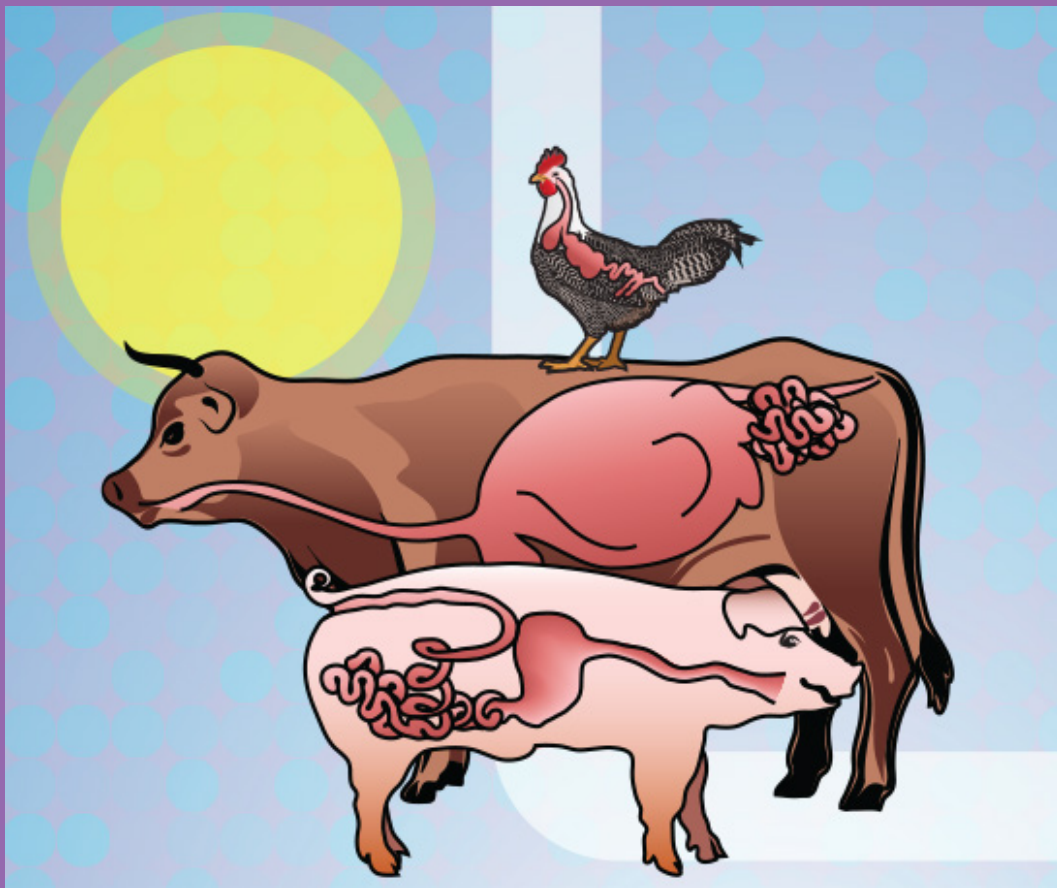


Symposium on Gut Health in Production of Food Animals

October 31–November 3, 2021

St. Louis, Missouri



Program and Abstracts

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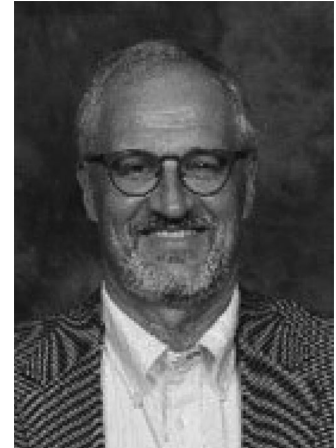
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WELCOME

On behalf of the Organizing Committee for the 9th Symposium on Gut Health in Production of Food Animals, I welcome you back to St. Louis, Missouri! After last year's cancellation due to the Covid pandemic, I am extremely excited to welcome you back to St. Louis and to once again have a true face-to-face Symposium. I am so looking forward seeing old friends and meeting new ones as we continue discussing the fascinating world of the intestine and its multifaceted role in food animal production.



The aim of the Symposium is to bring together a group of scientists from academia, government, and industry to discuss the role of gut health in animal production and the essential role that the gut plays in establishing and maintaining animal health. The overall aim of the conference is to promote the unifying concepts that the gut drives animal health and performance. Although the gastrointestinal tract is frequently described simply as “the gut,” it is actually made up of (1) an epithelium; (2) a diverse and robust immune arm, which contains most of the immune cells in the body; and (3) the commensal bacteria, which contain more cells than are present in the entire host organism. Understanding of the crosstalk between ALL of these interrelated components of the gut is what cumulatively makes the gut the basis for the well-being of animals and the motor that drives their performance. The abstracts submitted to the Symposium are defining these links and mechanisms that inter-connect the three components of the gut and how each can be manipulated to improve animal health.

As in the past, this year we have invited three distinguished plenary speakers that will cover current research topics in avian, bovine, and porcine gut health. Please take advantage of the presence of these scientists to engage in productive talks and develop collaborations between different laboratories in order to further the science of gut health.

I encourage all of you to please take advantage of the informal nature of the symposium—it was planned this way to encourage interaction between scientists. I again ask that senior researchers make a special effort to engage with the graduate students who are attending and presenting. Remember that, whatever your research specialty or food animal commodity, we are all working together to improve food quality for the consumer.

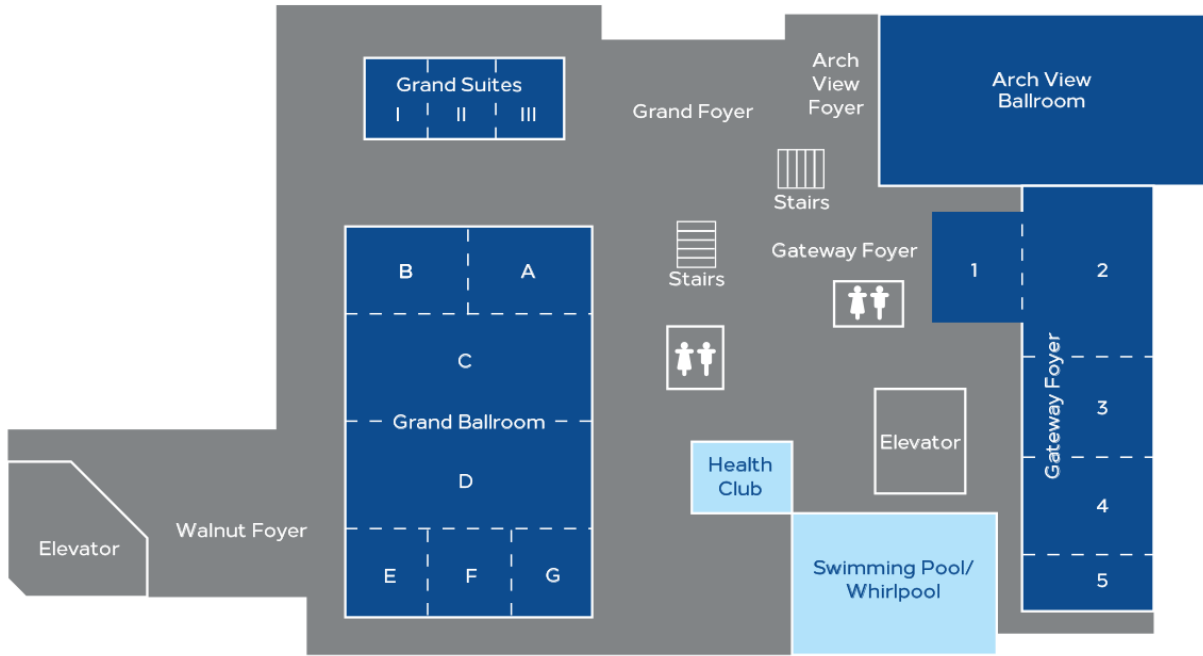
Welcome again and enjoy the Symposium and your stay in St. Louis!

Mike Kogut
Chair, Organizing Committee

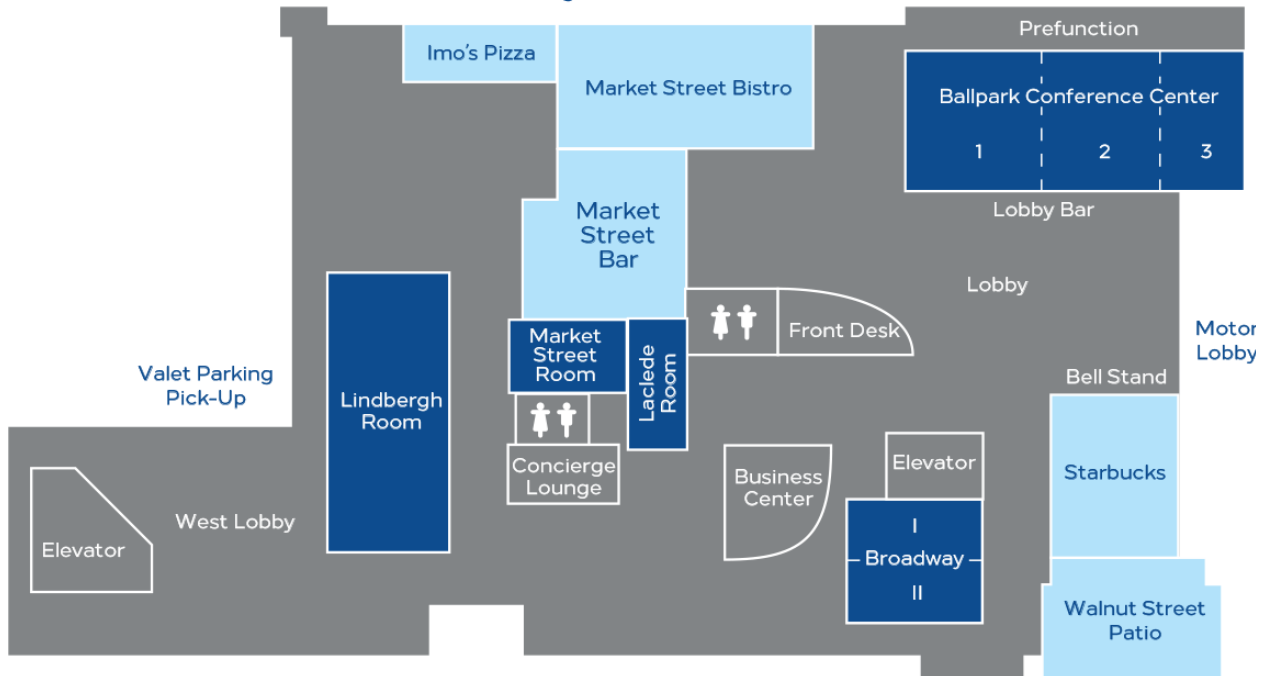


Hilton St. Louis at the Ballpark

Second Floor Convention Level



Lobby Level





Program

Sunday, October 31

5:00 pm – 7:00 pm Registration: Grand Foyer

Monday, November 1

7:00 am – 8:00 am Breakfast: Archview Ballroom

7:00 am – 6:00 pm Registration: Grand Foyer

SESSION 1

Chair: Mike Kogut, USDA-ARS
Salons ABC

8:00 am **Prophylactic targeting gut neuroimmunological axis to increase resistance to bacteria in layers.** (Abstract 100)

M. Mellata*, *Iowa State University, Ames, IA, USA.*

9:00 am **Regulation of host defense peptide and barrier function gene expression and disease resistance by butyrate, forskolin, and lactose.** (Abstract 101)

Q. Yang and G. Zhang*, *Oklahoma State University, Stillwater, OK, USA.*

9:30 am **Effects of an all-natural feed additive on the gut microbiome of weanling pigs experimentally infected with a pathogenic *Escherichia coli*.** (Abstract 102)

H. Xue*¹, D. Wang¹, L. Johnston¹, Y. He², C. Jinno², Y. Liu², and P. Ji³, ¹*Amlan International, Chicago, IL, USA*, ²*Department of Animal Science, University of California, Davis, CA, USA*, ³*Department of Nutrition, University of California, Davis, CA, USA.*

10:00 am Coffee Break: Grand Foyer

Sponsored by Jefe Nutrition Inc.

