

effects of selection age on growth and development, a complete diallele cross was made between the 4 selected quail populations. Growth and yield was measured on 4 replicate pens for each cross, with each pen containing a minimum of 20 birds. Growth and yield for all crosses were evaluated at each of the 4 selection ages: days 10, 17, 28, and 40. Of particular interest in this study is the change in both reciprocal and heterotic effects over time. In this study it was observed that reciprocal and heterotic effects did change over time. In both cases nonadditive genetic variation seems to play a much greater role prior to rather than post point of inflection (POI). In general, the utilization of a line selected at or prior to POI is advantageous as it maximizes growth potential due to the effects of nonadditive variation. This advantage was apparent for both growth and yield parameters in this study. It is interesting to note that the crosses that resulted in the most heterosis were those that included a line selected at POI and a second line selected for late body weight.

Key Words: Japanese quail, diallele cross, point of inflection

222 Gene expression profiling of host responses to Marek's disease virus: A comparison of genetically defined resistance and susceptibility. A. J. Sarson*^{1,2}, P. Parvizi¹, D. Lepp², M. Quinton¹, and S. Sharif¹, ¹University of Guelph, Guelph, ON, Canada, ²Guelph Food Research Centre, Agriculture and Agri-Food Canada, Guelph, ON, Canada.

Marek's disease virus (MDV) is a cell-associated oncogenic herpesvirus that induces lymphoid tumours in chickens. Genetic resistance to Marek's disease (MD) has been largely associated with the major histocompatibility complex (MHC). For example, chickens with the B21 and B19 haplotypes have been strongly correlated with resistance and susceptibility to MD, respectively. However, MD resistance is under polygenic control and therefore we sought to compare the gene expression profiles of MDV infected B19 and B21 chickens, to assess the role of non-MHC genes in MDV infection. Birds from both B21 and B19 haplotypes were divided into 2 groups with one group infected (10,000 plaque-forming units of JM-16, MDV at 5 days posthatch). On days 4, 7, 14 and 21 postinfection, gene expression profiles in spleen tissue were obtained using a chicken immune-specific microarray. LOWESS normalized signal intensity was analyzed for differential expression using a mixed model ($P \leq 0.05$). Microarray results indicated significantly differential gene expression across time and treatments (AH221, Bu-1, IgG, IgA, IgM, MHC class II β chain, granzyme A, and STAT2). However, only immunoglobulin genes were differentially expressed when comparing B19 and B21 infected chickens. A subset of genes derived from microarray analysis was validated by quantitative PCR. Overall, we noted gene expression patterns that differed between lines

in infected birds, as well as within lines when comparing infected and uninfected birds. These gene expression data have suggested novel candidate genes for resistance or susceptibility to MD emphasizing the involvement of several gene families, including those encoding immunoglobulins, MHC molecules, signal transduction molecules, and cytolytic proteins. Future directions will be aimed at further dissecting the function of these genes and their products in immunity to MD and genetic regulation of resistance to this disease.

Key Words: Marek's disease, disease resistance, microarray

223 Cholesterol levels in divergently selected Japanese quail lines following 35 generations of relaxed selection. C. B. Stephens*, H. L. Marks, M. P. Lacy, E. H. Foster, and M. M. Compton, *Department of Poultry Science, University of Georgia, Athens.*

The purpose of this experiment was to determine if cholesterol levels in a high cholesterol line (HL) and low cholesterol line (LL) of Japanese quail would drift back toward control line (CL) levels if selection pressure was removed. Japanese quail were divergently selected over 18 generations for high and low plasma cholesterol. After 18 generations, the cholesterol levels of high line quail averaged 28% more than controls and the cholesterol levels of low line quail averaged 31% less. The divergently selected lines were then regenerated without additional selection pressure for 35 generations. At 26 weeks of age, 15 male and 15 female quails from each genetic line were weighed and serum samples were obtained. Samples were analyzed for total cholesterol using an enzymatic cholesterol quantification assay. Mean total cholesterol for the HL (400 mg/dL) differed significantly ($P < 0.05$) from the LL (295 mg/dL) and CL (272 mg/dL). There was no significant difference between the LL and CL. No significant differences between cholesterol levels of males and females were observed in any of the lines. There was no significant correlation between cholesterol levels and body weight. These results suggested that genetic differences are still present in HL quail even after long term relaxed selection; however, cholesterol levels in the LL quail appear to have returned to CL levels. Minimum cholesterol levels are essential to many physiological functions including cell membrane development and maintenance, vitamin metabolism, and reproduction. This may be one explanation as to why LL quail returned to CL levels when selection pressure was removed. In the protocol used to generate the 2 divergent lines, quail with high and low cholesterol levels were selected at 4 weeks of age. In the current study, cholesterol was measured in 26-week-old birds. These results indicated the need for further research including assaying cholesterol at 4 weeks of age.

