high (>1 ppm) dietary organic Se levels. Organic Se is less toxic than sodium selenite. The objective of the current study is to examine the effect of