10:30 am **A *Lactobacillus* postbiotic product alleviates *Escherichia coli*-induced diarrhea in post-weaning piglets.** (Abstract 103)

P. Tacon¹, S. Della Zassa², C. Cull³, K. Lechtenberg³, and J. Leedle*⁴, ¹*ADARE Biome, Houdan, France*, ²*Adare Biome, Lawrenceville, NJ, USA*, ³*Midwest Veterinary Services Inc, Oakland, NE, USA*, ⁴*JL Microbiology, Hartland, WI, USA.*

11:00 am **Determining the in vitro effect of a blend of α -monoglycerides (Fractal) against *Clostridium perfringens* pathogenic strains isolated from field cases of focal duodenal necrosis and necrotic enteritis.** (Abstract 104)

L.-M. Gomez-Osorio*¹, L. Stabler², and M. Franca², ¹*Alura Inc, Durham, NC, USA*, ²*Department of Population Health, Poultry Diagnostic and Research Center, University of Georgia, Athens, GA, USA.*

11:30 am **Studies conducted at the University of Arkansas to evaluate curcumin as a feed additive to control bacterial and protozoal infections and reduce aflatoxicosis severity in poultry.** (Abstract 105)

G. Tellez-Isaias*¹, D. Hernandez-Patlan², B. Solis-Cruz², V. Petrone-Garcia², A. Leyva-Diaz², C. Vuong¹, D. Graham¹, C. Selby¹, J. Latorre¹, and B. Hargis¹, ¹*University of Arkansas, Fayetteville, AR, USA*, ²*UNAM, Cuautitlan Izcalli, Mexico, Mexico.*



- 12:00 pm – 1:00 pm Lunch: Archview Ballroom
- 1:00 pm – 3:00 pm Poster Session: Grand Foyer
- SESSION 2**
- Chair:** Mike Kogut, USDA-ARS
Salons ABC
- 3:00 pm **Role of the digestive tract microbiome on beef cattle performance.** (Abstract 106)
P. R. Myer*¹ and P. Y. Mulon², ¹*Department of Animal Science, University of Tennessee, Knoxville, TN, USA*, ²*College of Veterinary Medicine, University of Tennessee, Knoxville, TN, USA*.
- 4:00 pm **A broiler chronic gut inflammation model under real farming conditions and the alleviation of its negative consequences with an in-feed technology.** (Abstract 107)
A. Khadem^{1,2}, D. Ritter*³, and C. Gougoulis¹, ¹*Innovad NV/SA, Essen, Belgium*, ²*Lab of Nutrition, Faculty of Veterinary Medicine, Ghent University, Merelbeke, Belgium*, ³*Innovad USA, Salisbury, MD, USA*.
- 4:30 pm **Fluorescence-based detection of β -D-glucuronidase activity for assessment of ileal granulocyte degranulation in *Eimeria*-challenged broilers.** (Abstract 108)
A. Duff*, K. McGovern, M. Trombetta, and L. Bielke, *The Ohio State University, Columbus, OH, USA*.
- 5:00 pm **Microbiome characterization of commercial turkeys with cellulitis.** (Abstract 109)
D. Ayala*, D. Grum, E. Kimminau, N. Evans, K. Russo, M. M. Lahoti, B. Tribble, and T. P. Karnezos, *Purina Animal Nutrition Center, Gray Summit, MO, USA*.
- 5:30 pm **Characterization of anti-clostridial effects of a novel probiotic.** (Abstract 110)
M. Trombetta*¹, K. McGovern¹, A. Duff¹, H. Xue², D. Wang², L. Johnston², and L. Bielke¹, ¹*The Ohio State University, Wooster, OH, USA*, ²*Amlan, Chicago, IL, USA*.
- 7:00 pm – 9:00 pm Reception: Archview Ballroom
Sponsored by Jefe Nutrition Inc.

Tuesday, November 2

- 7:00 am – 8:00 am Breakfast: Archview Ballroom
- 7:00 am – 5:30 pm Registration: Grand Foyer
- SESSION 3**
- Chair:** Mike Kogut, USDA-ARS
Salons ABC
- 8:00 am **Intestinal microbiomes as complex ecosystems: Implications for intervention strategies.** (Abstract 111)
M. Bailey* and C. R. Stokes, *University of Bristol, Bristol, United Kingdom*.
- 9:00 am **Incorporating feed additives with coccidiosis control programs.** (Abstract 112)
S. M. Ramirez*¹, G. R. Murugesan¹, C. M. Pender¹, and B. Lumpkins², ¹*BIOMIN*



America Inc, Overland Park, KS, USA, ²Southern Poultry Feed and Research Inc, Athens, GA, USA.

- 9:30 am **Saponins-based solution as efficient as coccidiostats to manage coccidiosis and gut health in broiler chickens?** (Abstract 113)
M. el Amine Benarbia*, P. Engler, L.-S. Druhet, and P. Chicoteau, *Nor Feed, Beaucauzé, France.*
- 10:00 am Coffee Break: Grand Foyer
Sponsored by Phytobiotics
- 10:30 am **Evaluation of a novel plant-based technology aiding the control of coccidiosis in modern poultry production.** (Abstract 114)
A. Khadem^{1,2}, D. Ritter*³, and C. Gougoulis¹, ¹*Innovad NV/SA, Essen, Belgium, ²Lab of Nutrition, Faculty of Veterinary Medicine, Ghent University, Merelbeke, Belgium, ³Innovad USA, Salisbury, MD, USA.*
- 11:00 am **Identification of intestinal microbiota and mycobiota signatures associated with the severity of necrotic enteritis.** (Abstract 115)
Q. Yang and G. Zhang*, *Oklahoma State University, Stillwater, OK, USA.*
- 11:30 am **Effects of an all-natural feed additive on the intestinal integrity, mucosal immunity, and gut microbiome composition of *Eimeria*-infected broilers.** (Abstract 116)
H. Xue*¹, F. Rigo², B. Beirão², C. Fávoro², and M. Ingberman², ¹*Amlan International, Chicago, IL, USA, ²Imunova Análises Biológicas, Curitiba, Paraná, Brazil.*
- 12:00 pm – 1:30 pm Lunch: Archview Ballroom
Sponsored by Adisseo
- SESSION 4**
Chair: Glenn Zhang, Oklahoma State University
Salons ABC
- 1:30 pm **The culture of yak rumen anaerobic fungus *Orpinomyces* sp. YF3 promotes the degradation of stalks by microorganisms in the rumen of dairy goats.** (Abstract 117)
Z. Liu¹, Y. Li¹, C. Zhao¹, L. Wang^{1,2}, J. Yao¹, and Y. Cao*^{1,2}, ¹*Northwest A&F University, Yangling, Shaanxi, China, ²Harvard Medical School, Boston, MA, USA.*
- 2:00 pm **Development of a model to examine developmental changes in intestinal crypt cell proliferation and macrophage densities of neonatal piglets.** (Abstract 118)
A. J. Calderon*, J. L. Sandoval, J. D. Starkey, and C. W. Starkey, *Auburn University, Auburn, AL, USA.*
- 2:30 pm **Protected biofactors and antioxidants reduce the negative consequences of virus and cold challenge while enhancing performance by modulating immunometabolism through cytoskeletal and immune signaling.** (Abstract 119)
F. Perry*¹, L. Lahaye², E. Santin², C. Johnson¹, D. Korver³, M. Kogut⁴, and R. Arsenault¹, ¹*University of Delaware, Newark, DE, USA, ²Jefo Nutrition Inc, Saint-Hyacinthe, QC, Canada, ³University of Alberta, Edmonton, AB, Canada, ⁴USDA-ARS, Southern Plains Agricultural Research Center, College Station, TX, USA.*
- 3:00 pm **Microbiome metabolic modulation by a novel precision glycan for poultry.** (Abstract 120)
J. Claypool¹, K. Freeman¹, B. Blokker², M. C. Walsh³, C. Bortoluzzi*³,



and G. Schyns^{1,3}, ¹DSM Nutritional Products Ltd, Lexington, MA, USA, ²CRNA, DSM Nutritional Products SA, Village-Neuf, France, ³DSM Nutritional Products AG, Kaiseraugst, Switzerland.

3:30 pm

Coffee Break: Grand Foyer
Sponsored by Arm & Hammer

4:00 pm

Effects of a saponin and oregano blend on performance and oocyst shedding in turkey poults during a coccidiosis challenge. (Abstract 121)
S. Hutsko*, A. Garcia, E. Guaiume, D. Giesting, and R. Payne, *Cargill Animal Nutrition, Rice Lake, WI, USA.*

4:30 pm

Effects of lipid-based natural R2 products on performance and microbiome of broilers in comparison with common feed antimicrobial measures. (Abstract 122)
A. Mahfuz*¹, C. Jaeger¹, E. Weaver², and M. Dasari¹, ¹Feed Energy Company, Pleasant Hill, IA, USA, ²South Dakota State University, Brookings, SD, USA.

5:00 pm

Efficacy of mycotoxin deactivator on health and growth of broiler chickens under chronic dietary challenge of aflatoxins. (Abstract 123)
P. S. Ingewar¹, V. Patil², N. Kurkure², G. Bromfman*³, H. Yakout³, J. Dvorska⁴, and D. P. Preveraud⁴, ¹A2 Livestock Farms and Research, Nagpur, India, ²Department of Pathology, Nagpur Veterinary College, Maharashtra Animal & Fishery Science University, Nagpur, India, ³Adisseo USA Inc, Alpharetta, GA, USA, ⁴Adisseo France SAS, Antony, France.

6:00 pm – 8:00 pm

Reception: Archview Ballroom

Wednesday, November 3

8:00 am – 9:00 am

Breakfast: Archview Ballroom

8:00 am – 12:00 pm

Registration: Grand Foyer

SESSION 5

Chair: Cristiano Bortoluzzi, DSM
Salons ABC

9:00 am

Supplementation of functional amino acids above the requirement improves growth performance and immune status of weanling pigs challenged with *Salmonella Typhimurium*. (Abstract 124)
L. A. Rodrigues^{1,2}, M. O. Wellington², J. C. González-Vega³, J. K. Htoo³, A. Menconi⁴, S. M. Mendoza*⁴, A. G. Van Kessel², and D. A. Columbus^{1,2}, ¹Prairie Swine Centre Inc, Saskatoon, Saskatchewan, Canada, ²Department of Animal and Poultry Science, University of Saskatchewan, Saskatoon, Saskatchewan, Canada, ³Evonik Operations GmbH, Hanau-Wolfgang, German, ⁴Evonik Corporation, Kennesaw, GA, USA.

9:30 am

Nutrient transporters and tight junction expression and cecal short-chain fatty acid profile in *Eimeria*-challenged broilers fed diets with different levels of xylo-oligosaccharides. (Abstract 125)
Y. Lin* and O. Olukosi, *University of Georgia, Athens, GA, USA.*



- 10:00 am **A stimbiotic as an innovative concept to decrease *Salmonella* cecal count and improve growth performance in broilers chicken.** (Abstract 126)
X. Rousseau*, N. Amornthewaphat, G. A. Gomes, and T. T. dos Santos, *AB Vista, Marlborough, United Kingdom.*
- 10:30 am Coffee Break: Grand Foyer
Sponsored by Chr. Hansen
- 11:00 am **Effect of maternal and post-hatch supplementation of 25-hydroxycholecalciferol on duodenal crypt cell proliferation and local innate immunity of broiler chickens.** (Abstract 127)
S. F. Leiva*¹, L. P. Avila¹, G. A. Abascal-Ponciano¹, J. J. Flees¹, K. M. Sweeney², J. L. Wilson², J. D. Starkey¹, and C. W. Starkey¹, ¹*Department of Poultry Science, Auburn University, Auburn, AL, USA*, ²*Department of Poultry Science, University of Georgia, Athens, GA, USA.*
- 11:30 am **Dietary soy oligosaccharides affect the gastrointestinal health and feed efficiency of growing chicks.** (Abstract 128)
K. D. Teague*¹, G. Tellez-Isaias¹, V. Petrone-Garcia², C.N. Vuong¹, A. Blanch³, S. H. Rasmussen³, K. Brown³, and S. J. Rochell¹, ¹*University of Arkansas, Fayetteville, AR, USA*, ²*National Autonomous University of Mexico, Mexico City, Mexico*, ³*Hamlet Protein, Horsens, Denmark.*



Posters: Grand Foyer

- P100* **Nutritional strategies to improve intestinal digestibility and health of beef cattle fed a high-grain diet.**
W. Z. Yang*, *Agriculture and Agri-Food Canada, Lethbridge Research and Development Centre, Lethbridge, AB, Canada.*
- P101* **The inclusion of n-3 long-chain fatty acids in sow and piglet post-weaning diets modifies ileal mucosa immune indicators of low- and high-birth-weight piglets at the end of the post-weaning period.**
E. Llauradó-Calero*¹, I. Badiola², A. M. Pérez de Rozas², R. Lizardo¹, D. Torrallardona¹, E. Esteve-Garcia¹, and N. Tous¹, ¹*Animal Nutrition, IRTA, Constantí, Tarragona, Spain*, ²*CReSA, IRTA, Bellaterra, Barcelona, Spain.*
- P102 **The Animal Health and Nutrition Consortium: A collaborative model to fund precompetitive research and career development.**
C. Chen* and P. Ferket, *North Carolina State University, Raleigh, NC, USA.*
- P103* **Effect of postbiotic (Lumensa) from lactic acid bacteria on the growth of *Lactobacillus* strains from poultry and swine intestines.**
J. M. Yang, S. Yang*, and E. Wozniak, *Cytozyme Laboratories Inc. (A Verdesian Life Sciences Company), Salt Lake City, UT, USA.*
- P104* **Immunofeed project: Searching the control of gut inflammation.**
J. Tarradas*¹, A. Perez de Rozas², A. Alberdi³, N. Tous¹, M. Viñas⁴, M. H. Kogut⁵, and J. Brufau¹, ¹*Animal Nutrition, IRTA, Constantí, Spain*, ²*CReSA, IRTA, Bellaterra, Spain*, ³*Section for Evolutionary Genomics, UCPH, Copenhagen, Denmark*, ⁴*Integral Management of Organic Waste, IRTA, Caldes de Montbui, Spain*, ⁵*Southern Plains Agricultural Research Center, USDA-ARS, College Station, TX, USA.*
- P105 **Different tissues from the chicken gut affect plasmid transfer in vitro.**
J. Jochum*, L. Ott, and M. Mellata, *Iowa State University, Ames, IA, USA.*
- P106 **Dietary 25OHD3 supplementation modulates intestinal inflammation and barrier integrity in young broiler chickens.**
G. A. Abascal-Ponciano*¹, S. F. Leiva¹, L. P. Avila¹, J. J. Flees¹, K. M. Sweeney², J. L. Wilson², J. D. Starkey¹, and C. W. Starkey¹, ¹*Department of Poultry Science, Auburn University, Auburn, AL, USA*, ²*Department of Poultry Science, University of Georgia, Athens, GA, USA.*
- P107* **Gut microbiome leads to immune response development in neonatal Holstein calves.**
V. Gomes*¹, C. Hoffmann¹, D. Irlanda Castro Tardon¹, F. C. Ramos Santos¹, and D. J. Hurley², ¹*University of São Paulo, São Paulo, São Paulo, Brazil*, ²*University of Georgia, Athens, GA, USA.*
- P108 ***Melissa officinalis* as gut contractility modifier in swine—An ex vivo study.**
S. Suor-Cherer^{1,2}, H. Bui*^{1,2}, M. el Amine Benarbia^{1,2}, and M. Mendel^{2,3}, ¹*Labcom FeedInTech, Angers, France*, ²*Nor-Feed SAS, Angers, France*, ³*Institute of Veterinary Medicine, Warsaw University of Life Sciences, Warsaw, Poland.*
- P109* **Microbiome and nutrient digestibility of pigs fed corn, soy, and corn distillers grains (DDGS) in the presence of a mult carbohydrase complex.**
T. Dantas¹, R. Chaves¹, J. Barbi², N. Fagundes², M. Zangeronimo¹,



and V. Cantarelli*¹, ¹*Universidade Federal de Lavras, Lavras, Minas Gerais, Brazil*,
²*Adisseo Brazil, São Paulo, São Paulo, Brazil*.