Key Words: Japanese quail, cholesterol, divergent selection

Metabolism and Nutrition VI: Feed Additives

224 Cardiac morphology, fatty acid status and eicosanoid production in broiler birds: Effect of maternal omega-3 fatty acids. J. Bautista-Ortega, G. Cherian*, and D. E. Goeger, *Oregon State University, Corvallis.*

Metabolic, inflammatory (e.g., joint abnormalities), sudden death, ascites, and cardiovascular irregularities are major causes of morbidity and mortality in broiler chickens. The objective of this research was to

evaluate the contribution of a maternal diet rich in n-3 fatty acids on cardiac morphology, polyunsaturated fatty acid and eicosanoid metabolism in broiler birds. Fertile eggs with diverse n-6 and n-3 fatty acids were obtained by feeding breeder hens diets containing 3.0% sunflower oil (Low n-3), 1.5% sunflower oil and 1.5% fish oil (Medium n-3), or 3.0% fish oil (High n-3). These oils were chosen due to their high content of n-6 or n-3 fatty acids. The hatched chicks were fed a diet devoid of long chain n-6 or n-3 fatty acids for 6 weeks. Chicks hatched from Low n-3

eggs were heavier than those hatched from High n-3 ($P < 0.05$). The difference in initial body weight lasted up to day 42 of growth. The heart weight:body weight ratio at 28 days of age was lower for Low n-3 when compared to Medium n-3 or High n-3 birds ($P < 0.05$). The ventricular weight index was affected by bird age ($P = 0.003$), but not by maternal diet. The n-6 fatty acid in cardiac tissue was lower in High n-3 chicks than in Low and Medium n-3 chicks ($P < 0.05$). Lower concentrations of arachidonic acid (20:4n-6) in the cardiac tissues were evident up to day 14 of growth in High n-3 chicks ($P < 0.05$). Prostaglandin E₂ (proinflammatory) production by heart and peripheral mononuclear cells was lower in High n-3 chicks than in Medium or Low n-3 chicks. Because broiler birds are raised commercially for 5 to 6 weeks, and considering the role of eicosanoids in metabolic and inflammatory pathways, decreasing proinflammatory eicosanoid generation through maternal dietary manipulation could lead to fewer inflammatory and metabolic disorders in poultry.

Key Words: metabolic disorder, n-3 fatty acid, eicosanoid

225 Improvement in hot (dry) breast meat yield of broiler chickens with dietary AZOMITE[®], natural mineral supplement, as shown by statistical meta-analyses of data from 13 contract research trials and 10 integrator field trials. W. Emerson¹ and D. M. Hooge^{*2}, ¹Peak Minerals-AZOMITE, Inc., Warrensburg, MO, ²Hooge Consulting Service, Inc., Eagle Mountain, UT.

A hydrated calcium sodium aluminosilicate product (Azomite[®], Peak Minerals-Azomite, Inc., Warrensburg, MO) from a mound east of Yuba Lake near Levan, Utah, thought to be comprised of volcanic ash and ancient marine deposits, typically contains detectable quantities of 75 of the 92 naturally occurring elements on earth (UT-HCSAS). Based on research and commercial use since the 1940s, it is known to enhance plant growth, flowering, and fruit yields and flavor, and has been reported to have several beneficial effects in poultry production, including improved broiler chicken BW, feed conversion ratio, livability, carcass yield, and breast meat yield. This product is on the OMRI[®] list of approved organic feed ingredients and is FDA approved as an anticaking (flow) agent which may be added at levels up to 2% (40 lb/ton) of the diet; however, practical levels of inclusion have been about 0.5% (10 lb/ton) in prestarter or starter feeds dropping to about 0.4% (8 lb/ton) in grower, and 0.3% (6 lb/ton) or less in subsequent feeds. In broiler feeds, UT-HCSAS product may act as a mycotoxin binder, provide ultra-trace elements which have been studied to only a limited extent if any, and/or have some other complementary mode of action which has not yet been discovered. The objective of this report is to provide results of meta-analyses of data from 13 contract research trials and from 10 integrator field trials comparing negative control (nCON; no UT-HCSAS supplementation) diets vs. UT-HCSAS supplemented diets for broilers. In 13 contract research trials, hot (dry) breast meat yield means were 17.94% for nCON vs. 18.65% for UT-HCSAS (+0.70%; $P < 0.001$). In 10 integrator trials, hot (dry) breast meat yield means were 16.73% for nCON vs. 17.11% for UT-HCSAS (+0.38%; $P < 0.001$). The dietary UT-HCSAS supplement produced highly significant increases in hot (dry) breast meat yield of broiler chickens both in contract research and in commercial situations.

Key Words: Azomite, breast meat yield, ultra-trace minerals

226 The effects of supplemental guanidino acetic acid as a precursor of creatine in vegetable broiler diets on performance and carcass parameters. J. Ringel^{*1}, A. Lemme¹, M. S. Redshaw¹, and K. Damme², ¹Evonik Degussa GmbH, Hanau, Germany, ²Bavarian State Research Center for Agriculture, Kitzingen, Germany.

After the ban of animal protein many broiler producers switched to purely vegetable diets. Consequently performance losses were reported. A potential reason for this may be the lack of creatine, as creatine is not present in raw materials of plant origin. The experiment was carried out to test whether dietary supplementation of all-vegetable broiler diets with guanidino acetic acid, which is a natural precursor of creatine, improves production performance in broilers. Purely vegetable basal starter, grower and finisher diets with either no (control), 600 or 1,200 mg/kg (GAA/CreAmino[™]) were fed to 3,400 male Ross 308 broilers (170 birds per treatment × 6 pens for the control or × 7 pens for the CreAmino[™] treatments, respectively) for 35 days. At termination of the trial 5 birds per pen were slaughtered for carcass analyses. Overall weight gain was not affected by inclusion level. CreAmino[™] supplementation reduced feed intake resulting in a significantly improved feed conversion ratio ($P \leq 0.05$) over the 35 day period. Breast meat (as a percentage of carcass weight) linearly increased ($P \leq 0.05$) with CreAmino[™] inclusion level from 27.7% on the control diet to 28.9% at 600 mg/kg inclusion level to 29.5% at 1,200 mg/kg inclusion level. Results indicate that supplemental CreAmino[™] to all-vegetable broiler diets improves performance and carcass parameters in terms of feed conversion and breast meat yield.

Key Words: guanidino acetic acid, creatine, broiler

227 Field trial demonstrating the beneficial effect of dietary *Bacillus subtilis* C-3102 spores (Calsporin[®]) on brown shell color scores of eggs from hens on litter in three U.S. commercial flocks producing eggs for the free-range egg market versus pretrial color fan scores. D. M. Hooge^{*1}, N. Otomo², and S. C. Johnson³, ¹Hooge Consulting Service, Inc., Eagle Mountain, UT, ²Calpis Co. Ltd, Tokyo, Japan, ³Quality Technology International, Inc., Elgin, IL.

Three U.S. commercial Bovans Brown flocks each consisting of about 14,500 laying hens producing brown eggs were utilized to compare pretrial brown egg color fan scores (Ghen Corp., Japan; 1 lightest to 10 darkest) versus scores during supplementation of *Bacillus subtilis* C-3102 spores (*Bs* C-3102; Calsporin[®], Calpis Co. Ltd, Tokyo, Japan) at 300,000 cfu/g feed (egg sampling after about 2 to 3 wk). Brown eggshell color typically declines with age and may vary due to strain of hens or certain diseases. The flocks were at one company and were about 50 to 60 wk of age when the direct-fed microbial began to be added to feeds. In each flock, the pretrial, random egg sampling involved 3 sampling dates over about 2 1/2 wk and 100 eggs collected per sampling. During supplementation, in 2 flocks there were 2 and in 1 flock there were 3 egg sampling dates (100 eggs were taken at random per sampling). Brown eggs were color fan scored by the same person each time under fluorescent light and natural daylight (near a large window permitting sunlight to enter) in an egg processing plant. Pretrial vs. *Bs* C-3102 supplementation period egg scores for youngest to oldest flocks were: 1) pretrial 8.26, 7.11, 6.74 (avg 7.37^a; however, avg 6.93 with very high initial value removed) vs. during *Bs* C-3102 feeding 7.64, 6.60, 6.99 (avg 7.08^b, $P = 0.022$); 2) pretrial 7.87, 6.38, and 6.31 (avg 6.85^b) vs. 7.90 and 7.66 (avg 7.78^a, $P = 0.000$); and 3) pretrial 6.63, 5.63, and 6.70 (avg 6.32^b) vs. during *Bs* C-3102 feeding 6.72 and 7.99 (avg 7.36^a; $P = 0.000$).

Nonsignificant differences were found in % scores less than 5 (“too light”) between pretrial and *Bs* C-3102 feeding periods for the 3 flocks (4.33 vs. 5.33%; 8.33 vs. 1.00%; and 12.67 vs. 5.50%, respectively). Dietary *Bs* C-3102 significantly increased brown eggshell color fan scores (+0.93 and +1.04 units) in 2 of 3 flocks in spite of age progression.

Key Words: brown egg color, Calsporin, direct-fed microbial

228 Effects of *Candida* source yeast (CitriStim®) and *Saccharomyces* source yeast on performance of 21 day-old broiler chickens. H. Yang*, M. Sifri, and T. Radke, *ADM Alliance Nutrition, Inc., Quincy, IL.*

A 21-d broiler chicken study was conducted to evaluate whether yeast source and level affected performance. A total of 180 one-day-old male broiler type chickens housed in Petersime type cages were assigned to 1 of 5 dietary treatments with 6 pens and 36 birds per treatment. The 5 treatments were: 1) control with no added yeast source; 2) control + 0.2% CitriStim®; 3) control + 0.4% CitriStim; 4) control + 0.2% *Saccharomyces* source yeast (SSY); 5) control + 0.4% SSY. The broiler chicks received their respective meal diets for the entire study. ADG, ADFI and G/F were measured at the end of each week (d 7, 14, and 21). Liver weight was recorded on d 21. Increasing CitriStim inclusion levels from 0.0 to 0.4% linearly increased overall ADG and G/F ($P = 0.05$), final BW ($P = 0.06$), and liver weight as a percentage of BW ($P = 0.03$). CitriStim had a positive quadratic effect on overall ADG and final BW ($P = 0.07$). SSY tended to have a positive quadratic effect on ADG and final weight ($P = 0.19$), G/F ($P = 0.05$), and liver weight as a percentage of BW ($P = 0.08$). Factorial analysis using the last 4 treatments revealed no interactions between yeast source and level ($P > 0.20$). CitriStim outperformed SSY on ADG ($P = 0.09$), final BW ($P = 0.10$), and liver weight as a percentage of BW ($P = 0.02$). Yeast levels (0.2% vs. 0.4%) did not affect parameters measured in this study ($P > 0.05$). In summary, these data suggest that CitriStim and SSY can improve performance of broiler chickens and increase liver weight. CitriStim optimal inclusion level seemed to be 0.2%.