- P110 **Advanced Digestion Enhancing Protein Plus Technology (ADEPPT) helps poultry gain body weight through modulating gut microbiome and cytokines.**
J. Talukder*¹, D. Dubourdieu¹, M. H. Talukder², A. Srivastava¹, and R. Lall¹, ¹*Vets Plus Inc, Menomonie, WI, USA*, ²*Bangladesh Agricultural University, Mymensingh, Bangladesh*.
- P111* **Salmonella carriage in peripheral lymph nodes and feces of cattle at slaughter.**
L. Wottlin*, T. Edrington, R. Anderson, and D. Nisbet, *U.S. Department of Agriculture, Agricultural Research Service, Food and Feed Safety Research Unit, College Station, TX, USA*.
- P112 **Cecal microbiota transplantation: Unique influence of the donor line on growth, gut health, stress, and immune parameters of recipient chickens.**
Y. Fu*¹, J. Hu¹, and H. Cheng², ¹*Department of Animal Sciences, Purdue University, West Lafayette, IN, USA*, ²*Livestock Behavior Research Unit, USDA-ARS, West Lafayette, IN, USA*.
- P113* **Effects of Fusarium mycotoxins on broiler gut cytoprotective capacity.**
E. Griela¹, V. Paraskeuas¹, D. Bouziotis¹, K. Fegeros¹, G. Antonissen², and K. Mountzouris*¹, ¹*Agricultural University of Athens, Athens, Attica, Greece*,
²*Ghent University, Ghent, Flanders, Belgium*.
- P114 **Effects of nutritional-induction of chronic inflammation on broiler gut health and performance.**
G. Cardoso Dal Pont*¹, A. Lee¹, C. Bortoluzzi¹, C. Eyng², C. Gougoulas³, and M. Kogut⁴, ¹*Department of Poultry Science, Texas A&M Agrilife Research, College Station, TX, USA*, ²*Department of Animal Science, Western Parana State University, Marechal C. Rondon, PR, Braail*, ³*Innovad NV/SA, Essen, Belgium*,
⁴*USDA-ARS, Southern Plains Agricultural Research Center, College Station, TX, USA*.
- P115 **Effect of artificial colostrum supplementation in nursery pigs.**
H. J. Park*, V. Sampath, J. H. Song, W. J. Seok, and I. H. Kim, *Department of Animal Resource & Science, Dankook University, Cheonan, South Korea*.
- P116 **Lactating sows fed whey protein diet improved the blood profile of weaning pigs.**
J. H. Song*, V. Sampath, H. J. Park, and I. H. Kim, *Department of Animal Resource & Science, Dankook University, Cheonan, South Korea*.
- P117 **Effects of synergistic blend of organic acids supplementation in late gestating sows on litter performance.**
V. Sampath*¹, L. Pineda², Y. Han², and I. H. Kim¹, ¹*Department of Animal Resource & Science, Dankook University, Cheonan, South Korea*, ²*Trouw Nutrition R&D, Boxmeer, the Netherlands*.
- P118 **Supplementing quercetin extracted from the flower of Sophora japonica improves growth performance, apparent nutrient digestibility, and cecal microbiota in broiler chicks.**
J. H. Song*, D. X. Dang, J. Ahn, and I. H. Kim, *Department of Animal Resource & Science, Dankook University, Cheonan, South Korea*.



- P119 **Effects of feeding weaning pigs with a diet containing tributyrin and coated anise complexes on growth performance, nutrient digestibility, fecal noxious gas emission, fecal bacteria counts, fecal score, intestinal villus length, and serum hematology.**
D. X. Dang*, Q. Q. Zhang, J. M. Ahn, and I. H. Kim, *Department of Animal Resource & Science, Dankook University, Cheonan, South Korea.*
- P120 ***Escherichia coli*-expressed human lysozyme supplementation improves growth performance, apparent nutrient digestibility, and fecal microbiota in weaning pigs.**
D. X. Dang*, W. J. Seok, H. J. Park, and I. H. Kim, *Department of Animal Resource & Science, Dankook University, Cheonan, South Korea.*
- P121* **Use of pronutrients (plant-based molecules) alone and combined with butyrate and probiotics to improve performance in broilers though improving gut health.**
T. Chowdhury¹, S. Haldar², D. Diez⁴, C. Domenech⁴, and J. Pie^{*4,3}, ¹*Doctor's Agrovet Ltd, Dhaka, Bangladesh*, ²*Agrivet Consultancy Pvt. Ltd, Kolkata, Bangladesh*, ³*IFTA USA, Raleigh, NC, USA*, ⁴*Biovet S.A, Contantí, Tarragona, Spain.*
- P122 **Modified fluorescein isothiocyanate dextran assay procedure to determine intestinal permeability in samples containing high natural or synthetic pigments.**
C. N. Vuong, G. J. Mullenix, M. T. Kidd, W. G. Bottje, B. M. Hargis, and G. Tellez-Isaias*, *Division of Agriculture, University of Arkansas, Fayetteville, AR, USA.*
- P123* **Implications of psychobiotics and the gut–brain axis in livestock and performance animals: A meta-analysis.**
J. Pratt^{*1}, J. Hromadkova¹, N. Malmuthuge², and L. L. Guan¹, ¹*University of Alberta, Edmonton, AB, Canada*, ²*Agriculture and Agri-Food Canada, Lethbridge Research and Development Center, Lethbridge, AB, Canada.*

* Indicates the poster will be presented virtually



Session 1

100 Prophylactic targeting gut neuroimmunological axis to increase resistance to bacteria in layers. M. Mellata*, Iowa State University, Ames, IA, USA.

Poultry serve as a major reservoir for bacterial *Enterobacteriaceae* pathogens like *Salmonella* and *Escherichia coli*, which are a food safety concern. Although many probiotics are beneficial to poultry productivity, they induce poor host antimicrobial responses against enteric pathogens. We showed that some probiotics can even increase the level of *Enterobacteriaceae* in the chicken gut by increasing the level of norepinephrine. Furthermore, some bacteria like *Salmonella* actively promote immunotolerance in the chicken gut, which prevents antibacterial host responses and subsequently results in fecal *Salmonella* shedding and contamination of poultry products. Thus, novel prophylactics which can stimulate host intestinal responses and overcome these immunotolerant mechanisms to clear intestinal *Enterobacteriaceae* like *Salmonella* are needed. Our study demonstrates that prophylactics can alter intestinal immunological responses via neurochemical and metabolic pathways to improve bacterial resistance. These findings provide compelling evidence that targeting the neuroimmunological axis can be an effective strategy to minimize *Salmonella* persistence in poultry and improve food safety.

Key Words: gut, immunotolerance, prophylactics, neurochemicals, bacterial resistance

101 Regulation of host defense peptide and barrier function gene expression and disease resistance by butyrate, forskolin, and lactose. Q. Yang and G. Zhang*, Oklahoma State University, Stillwater, OK, USA.

The rising concern of antimicrobial resistance highlights a need for effective alternatives to antibiotics for livestock production. Butyrate, forskolin, and lactose are 3 natural products known to induce the synthesis of host defense peptides (HDP), a critical component of innate immunity. In this study, the synergy among butyrate, forskolin, and lactose in enhancing innate host defense, barrier function, and resistance to necrotic enteritis and coccidiosis was investigated. Our results indicated that the 3 compounds synergistically augmented the expressions of multiple HDP and barrier function genes in chicken HD11 macrophages. The compounds also showed an obvious synergy in promoting HDP gene expressions in chicken jejunal explants. Dietary supplementation of a combination of 1 g/kg sodium butyrate, 10 mg/kg forskolin-containing plant extract, and 10 g/kg lactose dramatically improved the survival of chickens from 39% to 94% ($P < 0.001$) in a co-infection model of necrotic enteritis. Furthermore, the 3 compounds largely reversed growth suppression, significantly alleviated intestinal lesions, and reduced colonization of *Clostridium perfringens* or *Eimeria maxima* in chickens with necrotic enteritis and coccidiosis ($P < 0.01$). Collectively, dietary supplementation of butyrate, forskolin, and lactose is a promising antibiotic alternative approach to disease control and prevention for poultry and possibly other livestock species.

Key Words: antibiotic alternative, host defense peptide, butyrate, necrotic enteritis, coccidiosis

102 Effects of an all-natural feed additive on the gut microbiome of weanling pigs experimentally infected with a pathogenic *Escherichia coli*. H. Xue*, D. Wang¹, L. Johnston¹, Y. He², C. Jinno², Y. Liu², and P. Ji³, ¹Amlan International, Chicago, IL, USA, ²Department of Animal Science, University of California, Davis, CA, USA, ³Department of Nutrition, University of California, Davis, CA, USA.

Homeostasis of the gut microbial ecosystem is essential for optimal growth performance and disease resistance in post-weaning pigs. A220 is a formulated feed additive that features a blend of a proprietary toxin-adsorbing mineral with a select blend of phytochemicals shown to have antibacterial properties against a variety of gram-negative and positive bacterial pathogens. This study aimed to assess the effects of A220 on the gut microbiome and further relate this to changes in growth performance and post-weaning diarrhea outcomes in pigs challenged with an enterotoxigenic *Escherichia coli* (ETEC). At 21 d of age, 36 piglets were weaned and randomly allocated to 1 of 3 groups: control (CON) or A220 supplemented at 0.25 or 0.5%. After a 7-d adaptation, all pigs were orally inoculated with 10^{10} cfu of F18 ETEC once daily from d 0 to d 2 post-inoculation (PI). Fecal consistency was scored twice daily from d 0–21 PI. Microflora in ileal digesta, ileal mucosa and fecal samples were profiled using 16S rRNA sequencing on d -7, 0, 7, and 21 PI. A220 supplementation at both levels increased feed efficiency from d 14–21 PI and reduced diarrhea frequency during the study ($P < 0.05$). Compared with CON, 0.5% A220 supplementation increased the relative abundance of *Firmicutes*, but reduced *Bacteroidetes* and *Proteobacteria* in feces on d 7 PI ($P < 0.05$). Within *Firmicutes* phylum, A220 at both 0.25% and 0.50% increased the relative abundance of *Lactobacillaceae* on d 7 PI ($P < 0.05$). A220 at both levels increased the relative abundance of *Prevotellaceae* and decreased that of *Rikenellaceae* in ileal digesta on d 21 PI ($P < 0.05$). A220 at 0.5% increased the relative abundance of *Clostridiaceae* and *Prevotellaceae*, and decreased that of *Enterobacteriaceae* and *Succinivibrionaceae* in ileal mucosa on d 21 PI ($P < 0.05$). A220 supplementation modified gut microbiota in favor of promoting a well-balanced gut microbial ecosystem, which may contribute to enhanced disease resistance and improved growth performance in weanling pigs faced with pathogenic challenges.

Key Words: microbiome, enterotoxigenic *Escherichia coli* (ETEC), post-weaning, pig

103 A *Lactobacillus* postbiotic product alleviates *Escherichia coli*-induced diarrhea in post-weaning piglets. P. Tacon¹, S. Della Zassa², C. Cull³, K. Lechtenberg³, and J. Leedle⁴, ¹ADARE Biome, Houdan, France, ²Adare Biome, Lawrenceville, NJ, USA, ³Midwest Veterinary Services Inc., Oakland, NE, USA, ⁴JL Microbiology, Hartland, WI, USA.