Key Words: yeast, mannanoligosaccharide, chicken

229 Molecular analysis of microbial community structure in the chicken ileum following organic acid supplementation. G. Nava¹, M. Attene-Ramos¹, H. R. Gaskins¹, and J. D. Richards*², ¹*University of Illinois, Urbana-Champaign*, ²*Novus International, Inc., St. Charles, MO.*

To compensate for possible decreases in animal production due to restrictions on the use of antibiotics as growth promoters, several nonantibiotic alternatives have been investigated. Organic acid supplementation (OAS) of feed or water has shown some promising results for affecting intestinal microbiota and reducing pathogenic bacteria in the gastrointestinal (GI) tract. However, few studies have explored the effects of OAS on microbial parameters using objective molecular-based techniques. The aim of the present study was to characterize via 16S rDNA gene-based approaches responses of the intestinal microbiota after OAS in chicks. Newborn chicks were randomly divided in 4 treatments: a) control (no antibiotic, no OAS); b) antibiotic administration (bacitracin MD); c) organic acid blend DL-2-hydroxy-4(methylthio) butanoic acid [HMTBA]; lactic, and phosphoric acid (HLP); and d) organic acid blend

HMTBA, formic, and propionic acid (HFP). Ileal contents and mucosal scrapings from 7 chicks/treatment/day were taken at 15, 22, and 29 days of age and genomic DNA was isolated for the molecular analysis of the intestinal microbiota. The data demonstrate that HFP blend treatment for 29 consecutive days affected ileal microbial populations as indicated by community fingerprinting analysis (16S rDNA PCR-DGGE). In parallel, total bacterial and lactobacilli populations were increased by the HFP blend treatment as demonstrated by targeted qPCR analysis of 16S rDNA. In summary, the present data demonstrate that OAS, HFP blend treatment in particular, shifts intestinal microbiota, generates more homogenous and distinct populations, and increases *Lactobacillus* spp. colonization of the chick ileum.

Key Words: intestinal microbiota, *Lactobacillus*, organic acids

230 Addition of protected sodium butyrate to broiler feed reduced *Salmonella* Enteritidis infection in birds. J. J. Mallo*¹, M. Puyalto¹, M. Locatelli¹, R. Balaña², and C. Rubio², ¹*Norel SA, Madrid, Spain*, ²*Universidad de Leon, Leon, Spain.*

Sodium butyrate is used to prevent *Salmonella* Enteritidis (S.) in animals with the difficulty of not reaching the lower gastrointestinal tract. Two groups of fifty 1-day-old broilers each were fed with: T0) standard broiler diet, or T1) standard broiler diet plus 0.13% of sodium butyrate protected with vegetal fats (pNa-B) until day 42 to study the effect of pNa-B as a preventing tool against S. infection at intestinal and systemic phases. At day 1, all birds were tested for S. (cloacal samples) and confirmed being negative. Twenty percent of birds of both groups were challenged on day 5 by inoculating orally 10^5 UFC of S. Cloacal samples were taken on days 6, 9, 13, 27, and 41 to monitor infection levels. At day 42 all birds were slaughtered: crop, caecum, liver and spleen were sampled, weighed and homogenized in water with peptones for further bacteriological analyses. The S. title of the samples was determined after enrichment (incubation in Muller-Kauffmann tetrathionate broth base) by plating successive dilutions in Brilliant Green Agar in order to count S. concentration (CFU per gram of tissue level).

The pNa-B showed a consistent and significant ($P < 0.001$) reduction of S. infection in birds from day 27 onwards (36, 74, 100 vs. 16, 20 and 6% of positive birds in T0 and T1, respectively, for days 9, 27 and 41). Also, pNa-B treatment prevented successfully infection not only at crop and caecum level (90 vs. 20 and 90 vs. 10% infected birds in T0 vs. T1, respectively, $P < 0.001$) but also at liver (20 vs. 0% infected birds for T0 vs. T1, $P < 0.05$). There were no differences at spleen level. These results demonstrate that the vegetal fat protection allows sodium butyrate to have an effect all along the gastrointestinal tract because it is slowly released during digestion. It has, therefore, a positive effect on bird health by preventing S. colonization at intestinal and systemic phases.

Key Words: *Salmonella*, butyrate, broiler

231 Effects of feeding two mushroom extracts and *Silybum marianum* on performance of broilers subject to necrotic enteritis. C. Ionescu*¹, D. Bravo¹, M. Lensing², and J. Van der Klis², ¹*Pancosma Research, Geneva, Switzerland*, ²*Schothorst Feed Research, Lelystad, The Netherlands.*

Three plant extracts were tested by a balanced factorial design to identify their effects on performance of broilers subject to a necrotic enteritis

(NE) challenge obtained by the double challenge of *E. maxima* (EM) and *Clostridium perfringens* (CP). The 3 plant extracts were Reishi (*Ganoderma lucidum*, G) at 70 g/t, Shiitake (*Lentinus edodes*, L) at 130 g/t and Milk Thistle (*Silybum marianum* containing 60% silymarin, S) at 280 g/t. The different extracts groups (G, L, S, G+L, G+S, L+S and G+L+S) were compared to a noninfected, not treated (NI/NT) and an infected, not treated (I/NT) group. A total of 1,026 broilers housed in litter cages were fed the products via feed from day 1 to 35. Growth parameters were measured at days 8, 16, 27, 35 whereas CP and EM lesion scores were measured at days 15 and 16.