Antibiotics and zinc oxide have long been used to prevent or cure post-weaning diarrhea. Now many countries are reducing



use or completely banning these substances due to antimicrobial resistance and environmental concerns. Without antimicrobials producers have increased demand for natural solutions. Lactobacilli postbiotics are known to have a strong effect in reducing diarrhea in children. Research suggests this postbiotic prevents pathogen adherence and shifts the gut microbiome toward beneficial flora. Our objective was to evaluate the postbiotic *Lactobacillus* LB on newly weaned piglet health and performance outcomes compared with Control and Zinc oxide (Zn) in a 42-d *E. coli* challenge study. Three hundred male pigs 18 to 22 d of age and 2.75 to 7.60 kg BW from a commercial farm were divided into 4 groups each having 15 pens of 5 piglets. The LB treatment was Control feed with 2 kg LB/MT. The Zn treatment was Control with 3000 ppm Zn fed for 21 d and then removed. The 4th treatment was LB+Zn: Control diet with LB and added Zn for the 1st 21 d then Zn was removed. On d 10, all pigs were gavaged with 5 mL of 1.3×10^9 cfu *E. coli*/mL. Response variables were clinical and fecal scores, ADG, and FCR, with data collected on specific study days. Statistical analyses were performed using SAS and a Tukey-Kramer test. Fecal score results showed a strong reduction in diarrhea in the LB group. No watery stool was present in any pen in the LB group, yet it was as high as 89% in Control and 7% in the Zn group. Duration was 5 d post-challenge in LB as opposed to 11 and 7 d for Control and Zn groups, respectively. LB+Zn reduced diarrhea to 5 d as well. The *E. coli* challenge was severe. Mortality ~40% in the Control group was and 25% in the LB group. At 42 d postweaning, LB piglets had better growth performance. FCR was 13% lower (1.00 vs 1.15; $P < 0.01$) and ADG was 50% higher (0.21 kg/d vs 0.14 kg/d; $P < 0.01$) compared with Control. ADG was not different between LB and Zn groups. In summary, the postbiotic *Lactobacillus* LB significantly reduced postweaning diarrhea and was a good alternative to zinc oxide in piglet production.

Key Words: piglet, postweaning diarrhea, postbiotic

104 Determining the in vitro effect of a blend of α -monoglycerides (Fractal) against *Clostridium perfringens* pathogenic strains isolated from field cases of focal duodenal necrosis and necrotic enteritis. L.-M. Gomez-Osorio^{*1}, L. Stabler², and M. Franca², ¹Alura Inc., Durham, NC, USA, ²Department of Population Health, Poultry Diagnostic and Research Center, University of Georgia, Athens, GA, USA.

The aim of this work was to determine the in vitro effectiveness of a blend of short-chain fatty acids (SCFA) and medium-chain fatty acids (MCFA) using α -monoglycerides through a minimum inhibitory concentration (MIC) test. *Clostridium perfringens* type G strains used in this study were previously isolated from field cases of focal duodenal necrosis (FDN) and necrotic enteritis

(NE) (Villegas et al., 2020, *J. Vet. Diagn. Invest.*, 32:268–276). Isolated colonies of the tested bacterial species were selected from a 24-h culture on a blood agar plate. MIC tests were done in triplicates using 2 samples of Fractal and 3 strains of *Clostridium perfringens*. The strains were isolate 1 and isolate 5 (obtained from chickens with FDN) and CP6 (obtained from a broiler chicken with NE). The microbicidal activity of the SCFA and MCFA α -monoglyceride product for CP6 strain is shown in Figures 1, 2 and 3. All isolates had MICs ≤ 0.08 $\mu\text{g/mL}$. Furthermore, the MICs for isolate 1 and isolate 5 were 0.04 respectively. For CP6 strain, the MIC was 0.08. The blend of SCFA and MCFA α -monoglycerides demonstrated high antimicrobial activity against different strains of pathogenic *Clostridium perfringens* isolated from field cases of FDN and NE under an in vitro test.

Key Words: focal duodenal necrosis, necrotic enteritis, α -monoglycerides, short-chain fatty acids, medium-chain fatty acids

105 Studies conducted at the University of Arkansas to evaluate curcumin as a feed additive to control bacterial and protozoal infections and reduce aflatoxicosis severity in poultry. G. Tellez-Isaias^{*1}, D. Hernandez-Patlan², B. Solis-Cruz², V. Petrone-Garcia², A. Leyva-Diaz², C. Vuong¹, D. Graham¹, C. Selby¹, J. Latorre¹, and B. Hargis¹, ¹University of Arkansas, Fayetteville, AR, USA, ²UNAM, Cuautitlan Cuautitlan Izcalli, Mexico, Mexico.

Several phytochemicals have been evaluated as feed additives in the poultry industry for nutritional purposes. However, phytochemicals play an essential role in the prevention of several diseases in poultry due to their antioxidant, anti-inflammatory, antibacterial, antiviral, antifungal, and immunomodulatory properties. Hence, in recent years, our laboratories have studied several phytochemicals as feed additives to control salmonellosis and necrotic enteritis, to reduce the severity of aflatoxicosis in broiler chickens, and to control coccidiosis in Leghorn chickens. Curcumin is a bright yellow chemical and the principal curcuminoid of turmeric (*Curcuma longa*), a member of the ginger family (Zingiberaceae). The aim of this presentation is to summarize the studies that have been published by our laboratories evaluating this remarkable phytochemical alone and in combination with other nutraceuticals: (1) Hernandez et al., 2018, *Front. Microbiol.* 9:1289; (2) Hernandez et al., 2019, *Animals* 9:184; (3) Solis et al., 2019, *Toxins* 11:121; (4) Leyva et al., 2021, *J. Anim. Sci. Biotechnol.* 12:23; (5) Petrone et al., 2021, *Sci. Rep.* 11:1–9.

Key Words: curcumin, salmonellosis, coccidiosis, aflatoxicosis, necrotic enteritis



Session 2

106 Role of the digestive tract microbiome on beef cattle performance. P. R. Myer*¹ and P. Y. Mulon², ¹Department of Animal Science, University of Tennessee, Knoxville, TN, USA, ²College of Veterinary Medicine, University of Tennessee, Knoxville, TN, USA.

The impetus behind the global food security challenge is direct, with the necessity to feed over 10 billion people by 2050. Developing a food-secure world, where people have access to a safe and sustainable food supply, is the principal goal of this challenge. To achieve this end, beef production enterprises must develop methods to produce more pounds of animal protein with fewer resources. Selection for feed-efficient beef cattle using genetic improvement technologies has helped to understand and improve the persistence and longevity of such traits within the herd. Yet genetic contributions to feed efficiency have been difficult to identify, and studies differing in genetics, feed regimens, and environments contribute to great variations in data and interpretation of the results. The mutualistic, commensal, and parasitic microorganisms that reside in the rumen and lower gastrointestinal tract of cattle and other ruminants exert enormous influence over animal physiology and performance. The ability to interrogate these systems at great depth has permitted a greater understanding of the microbiological and molecular mechanisms involved in ruminant nutrition and health. The work in our group in the field of bovine gut microbial ecology, as it relates to feed efficiency, permits the exploration of these critical microbial community networks. This knowledge will aid researchers seeking to address the grand challenge of maintaining host-efficient gut microbiomes throughout cattle production operations.

Key Words: cattle, gut, microbiome, rumen

107 A broiler chronic gut inflammation model under real farming conditions and the alleviation of its negative consequences with an in-feed technology. A. Khadem^{1,2}, D. Ritter*³, and C. Gougoulis¹, ¹Innovad NV/SA, Essen, Belgium, ²Lab of Nutrition, Faculty of Veterinary Medicine, Ghent University, Merelbeke, Belgium, ³Innovad USA, Salisbury, MD, USA.

Compromised intestinal health in modern production has been linked with chronic inflammation and significant economic losses. Although several challenges are artificially introduced in recent poultry models of gut failure/dysbiosis, the 'too clean' experimental conditions oppose a major limitation. Here we evaluated (1) a model of chronic gut inflammation under real farming conditions using, as a trigger, high non-starch polysaccharides (without NSPases), and (2) the ability of an in-feed technology (Lumance Innovad: esterified butyrate with plant extracts and essential oils) to alleviate inflammatory responses in broilers. In experiment 1, the high NSP (60% wheat + 5% rye) significantly increased macroscopic morphometric "dysbacteriosis" both at d 21 and d 28 over a standard diet (50% corn + 30% soy) ($P < 0.005$; 1 bird per pen scored, $n = 8$ pens/group; $n = 30$ birds/pen), evaluated according to Teirlynck et al. (2011). In experiment 2, a heatwave elevated the mean temperature to $\sim 32^\circ\text{C}$ for ~ 12 – 14 h/d inside the production between d 21 and d 29. Interestingly, although both intestinal and

systemic oxidative stress (measured as MDA) in the high NSP diet reduced by $\sim 30\%$ between d 28 and d 35, both inflammatory (IFN- γ) and immune (IgA) responses increased significantly (~ 33 and 40% , respectively) suggesting a cumulative impact over time. Importantly, Lumance (1 and 2 kg/ton) significantly increased the BW at the end of the life cycle (d 35) over the high-NSP ($P = 0.041$) and reduced the FCR ($P = 0.012$) ($n = 8$ pens/group; $n = 30$ birds/pen). Also, Lumance reduced, in a dose response manner, both intestinal and systemic MDA at d 28 ($P < 0.05$), intestinal IFN- γ at d 28 and d 35 ($P < 0.05$) and numerically both intestinal and systemic IgA at d 28 and d 35. In conclusion, we have successfully established a novel, dietary-induced model of chronic gut inflammation under real farming conditions, which can be seen as the sum of several stress points and evaluated the ability of an in-feed technology (Lumance Innovad) to alleviate its inflammatory responses in broilers.

Key Words: gut health, chronic inflammation model, real farming condition, biomarker, feed additive

108 Fluorescence-based detection of β -D-glucuronidase activity for assessment of ileal granulocyte degranulation in *Eimeria*-challenged broilers. A. Duff*, K. McGovern, M. Trombetta, and L. Bielke, *The Ohio State University, Columbus, OH, USA.*

Heterophil granule component β -D-glucuronidase has been used to assess degranulation activity in cell culture supernatant after bacterial challenge. Adaptation of this assay for site specific degranulation in gastrointestinal (GIT) tissue was evaluated as a potential indicator of localized inflammation in response to *Eimeria maxima* (EM) infection. Experiments (Exp) 1–3 compared Control (C1, 2, 3) and EM-infected groups (EM1, 2, 3) by *t*-test ($P < 0.05$), while Experiment 4 used ANOVA and Dunnett's post hoc analysis ($P < 0.05$) to compare C4 to EM-low (5×10^3 oocysts), -medium (1×10^4 oocysts), and -high (1.5×10^4 oocysts). Intestinal scrapings were collected into RPMI 1% penicillin/streptomycin on ice, gently homogenized, and centrifuged. Supernatants were incubated with RPMI and positive control with serum opsonized zymosan for 1 h at 42°C . Samples were tested in 3 replicates and incubated with 4-methylumbelliferyl- β -D-glucuronide for 4 h at 42°C . Liberated 4-methylumbelliferone (4-MU) was quantified fluorometrically at an excitation/emission wavelength of 360/460 nm. Body weight gain (BWG) was evaluated over the infection period and was significantly suppressed in all EM groups relative to C1–3 ($P < 0.05$), while only EM-high BWG was lower ($P = 0.008$) than C4. In Exp 1 and 2, EM1 and EM2 4-MU was significantly lower than C1 and C2 ($P = 0.046$ and 0.009 , respectively), while no differences were observed between C3 and EM3 in Exp 3 ($P = 0.351$). Exp 4 showed significant decrease in EM-low ($P = 0.003$) and EM-high ($P = 0.003$) 4-MU versus C4, but not EM-medium ($P = 0.357$). All assay positive controls were elevated relative to samples. Suppression of BWG indicates successful EM infection and supports the conclusion of a general observable decrease in degranulation in the GIT of EM-challenged broilers. In future iterations, addition of correlation analyses between 4-MU values, BWG, and EM lesion scores on a per bird basis would aid in



addressing variability within treatment groups. These results may provide new insight into GIT degranulation events occurring during coccidial infection.

Key Words: degranulation, *Eimeria*, gastrointestinal (GIT), inflammation, broiler

109 Microbiome characterization of commercial turkeys with cellulitis. D. Ayala*, D. Grum, E. Kimminau, N. Evans, K. Russo, M. M. Lahoti, B. Tribble, and T. P. Karnezos, *Purina Animal Nutrition Center, Gray Summit, MO, USA.*

Cellulitis in commercial turkeys has emerged as one of the leading causes of morbidity and mortality in the United States. According to the United States Animal Health Association industry survey, cellulitis ranks among the top 5 health issues for the turkey industry. It also represents a major cause of carcass condemnation at slaughter with significant economic losses for turkey producers. The main bacterial pathogens associated with the disease are *Clostridium* spp., avian pathogenic *Escherichia coli*, and *Staphylococcus aureus*. The aim of this study was to characterize the microbial community of birds with cellulitis and compare it to the microbial profile of healthy birds, to identify potential agents and routes of the infection. A total of 4 sample types including cecum, ileum, skin, and subcutaneous tissue (SBT) from 10 Nicholas turkeys (1) with cellulitis (Cell+ group), (2) without cellulitis (Cell- group), and (3) healthy birds (Control group) were collected between 16 and 18 weeks of age. Samples of Cell+ and Cell- groups were collected at one farm with a history of cellulitis, whereas samples of Control group were collected at a sister farm, with no history of cellulitis. The microbial profile of all samples was characterized by 16S metagenomics. The SBT microbiome of Cell+ samples was dominated by *Clostridium sensu stricto* with a relative abundance of 65.86% compared with 0.06% and 0.29% in the Cell- and Control groups, respectively. Ileal microbiome of Cell+ group was the second highest in abundance of *Clostridium sensu stricto* compared with Cell- and Control groups, with relative abundances of 31.27%, 0.09%, and 3.37%, respectively. STB and ileal microbiome from Cell+ group were dissimilar to Cell- and Control groups ($P < 0.05$). Through bacterial isolation, *C. septicum* and *C. perfringens* were isolated from SBT samples elucidating a potential synergistic effect in the development of the disease. Additionally, the high abundance of *Clostridium* spp. in the ileum and SBT provides insight on the potential translocation of *Clostridium* spp. from the intestine to subcutaneous breast tissue resulting in cellulitis.

Key Words: cellulitis, *Clostridium* spp., translocation, gut health

110 Characterization of anti-clostridial effects of a novel probiotic. M. Trombetta*¹, K. McGovern¹, A. Duff¹, H. Xue², D. Wang², L. Johnston², and L. Bielke¹, ¹The Ohio State University, Wooster, OH, USA, ²Amlan, Chicago, IL, USA.

Necrotic enteritis is an enteric disease primarily caused by overgrowth of *Clostridium perfringens* (CP) in the small intestine following a variety of predisposing factors. The objective was to determine if a novel probiotic showed anti-clostridial effects, survived pelleting temperatures and harsh environment of the gastrointestinal tract (GIT), and if anti-clostridial effects were retained through the GIT. The probiotic was tested against 8 strains of CP to determine overarching anti-clostridial effect. The probiotic suppressed all 8 strains of CP significantly ($P < 0.05$) when CP inoculated media was overlaid onto a pregrown colony of probiotic and zones of inhibition measured. Next, probiotic efficacy was compared against common antibiotics and commercial probiotics. Two antibiotics, penicillin (0.0625 mg/mL) and metronidazole (0.05 mg/mL), both commercial probiotics, and the experimental probiotic reduced CP growth with the experimental probiotic outperforming both commercial probiotics ($P < 0.001$) and metronidazole ($P = 0.007$). The CP strain showed resistance to the third antibiotic, BMD (0.022 mg/mL). A germination and sporulation assay was run to ensure the spores could survive pelleting. A lack of significant change ($P = 0.112$) in cell recovery was indicated the probiotic's ability to endure pelleting. A simulation digestive assay was performed mimicking the crop, proventriculus, and intestines to ensure the probiotic could survive digestion. When spores recovered from each section of the GIT were compared, the final concentration was significantly lower than the initial ($P = 0.018$) with a 2-fold reduction reaching the small intestine. The digestive assay was repeated with the addition of CP in the small intestines to determine if anti-clostridial properties were maintained. Using a 10^6 dose of spores, the reduction in CP was significant at $P = 0.103$. The results of the experiments indicate the probiotic is a candidate for treatment and control of necrotic enteritis due to its broad anti-clostridial properties and resilience in harsh environments.

Key Words: probiotic, poultry, necrotic enteritis, antibiotic alternatives, direct-fed microbial



Session 3

111 Intestinal microbiomes as complex ecosystems: Implications for intervention strategies. M. Bailey* and C. R. Stokes, *University of Bristol, Bristol, United Kingdom*

There are clear associations between colonization with intestinal microbiomes and the development of the mucosal immune system and of metabolic function. In laboratory rodents, single microbial species can expand whole sections of the immune system and colonization of gnotobiotic pigs with an oligobiota has similar effects. However, in the field, young animals rapidly become colonized with complex microbiomes acquired from their mothers and from the environment. These are a complex set of spatially-linked microbiomes in which oral, gastric, duodenal, jejunal, ileal, cecal and colonic compartments are sequential ecosystems: each compartment acquires microorganisms from the previous compartment and then contributes microorganisms to the next. Once intestinal microbiomes are considered as a set of sequentially-dependent, complex ecosystems, it is apparent that the strategies we use to manipulate them may need to be similarly complex to provide robust, predictable results over multiple units and management systems. Many trials document the administration of single organisms to weaning or growing pigs resulting in measurable change in some parameters and these effects are interpreted as direct effects of the administered organisms (“probiotics”) on host physiology. However, while this interpretation might be acceptable in a gnotobiotic system, it is less so where the probiotic competes with existing, complex ecosystems. In addition, the documented effects frequently vary between trials or disappear once applied in real-world husbandry systems. We propose that most administered ‘probiotics’ and prebiotics, and of many nutritional interventions act indirectly, by modifying the existing, complex spectrum of sequentially-dependent microbiomes. As a corollary, we propose that their effectiveness is dependent on the composition of the existing, complex set of microbiomes. Characterization and manipulation of the current, baseline microbiomes in a specific unit may be necessary before administration of nutritional interventions. In addition, microbial consortia may be more effective in modifying these microbiomes than single organisms.

Key Words: microbiome, ecosystem, probiotic, immunology

112 Incorporating feed additives with coccidiosis control programs. S. M. Ramirez*¹, G. R. Murugesan¹, C. M. Pender¹, and B. Lumpkins², ¹BIOMIN America Inc., Overland Park, KS, USA, ²Southern Poultry Feed and Research Inc., Athens, GA, USA.

Coccidiosis continues to be a major challenge in poultry production, especially in systems no longer using antibiotics. Many producers implement coccidiosis control programs utilizing combinations of coccidiosis vaccines, coccidiostats, and feed additives. Depending on the modes of action of the feed additive, combining or replacing different strategies may be advantageous. Two feed additives were evaluated: (1) a phytogenic (PHYT) as a replacement of a chemical coccidiostat, and (2) a synbiotic (SYN) as an enhancement of a coccidiosis vaccine. Both studies utilized 800 day-old Cobb 500 chicks randomly allocated to 1 of 4 treatment groups (8 replicate pens per treatment with 25 birds

per pen). The first study consisted of a non-challenged control (NCC), a challenged control (CC), CC supplemented with zoalene (ZOA; 125 ppm), or CC supplemented with a PHYT (PHYT; 125 g/MT). The second study consisted of NCC, CC, CC administered a coccidiosis vaccine at placement (VAC), or VAC supplemented with SYN (SYN; 500 g/MT). In each study, birds were raised on used litter and on d 19, 20, and 21, 1×10^8 cfu/bird of *Clostridium perfringens* was administered via the feed. Data from each study were analyzed independently using GLIMMIX procedure of SAS with significance reported at $P < 0.05$. The CC resulted in a 9-point ($P < 0.05$) and 6-point ($P < 0.05$) increase in FCR compared with the NCC for study 1 and study 2, respectively. In study 1, final body weight and FCR were significantly improved ($P < 0.05$) in the ZOA- and PHYT-supplemented groups compared with the CC, but were similar to each other as well as the NCC. In study 2, supplementation with SYN was able to improve FCR by 7 points compared with VAC group ($P < 0.05$) and was similar to the NCC. Body weight was numerically ($P > 0.05$) improved in SYN birds compared with VAC birds. Additionally, oocyst shedding was increased ($P < 0.05$) in VAC and SYN on d 14 and d 21, suggesting normal cycling of the vaccine oocysts had occurred. Incorporating either of these feed additives was advantageous in the context of each coccidiosis control program.

Key Words: coccidiosis, feed additive, broiler

113 Saponins-based solution as efficient as coccidiostats to manage coccidiosis and gut health in broiler chickens? M. el Amine Benarbia*, P. Engler, L.-S. Druhet, and P. Chicoteau, *Nor Feed, Beaucaouzé, France.*

Health in general—gut health in particular—is an important pillar of animal welfare. Gut health can be affected negatively in broiler chickens by coccidiosis. To limit the effect of this disease, coccidiostats have been used with success for decades. However, their intensive use in broiler chicken flocks has led to resistance. Moreover, societal demand for an antibiotic-free animal product is increasing. Thus, there is a need to develop natural and efficient tools to support modern poultry producers to fulfil the productivity needs along with market demand. Saponin-rich plants like *Yucca schidigera* and *Trigonella foenum-graecum* are promising tools. The objective of this presentation is to share the different evaluation methods applied to assess the efficacy of the saponin-rich plant-based solution Norponin XO 2 (NPXO2) and draw a clear picture of the available alternatives for gut health managers. From 2016 to 2021, 2 types of experimental design were applied. The first one consisted of experimental infestations within research facilities. In this experimental design, 4 groups of birds were used: infested-untreated control (IUC), untreated-uninfested control (UUC), infested-ionophore treated (positive control group), and infested-NPXO2 treated (NPXO2). The second experimental design was used in commercial farms with 2 groups, one with “conventional” coccidiosis management tools and one supplemented with NPXO2. In both designs, production performance parameters were monitored and gut health was assessed using the Johnson and Reid methodology to score intestinal lesion score (ILS) related to coccidiosis infestation. Results from the first experiment showed that both ionophore



and NPXO2 supplementation were able to reduce *Eimeria* spp. infestation-related ILS and maintain zootechnical performance. In the second experiment, in addition to the fact that NPXO2 supplementation was as efficient as conventional tools, NPXO2 birds displayed a higher livability. These results suggest that NPXO2 supplementation is a reliable tool to be included in gut health management in broiler chicken flocks.

Key Words: gut, *Eimeria*, chicken

114 Evaluation of a novel plant-based technology aiding the control of coccidiosis in modern poultry production. A.

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Coccidiosis in modern production has been linked with compromised intestinal health, chronic inflammation, reduction in antibiotic usage and economic losses. Even subclinical disease can lead to significant production losses. The use of anticoccidials; for example, ionophores and synthetics, has been associated with resistance, whereas vaccines have had various degrees of efficacy. Here we evaluated a novel phytogetic technology (Aflocox, Innovad) with or without an intestinal health enhancer technology (Lumance) (1) under a severe mixed coccidiosis infection in a battery cage setup, and (2) in a dietary-induced mild coccidiosis within a real production system. In experiment 1, a mixed *Eimeria* infection (*E. acervulina* ~130,000, *E. maxima* ~39,000, *E. tenella* ~32,000 and *E. mitis* ~11,000 oocysts/mL) at d 13 resulted in 25% mortality between d 19 and 21, which was reduced to 0% by Aflocox (200g/ton from d 13 onward) in combination with Lumance (d 1-d 12: 250 g/T; d 13 onwards: 1 kg/ton) ($P < 0.05$, $n = 4$ cages/treatment, $n = 5$ birds/treatment). In experiment 2, under farming conditions, a high non-starch polysaccharides (NSP) diet (60% wheat + 5% rye without NSPases) increased total *Eimeria* lesion scores at d 21 ($P = 0.09$) and significantly worsened macroscopic dysbacteriosis both at d 21 and d 28 over a standard diet (50% corn + 30% soy) ($P < 0.005$; 1 bird per pen scored, $n = 8$ pens/group; $n = 30$ birds/pen), evaluated according to Teirlynck et al. (2011). Both Aflocox and Aflocox in combination with Lumance (a) ameliorated dysbacteriosis over the NSP-challenged group and showed no difference over the standard diet at d 21 and d 28 ($P < 0.005$), and (b) reduced numerically total *Eimeria* lesion scores (1 bird per pen scored, $n = 8$ pens/group; $n = 30$ birds/pen) and OPGs, to the same level as the standard diet at d 21 and d 28. Importantly, Aflocox (200 g/ton) with or without Lumance (1 kg/ton) at the end of the life cycle (d 35) significantly increased the BW over the high-NSP and reduced the FCR ($P < 0.05$; $n = 8$ pens/group; $n = 30$ birds/pen). Thus, we have evaluated a novel phytogetic technology (Aflocox) against 2 setups of coccidiosis with great promise.

Key Words: coccidiosis, gut health, phytogetic, real farming conditions

115 Identification of intestinal microbiota and mycobiota signatures associated with the severity of necrotic enteritis.

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Necrotic enteritis (NE) is known to induce intestinal dysbiosis. However, the intestinal microbes that are associated with NE severity are yet to be characterized. Here, we investigated the link between the ileal microbiota/mycobiota and disease severity in a chicken model of clinical NE using 16S rRNA gene and ITS2 sequencing. Our results indicated that, while the total bacterial population in the ileum was increased by 2- to 3-fold in NE chickens, the total fungal population progressively declined in exacerbated NE, with the most severely infected chickens showing a nearly 50-fold reduction relative to mock-infected controls. The *C. perfringens* population was increased from 0.02% in healthy chickens to 58 to 70% in chickens with severe infection, with most the ileal microbes being markedly diminished. Compositionally, a large group of ileal microbes showed a significant positive or negative correlation with NE severity. *Firmicutes*, such as group A and B *Lactobacillus*, *Lactobacillus reuteri*, *Subdoligranulum variabile*, *Mediterraneibacter*, and *Staphylococcus* as well as 2 genera of *Actinobacteria* (*Corynebacterium* and *Kocuria*) and 2 closely related *Cyanobacteria* were progressively declined as NE was aggravated. Other *Firmicutes*, such as *Weissella*, *Romboutsia*, *Kurthia*, *Cuneatibacter*, *Blautia*, and *Aerococcus*, appeared much more sensitive and were rapidly abolished in chickens even with mild NE. On the other hand, *Enterococcus cecorum* and 2 *Escherichia/Shigella* species were only enriched in the ileal microbiota of chickens with extremely severe NE. Multiple fungi such as members of the *Wallemia* and *Aspergillus* species were obviously diminished in response to NE. Functionally, secondary bile acid biosynthesis was predicted to be suppressed by NE, while biosynthesis of aromatic and branched-amino acids and metabolism of most amino acids were enhanced. These intestinal microbes showing a strong correlation with NE severity may provide important leads for the development of novel diagnostic or therapeutic approaches to NE and possibly other enteric diseases.