The growth of NI/NT was significantly higher than I/NT during periods day 8–16, day 16–27 or the overall period 8–35 (resp. +149 g; +172 g and +365 g with $P < 0.01$). Feed intake in days 8 to 35 was reduced for I/NT animals compared to the NI/NT group (–557 g, $P < 0.01$). Feed conversion ratio was significantly different in day 8–16 for group NI/NT and I/NT (1.48 vs. 2.42, $P < 0.01$). EM lesion scores were increased in I/NT animals when compared to NI/NT ones (0.95 vs. 0.01, $P < 0.05$) as were CP lesion scores (2.53 vs. 0.14, $P < 0.05$). A significant increase in feed intake during day 16 to 21 period was observed for the G+L+S combination when compared to I/NT group (1,085 vs. 938, $P < 0.05$). The plant extracts tested, alone or in combination, did not improve broiler body weight gain, when they were subject to a necrotic enteritis leading to 38.8% mortality in the I/NT group. Their addition reduced mortality to a 20 to 30% value depending on the treatments.

Key Words: *Eimeria maxima*, *Clostridium perfringens*, plant extracts

232 Effects of two mushroom extracts on broiler microbial ecology during coccidiosis. L. Mazuranok¹, D. Bravo*¹, H. Panneman², C. Ionescu¹, and M. Naciri³, ¹Pancosma Research, Geneva, Switzerland, ²Dr. Van Haeringen Laboratorium BV, Wageningen, The Netherlands, ³INRA, Nouzilly, France.

A large scale trial was conducted to evaluate the effects of shiitake and reishi mushroom extracts on the health and the microbial composition of duodenum samples from birds challenged with *Eimeria acervulina* at 14 days of age. At day 21 of age, so 7 days postinoculation, the lesion scores were evaluated and duodenum samples (mucosa and content) were taken from 6 birds in each experimental group. The microbial composition of the duodenum samples was determined using the MCPC method (T-RFLP). All treatments had a positive effect on broiler health. This positive effect of the different mushroom extracts was also reflected in the microbial profiles of the duodenum samples; we have found a number of clear correlations between the microbial composition, the health of the birds and the treatment applied. Comparison of the duodenum microbial profiles from the different treatments also indicates that there is an optimal dose for each mushroom extract.

Key Words: *Eimeria*, microflora, plant extracts

233 Effects of feeding two mushroom extracts and milk thistle on blood parameters of broilers subject to necrotic enteritis. C. Ionescu*¹, D. Bravo¹, M. Lensing², J. Van der Klis², T. T Niewold³, and V. Bruggeman³, ¹Pancosma Research, Geneva, Switzerland, ²Schothorst Feed Research, Lelystad, The Netherlands, ³Faculty of Bioscience Engineering, Leuven, Belgium.

Three plant extracts were tested by a balanced factorial design to identify their effects on performance of broilers subject to a necrotic enteritis

(NE) challenge obtained by the double challenge of *E. maxima* (EM) and *Clostridium perfringens* (CP). The 3 plant extracts were Reishi (*Ganoderma lucidum*, G) at 70 g/t, Shiitake (*Lentinus edodes*, L) at 130g/t and Milk Thistle (*Silybum marianum* containing 60% silymarin, S) at 280 g/t. The different extracts groups (G, L, S, G+L, G+S, L+S and G+L+S) were compared to a noninfected, not treated (NINT) and an infected, not treated (INT) groups. The 1,026 broilers held in cages were fed the products from day 1 to day 35. In addition to performance, blood parameters were measured. Glucose, acid α -glycoprotein (AGP), corticosterone, cholesterol, albumin, FK-rapamycin-associated proteins (FRAPs) and ceruloplasmin were measured on 12 chickens per treatment (day 16) and on 6 chickens per treatment (days 27 and 35). The INT broilers showed a significant decrease in cholesterol (3.4 vs. 3.9 mmol/L, $P < 0.001$) and in albumin (10.5 vs. 11.7 g/L, $P < 0.05$) when compared to NINT. Glucose was numerically increased in INT broilers when compared to NINT (210 vs. 201.9 mg/dL, $P > 0.1$). AGP was also increased numerically (382.6 vs. 318.9 μ g/mL, $P > 0.1$) as was FRAPS (1,192 vs. 1,118 mM, $P > 0.1$) and Ceruloplasmin (71.7 vs. 54.4 mg/L, $P > 0.1$) showing that some of the selected blood parameters were modified during the infection. Corticosterone was reduced significantly by the G+L+S combination when compared to INT (4.3 vs. 7.6 ng/mL, $P < 0.05$) as was AGP (185.3 vs. 225.8, $P < 0.05$) and ceruloplasmin (58.5 vs. 71.7, $P < 0.05$). S introduction reduced significantly FRAPS concentration when compared to INT (1,014 vs. 1,192, $P < 0.001$).