Key Words: necrotic enteritis, microbiome, mycobiome, dysbiosis, *Clostridium perfringens*

116 Effects of an all-natural feed additive on the intestinal integrity, mucosal immunity, and gut microbiome composition of *Eimeria*-infected broilers. H. Xue^{*1}, F. Rigo², B. Beirão², C. Fávoro², and M. Ingberman², ¹Amlan International, Chicago, IL, USA, ²Imunova Análises Biológicas, Curitiba, Paraná, Brazil.

M52 is a natural anticoccidial feed additive that has been shown to help prevent coccidiosis, maintain bird productivity, and has potential as an alternative to ionophores and chemical coccidiostats. This study further evaluated the effects of the product on host anti-*Eimeria* immunity, gut microbiome composition and intestinal integrity of broilers challenged with experimental coccidiosis. In this 28-d study, day-old Cobb broiler chicks were randomly assigned to 1 of 3 groups: (1) unchallenged control; (2) *Eimeria*-infected control; and (3) *Eimeria*-infected + M52 (70 g/MT feed). On d 14, chickens from treatments 2 and 3 were challenged with 100X Bio-Coccivet R Vaccine, a live polyvalent vaccine consisting of sporulated oocysts of 7 *Eimeria* spp. Peripheral blood mononuclear cell phenotype, ceca-cecal tonsil cytokine mRNA expression, duodenal/jejunal histopathology and gut microbiome of cecal content



were examined. *Eimeria* challenge induced moderate to severe parasitic enteritis manifested with prominent villous hyperplasia, heterophil mucosal infiltration, and hemorrhagic or necrotic foci on d 19. The product markedly reduced these histopathological changes. On d 28, M52 significantly increased the abundance of CD4-TCRV β 1⁺, CD8-CD28⁺ and CD4-TCRV β 1⁺ subsets, which help uphold mucosal immune homeostasis and develop competent mucosal and systemic adaptive immunity when faced with pathogen insults. On d 19, M52 dampened *Eimeria* challenge-associated upregulation of cecal IL-10, whose immunosuppressive properties can also be exploited by pathogens

to facilitate their own survival. Before *Eimeria* challenge, M52 enhanced the relative abundance of *Blautia* and *L-Ruminococcus* genera, 2 short-chain fatty acid producers, and further dampened the impairment on microbiota diversity associated with the subsequent *Eimeria* challenge. Collectively, M52 treatment promoted a well-balanced immune homeostasis, dampened intestinal damage, and preserved the microbiota diversity, which all contribute to an enhanced resilience to *Eimeria* spp. challenge.

Key Words: coccidiosis, anti-*Eimeria* immunity, IL-10, microbiome, intestinal integrity



Session 4

117 The culture of yak rumen anaerobic fungus *Orpinomyces* sp. *YF3* promotes the degradation of stalks by microorganisms in the rumen of dairy goats. Z. Liu¹, Y. Li¹, C. Zhao¹, L. Wang^{1,2}, J. Yao¹, and Y. Cao^{*1,2}, ¹Northwest A&F University, Yangling, Shaanxi, China, ²Harvard Medical School, Boston, MA, USA.

We studied the effects of yak rumen anaerobic fungus *Orpinomyces* sp. *YF3* on the fermentation of stalks in 2 experiments. The first experiment investigated whether *Orpinomyces* sp. *YF3* (0, 5, 10, 15%) could promote the in vitro fermentation of wheat straw. We found that 15% addition of *Orpinomyces* sp. *YF3* increased the activity of xylanase and acetylesterase and reduced the NH₃-N concentration with 3-d fermentation. In addition, the 15% addition improved the percentage of acetate and the ratio of acetate to propionate (A:P) and decreased the percentage of butyrate with 5-d fermentation. The second experiment explored the effects of repelling rumen fungi and 15% addition *Orpinomyces* sp. *YF3* on fermentation profile and microbial diversity. Four treatments were set up: control (C), antibiotic (CA, d 0 treated with 0.25 mg/mL cycloheximide), yak fungi (CF, d 4 to 8 replaced saliva with 15% *Orpinomyces* sp. *YF3* culture), and antibiotic + yak fungi (CAF + *Orpinomyces* sp. *YF3*) groups. CF improved the activity of carboxymethyl cellulase and avicelase, the concentration of NH₃-N, total volatile fatty acid (VFA) and acetate, and A:P, but reduced propionate concentration. Additionally, CF increased the relative abundance of fiber-degrading-related bacteria (*Rikenellaceae_RC9_gut_group*, *Ruminococcus*, *Pyramidobacter*, etc.) and acetogenic-related bacteria (*Anaerovorax*), but decreased that of starch-degrading bacteria (*Prevotella*), propionate-producing-related bacteria (*Fibrobacter*), and 4 yeasts (*Vishniacozyma*, etc.). Similarly, CAF improved the activity of avicelase, increased acetate percentage, and reduced propionate percentage and total VFA concentration. CAF showed similar effects on microbial diversity, with increased relative abundance of fiber-degrading-related bacteria (*Christensenellaceae_R-7_group*) and acetogenic-related bacteria (*Anaerovorax*), and decreased relative abundance of starch-degrading bacteria (*Streptococcus*). In conclusion, treating forage with *Orpinomyces* sp. *YF3* is probably a practical strategy to promote roughage degradation in ruminants.

Key Words: yak, rumen anaerobic fungi, stalk degradation, microorganism

118 Development of a model to examine developmental changes in intestinal crypt cell proliferation and macrophage densities of neonatal piglets. A. J. Calderon*, J. L. Sandoval, J. D. Starkey, and C. W. Starkey, Auburn University, Auburn, AL, USA.

Young piglets are more susceptible to severe immune challenges because their immune system is not fully developed at birth. A randomized complete block design experiment utilizing a 4 × 2 factorial treatment arrangement was conducted to evaluate the effect of dietary protein source on intestinal crypt cell proliferation and local macrophage populations of neonatal piglets. Male and female piglets (n = 123) from 5 farrowing groups were fed 1 of

3 liquid diets: (1) Whey (MLK) only, (2) MLK + spray-dried plasma (SDP), or (3) MLK + soy protein concentrate (SPC). After receiving sow colostrum, piglets were reared in Rescue Decks® until tissue collection. A fourth group was left in the farrowing crate and nursed the sow until sampling (SOW). Duodenal (DUO), jejunal (JEJ), and ileal (ILE) tissue was collected at 6, 14, 19, and 25 d of age. One hour before euthanasia, pigs were injected with 5'-bromo-2'-deoxyuridine (BrdU) to label proliferating (BrdU+) cells. Proportion of proliferating (BrdU+), crypt epithelial cells (PCEC) and CD172a (total) and CD80+ (pro-inflammatory) macrophage populations was assessed after cryohistology and immunofluorescence staining. At 6 d old, male piglets fed SDP had greater JEJ PCEC compared with SOW males (*P* = 0.0081). At d 14, male piglets fed SPC had higher DUO PCEC than those fed SDP (*P* = 0.0074). Females fed SPC tended to have greater JEJ (*P* = 0.0894) and ILE (*P* = 0.0793) PCEC than SPC-fed males. At d 6, male SOW-fed piglets had the largest populations of both DUO pro-inflammatory (CD80+; *P* = 0.0478) and proliferating, pro-inflammatory (BrdU+;CD80+; *P* = 0.0040) macrophages. In the DUO, at d 19, SDP-fed and male SPC-fed piglets exhibited the highest total macrophage density (*P* = 0.0025). In the ILE, on d 19, SDP-fed females had the highest pro-inflammatory macrophage density compared with all other groups (*P* = 0.0465). These data establish a model to evaluate developmental intestinal innate immunity and indicate that dietary protein source can impact PCEC, which may benefit renewal of the intestinal epithelial barrier.

Key Words: immune system, small intestine, intestinal macrophages, spray-dried plasma

119 Protected biofactors and antioxidants reduce the negative consequences of virus and cold challenge while enhancing performance by modulating immunometabolism through cytoskeletal and immune signaling. F. Perry*¹, L. Lahaye², E. Santin², C. Johnson¹, D. Korver³, M. Kogut⁴, and R. Arsenault¹, ¹University of Delaware, Newark, DE, USA, ²Jejo Nutrition Inc., Saint-Hyacinthe, QC, Canada, ³University of Alberta, Edmonton, AB, Canada, ⁴USDA-ARS, Southern Plains Agricultural Research Center, College Station, TX, USA.

The aim of this study was to evaluate the effectiveness and mechanism of action of 2 feed additives in reducing the impacts of physiological stressors. We compared the effects of protected biofactors and antioxidants [P(BF+AOx)], and protected biofactors and antioxidants with protected organic acids and essential oils [P(BF+AOx)+P(OA+EO)] on the immune and metabolic health of Ross 308 chickens. These biofactors and antioxidants were derived from vitamins, and *Aspergillus niger*, *Aspergillus oryzae*, and *Bacillus subtilis* fermentation extracts. All Ross 308 chickens were exposed to a double dose of live bronchitis vaccine at d 0 and environmentally challenged by reducing the temperature from 30–32°C to 20–23°C at d 3 for 48 h. Control birds were fed without feed additives in the diet. Performance data, jejunum and liver samples were collected to evaluate the effects of these treatments on growth, cytokine expression and kinome peptide array. Analysis of variance was used for statistical analysis of the performance and gene expression data



($P = 0.05$), and PIIKA2 was used for statistical evaluation and comparison of the kinome peptide array data. The P(BF+AOx) and P(BF+AOx)+P(OA+EO) treatments significantly increased bird weight gain and feed conversion ratio. The kinome peptide array data showed increased activity of cytoskeletal, cell growth and proliferation proteins, and metabolic signaling in the jejunum of P(BF+AOx)+P(OA+EO) treated chickens. There was also increased phosphorylation and activity of proinflammatory and immune proteins in the liver compared with the jejunum. There was a significant decrease in IL-6 gene expression in the jejunum of P(BF+AOx)+P(OA+EO) samples compared with control at d 15, and a decreased expression of the anti-inflammatory marker IL-10 for P(BF+AOx)+P(OA+EO) and P(BF+AOx) liver groups when compared with control at d 7. P(BF+AOx)+P(OA+EO) improves gut health via growth and metabolic signaling in the jejunum while both treatments induce immunomodulation.

Key Words: biofactor, antioxidant, immunometabolism, kinome peptide array, gut health

120 Microbiome metabolic modulation by a novel precision glycan for poultry. J. Claypool¹, K. Freeman¹, B. Blokker², M. C. Walsh³, C. Bortoluzzi^{*3}, and G. Schyns^{1,3}, ¹DSM Nutritional Products Ltd., Lexington, MA, USA, ²CRNA, DSM Nutritional Products SA, Village-Neuf, France, ³DSM Nutritional Products AG, Kaiseraugst, Switzerland.

The objective of the present study was to evaluate the complete metagenomics and metabolomics of the cecal microbiome as well as the intestinal transcriptomics of broiler chickens supplemented with a novel precision glycan Microbiome Metabolic Modulator (MMM). Day-old chicks were placed on a completely randomized block design with 2 treatments, 21 replicates, and 40 birds/replicate. The treatments consisted of a non-supplemented control or feed supplemented with 500 ppm of MMM2 precision glycan (Glycan M2-1, Midori USA, Inc., Cambridge, MA, USA; commercially available as Symphiome Poultry; DSM Nutritional Products). Cecal content samples were collected at 24 and 42 d of age from 1 bird/pen, and frozen at -80°C for further analyses. Ileal tissue samples were collected at 42 d of age into RNAlater solution and frozen at -20°C until RNA extraction. Metagenomic DNA from the cecal content was isolated and sequenced by an Illumina HiSeq 3000 platform, and the entire metabolomics analysis was performed. Ileal mRNA was isolated, and the gene expression analysis was performed by a chicken Gene expression Microarray, 4x44K (Agilent). Related to the microbiome analysis, increased energy production around the TCA cycle associated with a concomitant increase of acetyl-CoA, justified mainly by a significant acetylation of multiple amino acids and increased lipid biosynthesis was observed. The increased carbon flow was also directed to the production of short chain fatty acids, mainly propionate by the acrylate pathway. About the nitrogen metabolism, ammonia was found to be largely detoxified through pathways to polyamines, out of the uric acid cycle at d 24, and through the asparagine outlet at 42 d. Interestingly, host glutamine synthetase was significantly decreased suggesting decreased ammonia toxicity. Regarding the host meta-transcriptomics, it was shown that IL-4 and IL-4-like, as well as IL-10 family were positively associated with MMM2 supplementation, indicating a possible anti-inflammatory and/or

regulatory role of MMM2, most likely as a secondary outcome from the metabolic modulation of the microbiome.