Key Words: *Eimeria maxima*, *Clostridium perfringens*, plant extracts

234 Effect of feeding two mushroom extracts, a milk thistle extract and their combinations on the performance of *E. acervulina*- and *E. tenella*-challenged broilers. C. Ionescu*¹, D. Bravo¹, L. Mazuranok¹, and M. Naciri², ¹Pancosma Research, Geneva, Switzerland, ²INRA, Nouzilly, France.

Three plant extracts were tested by a balanced factorial design to determine their effects on broiler chicken performance after an *E. acervulina* (EA) and *E. tenella* (ET) challenge at 14 days of age. The plant extracts were Reishi (*Ganoderma lucidum*, G) at 70 g/t, Shiitake (*Lentinus edodes* - L) at 130 g/t and Milk Thistle (*Silybum marianum*, S, containing 60% silymarin) at 280 g/t. The different extract groups (G, L, S, G+L, G+S, L+S, G+L+S) were compared to a noninfected nontreated (NINT) and an infected nontreated (INT) groups. The 216 broilers held in cages were fed the different products from day 1 to day 21. Live weight, feed intake, feed conversion ratio were measured at day 7, 14, 21. Oocyst excretion was evaluated from day 17 to 22 and EA and ET lesion scores at day 21. Coccidiosis induced depressed performance in INT vs. NINT including a reduced growth (–150.4 g, $P < 0.01$), a reduced feed intake (–155.7 g, $P < 0.1$) and an increase in feed conversion ratio (+6.25%, $P < 0.1$) on D14–D21 period. INT and NINT had significant different lesion scores for EA (3.09 vs. 0.05, $P < 0.01$) and ET (3.44 vs. 0.04, $P < 0.01$) at D21.

From day 14 to 21, G+L improve significantly growth when compared to INT group (272.1 g vs. 251.6 g, $P < 0.05$). This increase was significant for G+S and G+L+S groups (respectively, 261.6 g, 266.8 g, $P < 0.05$). The ET lesion scores were significantly reduced in L or G+L+S groups (respectively 2.19, 2.35 vs. 3.46, $P < 0.05$) or for G+S group ($P = 0.057$). The EA lesion scores were also significantly reduced in G+L and L+S groups when compared to INT group (respectively, 1.59, 1.71 vs. 3.10, $P < 0.01$), as was G+S (1.38, $P < 0.05$).

The combinations G+L, G+S or G+L+S showed some interesting improvements in growth or a reduction in ET and EA lesion scores in

challenged broilers, showing that plant extracts can be used beneficially during an ET and EA challenge

Key Words: performance, *Eimeria*, plant extracts

235 Effect of feeding two mushroom extracts and a milk thistle extract and their combinations on blood parameters of *E. acervulina*- and *E. tenella*-challenged broilers. C. Ionescu*¹, D. Bravo¹, L. Mazuranok¹, M. Naciri², T. Niewold³, and V. Bruggeman³, ¹*Pancosma Research, Geneva, Switzerland*, ²*INRA, Nouzilly, France*, ³*Faculty of Bioscience Engineering, Leuven, Belgium*.

Three plant extracts were tested by a balanced factorial design to determine their effects on broiler chicken performance after an *E. acervulina* (EA) and *E. tenella* (ET) challenge at 14 days of age. The plant extracts were Reishi (*Ganoderma lucidum*, G) at 70 g/t, Shiitake (*Lentinus edodes*, L) at 130 g/t and Milk Thistle (*Silybum marianum*, S), containing 60% silymarin) at 280 g/t. The different extract groups (G, L, S, G+L, G+S, L+S, G+L+S) were compared to a noninfected not treated (NINT) and an infected nontreated (INT) groups. The 216 broilers held in cages were fed the different products from day 1 to day 28. In addition to performance, blood parameters as cholesterol, ceruloplasmin, corticosterone, albumin, a-acid glycoprotein (AGP) were measured on days 13, 21 and 28 and glucose for the last 2 days, on 12 and 6 birds per treatment, respectively. Ceruloplasmin was increased significantly in INT broilers when compared to NINT (49.9 vs. 30.3 mg/L, $P < 0.05$). Albumin and cholesterol were significantly decreased by the infection, respectively (7.04 vs. 7.96 g/L, $P < 0.05$ and 3.0 vs. 3.6 mmol/L, $P < 0.001$). AGP increased significantly for G broilers when compared to INT (238.8 vs. 227.9 $\mu\text{g/mL}$, $P = 0.052$). G+L reduced significantly ceruloplasmin compared to INT (46.0 vs. 49.9, $P < 0.001$). Albumin was not influenced either by the individual extracts or their combinations when compared to INT. Cholesterol was reduced for L compared to INT (2.78 vs. 3.02, $P < 0.05$). Glucose was significantly increased by L when compared to INT (251.5 vs. 230.0 mg/dL, $P < 0.001$). The G+L+S combination tended to decrease corticosterone ($P = 0.07$) when compared to INT. Showing that some plant extracts can counter some of the blood modifications induced by *E. acervulina* and *E. tenella*.

Key Words: blood parameters, *Eimeria*, plant extracts

236 Effects of graded levels of melamine in young broiler chicks. D. R. Ledoux*, K. C. Zavarize, R. A. Murarolli, R. E. Kutz, G. E. Rottinghaus, A. J. Bermudez, and M. Lin, *University of Missouri, Columbia*.