Key Words: broiler, microbiome metabolic modulator, nitrogen metabolism

121 Effects of a saponin and oregano blend on performance and oocyst shedding in turkey poults during a coccidiosis challenge. S. Hutsko^{*}, A. Garcia, E. Guaiume, D. Giesting, and R. Payne, *Cargill Animal Nutrition, Rice Lake, WI, USA.*

Coccidiosis in turkeys leads to decreased ADG, increased FCR, damaged intestinal integrity and, in clinical cases, increased mortality. Over the past decades of chemical and medication usage, *Eimeria* species have developed resistance to anticoccidial drugs limiting their effectiveness. So, this creates an urgent need to develop effective prevention and control strategies. Two studies were conducted to evaluate the potential of a proprietary saponin/oregano blend to maintain performance and reduce oocyst shedding in turkey poults during a coccidiosis challenge. In study 1, poults were raised in battery cages d 0-14 and then were randomly assigned to 1 of 4 treatments: Control (C; non-medicated, non-infected), Negative Control (NC; non-medicated, infected), Zoalene (ZO; 125 ppm Zoalene, infected) and Experimental (E; saponin/oregano blend; 2 lb/t, infected), each with 7 replicates of 8 poults/replicate. On d 16 poults were gavaged with 1 mL of coccidia inoculum (100,000 oocysts/mL) and on d 25 birds were weighed and excreta collected for oocyst counts. The E birds had higher ADG compared with the NC and ZO birds and a lower FCR compared with NC ($P < 0.05$). Shedding of *E. adenoids* was decreased in the E group compared with NC, and shedding of *E. meleagrimitis* and *E. gallopavonis* was intermediate between the NC and ZO groups. In study 2, poults were again raised in battery cages d 0-14 and then were assigned to 1 of 5 treatments: Control (C; non-medicated, non-infected), Negative Control (NC; non-medicated, infected), Zoalene (ZO; 125 ppm, infected), Natustat (NS; 4lb/t, infected), Experimental (E; saponin/oregano blend; 2 lb/t, infected), each with 7 replicates of 8 poults/replicate. On d 16 poults were gavaged with 1 mL of coccidia inoculum (100,000 oocysts/mL). On d 21, birds were weighed and excreta collected for oocyst counts. Birds in the E group showed improved ADG and FCR compared with the NC and NS groups ($P < 0.05$). Oocyst shedding in the E group was intermediate between the NC and ZO groups. Overall, this saponin and oregano blend was effective at improving performance and reducing oocyst shedding in poults during a coccidiosis challenge.

Key Words: cocci, prevention, turkey, oocyst, saponin

122 Effects of lipid-based natural R2 products on performance and microbiome of broilers in comparison with common feed antimicrobial measures. A. Mahfuz^{*1}, C. Jaeger¹, E. Weaver², and M. Dasari¹, ¹Feed Energy Company, Pleasant Hill, IA, USA, ²South Dakota State University, Brookings, SD, USA.

Due to the recent restrictions of antibiotic, antibiotic as growth promoter (AGP) usage in animals and the negative effects of formaldehyde on animal performance, the animal feed industry has started to evaluate alternatives to AGP and formaldehyde for flock health and performance. R2 is Feed Energy's patent



pending low pKa, lipid-based line of products that provides nutrient-dense source of essential fatty acids along with feed biosecurity benefits. The objective of this study was to determine the effects of R2 product OptimizR2 on broiler health and performance in comparison with commonly used antimicrobial measures. One-day-old male Ross 308 chicks ($n = 320$) were placed in 40 cages of 8 birds/cage. The treatments consisted of feeds formulated to meet NRC with 4% added lipids to produce 4 dietary treatments (SBO: Basal Diet+Refined SoyOil, SBO-B: SBO+Bacillus product, SBO-F: SBO+Formaldehyde product, Basal Diet+OptimizR2). Treatments were randomly assigned to provide 10 replications/treatment. The birds were fed a starter and grower feeds from d 1 to d 21 and d 22 to d 35, respectively. Microbial phylogenetic diversity analysis of d-35 cecal samples of birds were conducted using 16S rRNA gene sequences. Performance parameters measured were body weight (BW), average daily gain (ADG), feed conversion (FC), and mortality. Differences in performance between groups were analyzed for significance ($P < 0.05$) using ANOVA. The numerical differences in BW (SBO = 4.30 lb, OptimizR2 = 4.50 lb, SBO-B = 4.33 lb, SBO-F = 4.19 lb) and ADG (SBO = 0.12, OptimizR2 = 0.13, SBO-B = 0.12, SBO-F = 0.12) at the end of the trial were different ($P < 0.05$). The dietary addition of R2 to the broiler diets also improved FC ($P < 0.05$). Cecal microbiota showed much higher diversity with beneficial bacteria in R2 group. R2 preserve higher population of lactobacillus and eliminate harmful gram-negative bacteria compare with bacillus group. Gut beneficial lactobacillus level was low in formaldehyde group. The addition of R2 to feeds improves performance and offers benefits to the microbiome in broilers.

Key Words: broiler, microbiome, nutrition

123 Efficacy of mycotoxin deactivator on health and growth of broiler chickens under chronic dietary challenge of aflatoxins.

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Aflatoxins are hepatotoxic and carcinogenic, and display immunosuppression properties for both humans and animals. This is also why they are the most widely studied and regulated mycotoxins. Strategies to mitigate aflatoxins prevalence includes the use of clays in animal feed as sequestering agents. Innovative approach consists in providing ingredients controlling inflammation and promoting immune. The objective of this study is to evaluate the impact of naturally contaminated diet with aflatoxins (AFB1) on health and performance of commercial broilers, and the efficacy of a mycotoxin deactivator based on clays, inactivated yeast and fermentation extracts. A total of 7200 straight run Vencobb 430 chicks were assigned for 42 d to 1 of 3 treatments in a randomized block design (8 pens per treatment): (1) BD: basal diet with residual mycotoxins; (2) MT: diet with 56 ppb AFB1; and (3) TN: MT + mycotoxin deactivator at 2 kg/t. Performance parameters were recorded on weekly basis, and blood was collected at d21 and d42. MT group shows significant lower BW than BD from 14 to 42 d, resulting in a decreased FCR (+2.6% for the overall period). TN can restore the performance compared with MT (-9.7% FCR) and to BD (-7.1% FCR). AFM1 in plasma, as a biomarker of chronic exposure, showed reduction of AFB1 assimilation (from -42% to -75%, $P < 0.01$) in the TN treated birds. AFB1 induces inflammation as shown by the increased secretion of pro-inflammatory cytokines such as IL1b, IL6, IL8, TNFa between BD and MT. TN treatment aimed to decrease these parameters relative to MT and to promote the production of anti-inflammatory IL10. Birds receiving TN treatment have higher antioxidant indicators such as superoxide dismutase, glutathione and glutathione peroxidase compared with MT and showed lower lipid peroxidation marker like malondialdehyde. This study highlights the complementary modes of action of this mycotoxin deactivator by inhibiting AFB1 in the intestine and by repairing damage caused at the gut level on inflammation, immune response and redox balance. This leads to sustained broiler resilience and performance.

Key Words: aflatoxin, broiler, immunity, inflammation, antioxidant



Session 5

124 Supplementation of functional amino acids above the requirement improves growth performance and immune status of weanling pigs challenged with *Salmonella* Typhimurium. L. A. Rodrigues^{1,2}, M. O. Wellington², J. C. González-Vega³, J. K. Htoo³, A. Menconi⁴, S. M. Mendoza^{*4}, A. G. Van Kessel², and D. A. Columbus^{1,2}, ¹Prairie Swine Centre Inc., Saskatoon, Saskatchewan, Canada, ²Department of Animal and Poultry Science, University of Saskatchewan, Saskatoon, Saskatchewan, Canada, ³Evonik Operations GmbH, Hanau-Wolfgang, German, ⁴Evonik Corporation, Kennesaw, GA, USA.

The functional amino acids (FAA) Met, Thr, and Trp play an important role supporting the immune system and gut health. Two studies were designed to evaluate the supplementation of FAA above requirements during a *Salmonella* Typhimurium (ST) challenge. Experiment 1 was conducted for 14 d in a 2 × 2 × 2 factorial arrangement, consisting of 2 CP levels (16% or 20%), 2 FAA levels (Met, Thr, and Trp at 100% [FAA⁻] or 120% of requirements [FAA⁺]), and 2 challenge conditions (saline [CT] or ST inoculation). Pigs (initial BW = 13.9 kg; 8 pigs/treatment [Trt]) received the diets from d 0 to 14, and on d 7 pigs were inoculated. Pigs inoculated with ST had higher rectal temperature, serum haptoglobin, and activity of antioxidant systems, softer feces, and lower growth compared with CT pigs. Pigs challenged with ST and fed FAA⁺ diets had a less severe acute inflammatory response and greater growth compared with FAA⁻ counterparts. Pigs fed 16% CP diets had lower cecal ST score compared with pigs fed 20% CP diets. Protein level did not affect growth and immune status. Experiment 2 was conducted for 21 d to evaluate whether providing an adaptation period of FAA⁺ is beneficial during health challenges. All pigs (initial BW = 11 kg, 8 pigs/trt) were inoculated with ST on d 14. Pigs were fed FAA⁻ or FAA⁺ diets at different periods. The 4 treatments included (1) FAA⁻, only FAA⁻, (2) FAA+15, pigs received FAA⁻ and from d 15 FAA⁺, (3) FAA+8, pigs received FAA⁻ and from d 8 FAA⁺, and (4) FAA⁺, only FAA⁺. As in Exp. 1, pigs experienced an acute inflammatory response due to ST regardless of the treatments. Pigs fed FAA⁺ diets had lower levels of serum haptoglobin, activity of antioxidant systems, cecal ST score, and greater growth compared with FAA⁻. Pigs fed FAA+15 and FAA+8 had intermediate activity of antioxidant systems and growth compared with FAA⁻ and FAA⁺. Both experiments demonstrated that pigs fed FAA⁺ are better equipped to counteract an ST infection while maintaining optimum growth, and the benefits are greater when pigs are fed FAA⁺ diets for a longer period.

Key Words: functional amino acids, pig, *Salmonella*

125 Nutrient transporters and tight junction expression and cecal short-chain fatty acid profile in *Eimeria*-challenged broilers fed diets with different levels of xylo-oligosaccharides. Y. Lin^{*} and O. Olukosi, University of Georgia, Athens, GA, USA.

A total of 252 Cobb 500 male broiler chicks were used in a 21-d experiment to study the possibility of xylo-oligosaccharides (XOS) helping to recover gut impairment in *Eimeria*-challenged broilers by regulating the expression of nutrient transporters and tight junctions, and cecal short-chain fatty acids (SCFA), which is

an indicator of bacterial status. Birds were allocated to 6 treatments in a 3 × 2 factorial arrangement (3 corn-soybean diets with 0, 0.5, 1 g/kg XOS × with or without *Eimeria* challenge). Each treatment had 6 replicates with 7 birds per replicate. Challenged groups were inoculated with a solution containing *E. maxima*, *E. tenella*, and *E. acervulina* oocysts on d 15. On d 21, jejunal tissue was collected for gene expression analysis and cecal content was collected for SCFA analysis. The *Eimeria* × XOS interaction for tight junction claudin 1 showed that both 0.5 and 1 g/kg XOS alleviated ($P < 0.05$) *Eimeria*-induced claudin 1 upregulation. The *Eimeria* × XOS interaction for sugar transporters showed the extent of *Eimeria*-induced GLUT2 and GLUT5 downregulation was smallest in the 0.5 g/kg XOS supplemental treatment. In addition, *Eimeria* upregulated ($P < 0.01$) tight junction JAM2 and glucose transporter GLUT1 but downregulated ($P < 0.01$) the peptide transporter PepT1, amino acid transporters rBAT, CAT2, y+LAT2, and zinc transporter ZnT1. *Eimeria* decreased ($P < 0.05$) cecal saccharolytic SCFA acetate, butyrate and total SCFA, but increased ($P < 0.05$) cecal branched-chain fatty acids isobutyrate and isovalerate. The supplementation of XOS tended to decrease the concentration of isobutyrate ($P = 0.080$) and isovalerate ($P = 0.062$). In conclusion, *Eimeria* challenge triggered changes in expression of tight junction and nutrient transporter genes. Supplemental XOS helped reverse the gene expression changes in tight junction claudin 1 and glucose transporter GLUT2 and GLUT5, and showed the potential of alleviating the *Eimeria*-induced unfavorable cecal fermentation pattern.

Key Words: xylo-oligosaccharides, *Eimeria*, tight junction, nutrient transporter, short-chain fatty acids (SCFA)

126 A stimbiotic as an innovative concept to decrease *Salmonella* cecal count and improve growth performance in broilers chicken. X. Rousseau^{*}, N. Amornthwaphat, G. A. Gomes, and T. T. dos Santos, AB Vista, Marlborough, United Kingdom.