A study was conducted to determine the toxicity of melamine (M) in young broiler chicks fed dietary treatments from hatch to 14 days. A second objective was to determine if M could be detected in tissues of broilers fed these dietary concentrations of M. One hundred and seventy-five day-old male broilers were purchased from a commercial hatchery and assigned to 7 dietary treatments with 5 replicate pens of 5 chicks assigned to each treatment. The diets contained 0, 0.5, 1.0, 1.5, 2.0, 2.5, and 3.0% M. There was no difference ($P > 0.05$) in feed intake (FI) among controls and chicks fed 0.5 or 1% M. Feed intake was reduced ($P < 0.001$) in chicks fed diets containing $\geq 1.5\%$ M. Body weight gain

(BWG) decreased significantly in birds fed $\geq 1.0\%$ M, with the greatest decrease in BWG observed in birds fed $\geq 2\%$ M. Body weight gain over the 14 day feeding period averaged 392, 377, 335, 324, 254, 241, and 207 g, respectively, for birds fed 0, 0.5, 1.0, 1.5, 2.0, 2.5, and 3% M. Birds fed 2.5 and 3.0% M were less efficient ($P < 0.001$) in converting feed to gain compared to all other dietary treatments (averaging 1.96 vs. 1.18 g:g). Mortality was observed in chicks fed 2.5 and 3% M as early as day 5 of the study, and by day 14, mortality was 12, 20 and 30%, respectively, in chicks fed 2, 2.5 and 3% M. One control chick died by day 14, whereas there was no mortality in chicks fed 0.5, 1.0, or 1.5% M. Gross lesions in necropsied birds were completely uniform with all birds having enlarged pale kidneys and gallbladders containing opaque bile. Microscopic examination of the bile and histopathologic examination of the renal tubules, revealed crystals similar to those observed within the renal tubules of cats with M associated renal failure. Results indicate that over a 14 day feeding period, M concentrations $\geq 1.0\%$ depressed growth performance, whereas M concentrations $\geq 2.0\%$ caused increased mortality, crystal formation in bile, and histopathologic lesions in kidney.

Key Words: broilers, melamine, kidney lesions

237 Meta-analysis of the effect of a mixture of carvacrol, cinnamaldehyde and capsicum oleoresin in broilers. D. Bravo* and C. Ionescu, *Pancosma Research, Geneva, Switzerland*.

This abstract presents a meta-analysis of broiler studies involving a botanical composition comprised of carvacrol, cinnamaldehyde and capsicum oleoresin (XT). Data from 13 studies with side by side comparisons of XT to a negative control diet or to a positive control diet (AB) provided 38 treatment groups which were pooled for evaluation. The effect of XT addition was investigated using treatment means from trial groups with either a fixed effect of XT (present or absent) or AB (present or absent) and a random effect of the trial. For each measure of performance, mean value of XT or positive or negative controls, the number of groups involved, partial r^2 , and P -value were determined. Addition of XT increased average daily gain (51.3 vs. 48.9 g/d, $N = 38$, $r^2 = 0.61$, $P < 0.001$), increased the feed intake (84.1 vs. 81.9 g/d, $N = 27$, $r^2 = 0.23$, $P < 0.01$) and decreased feed conversion ratio (1.68 vs. 1.73, $N = 27$, $r^2 = 0.42$, $P < 0.001$). Addition of AB also increased the daily gain (50.4 vs. 48.9 g/d, $N = 16$, $r^2 = 0.59$, $P < 0.001$), increased feed intake (84.0 vs. 81.9 g/d, $N = 16$, $r^2 = 0.26$, $P = 0.04$) but did not alter feed conversion ratio (1.71 vs. 1.73, $N = 16$, $r^2 = 0.13$, $P = 0.172$). When XT was compared to AB, the following results (XT vs. AB) were observed: tendency for higher daily gain (51.3 vs. 50.4 g/d, $N = 23$, $r^2 = 0.14$, $P = 0.060$), same feed intake (84.1 vs. 84.0 g/d, $N = 23$, $r^2 = 0.0$, $P = 0.952$) and tendency for lower feed conversion ratio (1.68 vs. 1.71, $N = 23$, $r^2 = 0.19$, $P = 0.08$).

Depending on the major cereal of the diet, the pattern of the results was different. For example, XT was more efficacious for improving daily gain in corn based diet whereas it decreased more feed conversion ratio in wheat based diet.

Meta-analysis using a data set consisting of a diverse population of trials avoided emphasis of a particular trial while illustrating the robust nature of XT. Meta-analysis is useful for developing a statistically valid framework for additive use in diets of varying composition.

Key Words: plant extracts, broiler, meta-analysis

238 Effects of dietary inclusion of essential oil blends on broiler performance, carcass characteristics and sensory quality of meat. H. Schulze¹, P. Plumstead*¹, H. Bento¹, V. Ravindran², and G. Ravindran², ¹Danisco Animal Nutrition, Marlborough, United Kingdom, ²Institute of Food, Nutrition and Human Health, Massey University, Palmerston North, New Zealand.

Extracts of essential oils (EO) such as thymol, carvacrol, and cinnamaldehyde that occur naturally in oregano, thyme, and cinnamon have previously been shown to have positive effects on broiler performance. However, it was not known if these EO compounds affect the sensory characteristics of the broiler meat produced. The present study examined the effects of feeding 3 different blends of EO (Danisco Animal Nutrition, United Kingdom) on broiler performance, carcass characteristics and sensory quality of the meat. Ross 308 broiler chickens were grown to 35 d of age using a 4 × 2 factorial arrangement of treatments. There were 2 genders (male/female) and 4 dietary treatments consisting of a Control diet with/without 1 of 3 different blends of EO (EOB1, EOB2, EOB3). A pen of 30 birds was the experimental unit and each sex × dietary treatment combination was replicated 6 times. Body weight (BW) and feed intake was determined at 10, 21 and 35 d of age and the feed conversion ratio (FCR) calculated. At 35 d of age, 6 birds per pen were slaughtered to evaluate the dressing percentage, breast meat yield, and sensory characteristics of the breast meat. All 3 blends of EO evaluated in the present study significantly ($P < 0.05$) improved FCR from 0–10 d of age. The BW gain and feed intake from 0–35 d was significantly ($P < 0.05$) increased when EOB2 was added to the Control diet. There was no effect of dietary EO treatment on dressing percentage, breast meat yield, or sensory characteristics of the breast meat. These results suggested that the EO blends evaluated can significantly improve broiler performance without negatively affecting the sensory quality of the meat produced.

Key Words: essential oils, broiler, performance

239 Effect of feed restriction on core body temperature dynamics in meat-type chickens. R. A. Renema*¹, M. J. Zuidhof², D. S. Peters², J. Berezowski², and C. Oullette¹, ¹Dept. of AFNS, University of Alberta, Edmonton, AB., Canada, ²Ag Research, Alberta Agriculture, Edmonton, AB., Canada.

Feed intake affects the heat increment of the chicken. Ad libitum fed birds have a higher core body temperature than feed restricted birds, and are predicted to have less range in their daily temperature cycling than feed restricted birds. Bird:bird core temperature variation in response to feeding level is not well understood and has implications for calculations of growth efficiency. A total of 30 female broilers from an experimental yield strain (Aviagen, Inc.) were raised on a broiler breeder growth profile until 6 wk of age, and surgically implanted into the abdominal cavity with a live broadcasting temperature reader (mean/bird = 1,700 temperatures/d) in a 20 min procedure. The indwelling remote temperature sensors are cylindrical, approximately the size of an AA battery. Birds were housed individually in cages containing temperature data loggers recording local temperatures for each bird. Following 4 wk on a nutrition study, birds were acclimated to a base ration for 4 d and randomly allocated to 1 of 2 feeding level treatments: Ad libitum (full fed) or Feed restricted (fed calculated maintenance requirement daily for 7 d). Maintenance level based on book 125 kcal/kg metabolic BW. Treatments switched in a second, 7 d period. Data from the first day of each wk was discarded to allow birds to clear previous feed.

Core body temperature was significantly reduced in feed restricted birds ($P < 0.0001$). Ad libitum fed birds averaged 40.05 C while feed restricted birds averaged 39.81 C. Local microclimate temperature, which was included as a random variable in the mixed model, significantly affected the response to feed restriction, demonstrating the need for thorough data collection in this type of analysis. There was some variance in response to feed restriction, although all Feed restricted birds underwent a decrease in core temperature. Live, constant temperature recording is a practical way to collect and quickly apply data in nutritional studies.

Key Words: feed restriction, ad libitum feeding, body temperature

Symposium: Use of Multimedia Educational Tools in Poultry and Egg Processing Initiatives for Teaching, Extension, and Outreach

240 Multi-media educational tool for poultry meat and egg processing instruction. J. L. Emmert*¹, C. M. Owens¹, C. Z. Alvarado², S. R. McKee³, and S. F. Bilgili³, ¹University of Arkansas, Fayetteville, ²Texas Tech University, Lubbock, ³Auburn University, Auburn, AL.

Considering job availability and recent mergers, there is a high demand for students and personnel with basic knowledge in poultry processing, product technology, and food safety. However, educational opportunities in these areas can be limited. Full or partial courses may be offered at 4 year academic institutions in departments of poultry science, animal science, or food science; however, the number of institutions with faculty expertise in these areas is decreasing. Workshops and company-based training may also provide this education, but the offerings can be limited. On-the-job training is another source of education, but it is informal and general. Therefore, there is a tremendous need for a widely available curriculum that can be implemented or adapted by institutions and companies to produce students and workers capable of meeting the increasing challenges that will be faced in the areas of poultry processing, products, and food safety. The overall objectives of this project

were to 1) develop standardized curriculum modules for the areas of egg science and technology, poultry meat science and technology, and food safety, 2) use a multi-media approach, making use of computer-based technology, and 3) target developed curriculum materials to 4-year agricultural institutions and industry. A multi-media poultry meat and egg processing curriculum with broad applications that addresses a national and international education need was developed by a team of faculty at multiple institutions. The developed modules are versatile and can be used alone or with other course material thereby enhancing program quality and supplementing available resources. Single or multiple modules, delivered on a CD, including a presentation window, graphics, and video, can be incorporated into classrooms as lectures or used independently by individuals for self-learning. These materials could also be used to supplement university-hosted industry workshops on poultry processing related areas that are presented in English and/or Spanish. Furthermore, these materials provide strong reference materials for individuals for use beyond the learning phase.

Key Words: education, poultry processing, instruction