Salmonella control in poultry flocks and its public health impact is crucial. The objective of this study was to evaluate the effects of a stimbiotic (Signis, AB Vista, Marlborough, UK). A total of 900 day-old chicks were randomly allocated to 60 pens. The trial design was a complete 2 × 2 × 2 factorial with 2 based diets, a standard commercial diet with (PC) or without a multi NSP enzyme and a prebiotic (NC), with or without the stimbiotic at 100 g/ton of feed fed to males or females. Body weight (BW), feed intake (FI), and livability were recorded per pen. The feed conversion ratio was corrected for mortality (mFCR) and BW (mbwFCR). Four birds per pen were randomly selected and cecal content collected and pooled for the enumeration of *Salmonella* by most probable number (MPN) test culture. Performance data were submitted to a 2-way ANOVA, means were separated using a Student's test with significance accepted when $P \leq 0.05$. Livability and *Salmonella* MPN were analyzed by Chi-squared where means were separated using Wilcoxon test. Contingency analysis was performed on the presence/absence % of *Salmonella*. No effect was observed on livability. For almost all criteria tested there was an interaction between the stimbiotic and sex, which means in this study a greater effect in males. An interaction between diet and stimbiotic was noticed on *Salmonella* count ($P < 0.05$), which was reduced



for birds fed the stmbiotic, but this effect was more pronounced when supplemented on top of the NC. As a result, the proportion of *Salmonella* positivity was reduced from 26.7% to 13.3% when the stmbiotic was supplemented regardless of the diet. There was an interaction between the diet and the stmbiotic on mFCR ($P < 0.05$), mbwcFCR ($P < 0.05$), and FI ($P < 0.05$), with a larger effect noticed when supplemented to NC. In conclusion, birds fed the stmbiotic showed better performance while reducing *Salmonella* positivity, irrespective of sex and diet. Thus, the stmbiotic can serve as a nutritional strategy to improve performance and gut resilience mitigating *Salmonella* proliferation in the intestinal tract.

Key Words: stmbiotic, *Salmonella*, gut resilience, performance

127 Effect of maternal and post-hatch supplementation of 25-hydroxycholecalciferol on duodenal crypt cell proliferation and local innate immunity of broiler chickens.

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Previous studies demonstrate that maternal supplementation of the circulating metabolite of vitamin D₃ (D3), 25-hydroxycholecalciferol (25OHD3), enhances the immunocompetence of broiler chick offspring. To assess the effect of combining maternal (MD) and post-hatch (PD) dietary 25OHD3 inclusion on duodenal (DUO) crypt cell proliferation and local innate immunity of young broiler chickens, a randomized complete block design experiment with a 2 × 2 factorial treatment structure was conducted. All diets were formulated to provide 5,000 IU of vitamin D. From 25 to 41 wk-of-age, broiler breeder hens were fed 1 of 2 MD: 5,000 IU D3 per kg of feed (MCTL) or 2,240 IU of D3 + 2,760 IU of 25OHD3 per kg of feed (M25OHD3). Male broiler offspring (n = 480) hatched from eggs collected from 41-wk-old hens were fed 1 of 2 starter PD: 5,000 IU D3 per kg of feed (PCTL) or 2,240 IU D3 + 2,760 IU 25OHD3 (P25OHD3). DUO samples (n = 12 birds per treatment per day) were collected on d 3, 6, 9, 12, 15, 18, and 21 for cryohistological and immunofluorescence analysis to facilitate the enumeration of total macrophages, CD80+ macrophages (pro-inflammatory macrophages), and mitotically active cells (BrdU+) to calculate the proportion of proliferating cells per duodenal crypt (PPC). Broilers from the M25OHD3:PCTL group had higher PPC than MCTL:PCTL on d 3 ($P = 0.002$). On d 9, MCTL:P25OHD3 broilers had more proliferating, proinflammatory macrophages compared with those from the M25OHD3:P25OHD3 treatment (32 vs. 17 cells per mm²; $P = 0.023$). M25OHD3:PCTL broilers had more total proliferating macrophages than M25OHD3:P25OHD3 birds (89 vs. 56 cells per mm²; $P = 0.033$). At d 21, a MD × PD interaction was observed, where birds from

the M25OHD3:P25OHD3 treatment had more proliferating macrophages than M25OHD3:PCTL broilers ($P = 0.029$). In conclusion, these results indicate that combined MD and PD 25OHD3 supplementation may alter early post-hatch duodenal development and local intestinal innate immunity parameters.

Key Words: 25-hydroxycholecalciferol, vitamin D, intestinal development, intestinal macrophages

128 Dietary soy oligosaccharides affect the gastrointestinal health and feed efficiency of growing chicks.

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The objective of this experiment was to investigate the effects of the soy galactooligosaccharides (GOS) raffinose and stachyose on performance and gastrointestinal health in young broilers. Birds were fed a GOS-devoid diet based on soy protein isolate (SPI) or the SPI diet with 0.9, 1.8, 2.7, or 3.6% GOS. Stachyose and raffinose were maintained at a ratio of 4:1, similar to what is found in soybean meal, and were added at the expense of corn starch. These 5 treatments were administered to 10 replicate battery cages of 8 birds (0.04 m²/bird). Birds had ad libitum access to feed and water and BW and feed consumption were recorded on 0, 7, 14, and 21 d post-hatch for calculation of feed intake (FI), body weight gain (BWG), and feed conversion ratio (FCR). On 14 and 21 d, whole blood was collected for complete blood counts. Before blood collection on 21 d, birds were orally gavaged with fluorescein isothiocyanate-dextran (FITC-d), and serum samples were analyzed for FITC-d as a marker of gut leakage. Excreta were collected on d 14 for moisture analysis. Crop presumptive lactic acid bacteria (LAB) counts and crop and ceca pH were recorded at d 21. From 0 to 21 d, FI increased linearly ($P < 0.01$) as dietary GOS increased, whereas BWG increased ($P < 0.05$) quadratically. Feed conversion ratio increased ($P < 0.01$) linearly, with a 3-point increase from birds fed SPI to 3.6% GOS. On d 14, there was a linear increase ($P < 0.01$) in excreta moisture as dietary GOS increased. There was a quadratic increase ($P < 0.05$) in crop LAB recovery and a tendency for lower ($P = 0.08$) crop pH as GOS increased, whereas ceca pH decreased ($P < 0.01$) linearly. At both d 14 and 21, linear increases ($P < 0.05$) in whole blood heterophil to lymphocyte ratios were observed as dietary GOS increased. Serum concentrations of FITC-d increased quadratically ($P < 0.01$) as dietary GOS increased, with the greatest numerical FITC-d observed at 1.8%. No histopathological lesions were observed in duodenum or ileum of all groups. Results from this trial indicate that soy GOS have dose-dependent effects on broiler health and feed efficiency from 0 to 21 d.

Key Words: soybean meal, oligosaccharide, raffinose, stachyose



Posters

P100 Nutritional strategies to improve intestinal digestibility and health of beef cattle fed a high-grain diet. W. Z. Yang*, *Agriculture and Agri-Food Canada, Lethbridge Research and Development Centre, Lethbridge, AB, Canada.*

Several mechanisms whereby probiotics (yeast or bacteria) may improve gut health, intestinal microbial balance and production efficiency have been proposed, but few of these have been directly examined in experiments with cattle. With ruminants, the challenge is to deliver probiotics with high activity post-ruminally due to the highly proteolytic environment of the rumen. Two experiments were conducted to determine the effect of adding rumen protected and non-protected yeast products on intestinal digestibility and immune response in finishing beef cattle. Cattle were fed ad libitum diet containing 10% silage and 90% barley concentrate (dry matter [DM] basis). In Exp. 1, 5 rumen cannulated beef heifers (body weight, 650 kg) were used in a 5 × 5 Latin square with 5 treatments: (1) control; (2) monensin (Mon); (3) live yeast (LY); (4) encapsulated LY (EY); and (5) mixed of LY and EY (MY). Intake of DM (average 11.7 kg/d) was not affected by treatments. However, greater ($P < 0.03$) digestibility (% of intake) of organic matter and fiber in the intestine was observed with either EY or MY versus control diet. Heifers fed protected LY had less ($P < 0.05$) fecal *Escherichia coli* counts than control and Mon diets. The reduced fecal *E. coli* counts suggest an antipathogens activity of LY in the lower gut. In Exp. 2, 5 beef heifers (body weight, 561 kg) with ruminal and duodenal cannulas were used in a 5 × 5 Latin square with 5 treatments: (1) control diet; (2) monensin (Mon); (3) ruminal delivery of yeast culture (rYC); (4) duodenal delivery (dYC); and (5) combination of 3 and 4 (rdYC). Fecal IgA concentration was higher ($P < 0.05$) with dYC and rdYC than control and rYC. The duodenal delivery of YC resulted in trend of greater ($P < 0.08$) fecal IgA concentration (76 vs. 59 µg/g). These results indicate the potential post-ruminal activity of LY, and benefits to feeding protected yeast on improving intestinal digestibility. The study suggests that feeding rumen protected yeast products to feedlot cattle may exert potential beneficial health and food safety effects that reduce possibly pathogen excretion and increase of immune response.

Key Words: beef cattle, intestinal health, yeast products

P101 The inclusion of n-3 long-chain fatty acids in sow and piglet post-weaning diets modifies ileal mucosa immune indicators of low- and high-birth-weight piglets at the end of the post-weaning period. E. Llauradó-Calero*¹, I. Badiola², A. M. Pérez de Rozas², R. Lizardo¹, D. Torrallardona¹, E. Esteve-García¹, and N. Tous¹, ¹*Animal Nutrition, IRTA, Constantí, Tarragona, Spain*, ²*CRESA, IRTA, Bellaterra, Barcelona, Spain*.

Although n-3 long-chain fatty acids (LCFA) are associated with anti-inflammatory effects, very little is known about their effects on the gut immunity of weaned piglets. The aim of this study was to evaluate the impact of n-3 LCFA in sow and piglet diets on different immune indicators of ileal piglet mucosa 28 d post-weaning. Twelve sows were randomly assigned to a control or an n-3 LCFA diet from insemination until weaning. At birth, the 2 lowest (LBW) and the 2 highest birth weight (HBW) piglets per

litter were selected; at weaning, one piglet of each birth weight was randomly assigned to either a control or an n-3 LCFA diet. At the end of the post-weaning period, all piglets were sacrificed and mucosa samples from ileum were collected to determine immune indicators by RT-PCR. An interaction between piglet diet and piglet birth weight was observed for tumor necrosis factor α (TNF- α) ($P = 0.022$) and toll-like receptor (TLR)2 ($P = 0.050$). The highest TNF- α concentration was found in HBW piglets fed n-3 LCFA while the lowest was in LBW piglets fed the same diet. However, the highest concentration of TLR-2 was observed in LBW piglets fed the n-3 diet and the lowest in LBW piglets fed the control diet. Moreover, an interaction between maternal diet, piglet diet, and piglet birth weight was detected for interleukin 2 (IL-2) ($P = 0.044$), interferon γ (INF- γ) ($P = 0.037$) and TLR-4 ($P = 0.001$). The highest concentrations of IL-2 and TLR-4 were found in HBW piglets fed the n-3 LCFA maternal and control piglet diet. However, the lowest concentration of IL-2 was observed in HBW piglets fed the control maternal and piglet diet, and the lowest concentrations of TLR-4 in LBW piglets fed the maternal n-3 LCFA and piglet control diet. In terms of INF- γ , the highest concentration was found in LBW piglets fed maternal and piglet control diet, and the lowest in HBW piglets fed maternal and piglet n-3 LCFA diet. To conclude, the inclusion of n-3 LCFA in sow and piglet post-weaning diets modifies gut immunity differently depending on piglet birth weight.

Key Words: swine nutrition, n-3 long-chain fatty acids, gut immunity

P102 The Animal Health and Nutrition Consortium: A collaborative model to fund precompetitive research and career development. C. Chen* and P. Ferket, *North Carolina State University, Raleigh, NC, USA.*

The Animal Health and Nutrition Consortium (AHNC) is a new industry-member supported consortium with the mission to promote innovation and advances in production and companion animal health and welfare, with a special focus on gut health, nutrition, using precision technologies and artificial intelligence (AI) big data analytics. The research focus is on precompetitive research topics, driven by industry needs. The AHNC provides a framework to bring industry partners together with an interdisciplinary team of over 200 food animal faculty distributed across North Carolina State University departments. The consortium sponsors precompetitive research and solutions that encompass the health and nutrition of production and companion animals including, but not limited to, the potential value of feed ingredients and additives; digestive physiology; gut health and the enteric microbiome; impact on environmental sustainability and climate change, efficiency of nutrient utilization and minimization of environmental emissions; animal food quality and safety; integration of nutrition and animal welfare and well-being; big data analytics; and other emerging issues relevant to livestock, aquaculture, and companion animals. Benefits accrue to all AHNC partners in the form of resources for faculty research, leveraged research funding for industry, and developing the next generation of industry employees and policymakers. The AHNC provides defined engagement rules for members from competing companies with an opportunity to leverage



their investments through 1 of 3 memberships: \$50,000 for full membership with the privilege of 2 votes at advisory board meetings, \$25,000 for associate membership with one vote, and \$0 for non-profit membership (no voting rights). Any intellectual property generated from the consortium will be available for non-exclusive license to members in good standing. Future extension and education components of the AHNC include industry workshops, academic symposia, graduate student fellowships, undergraduate scholarships, and the AHNC Summer Institute.

Key Words: industry consortium, funding model, industry-academic collaboration, research, career development

P103 Effect of postbiotic (Lumensa) from lactic acid bacteria on the growth of *Lactobacillus* strains from poultry and swine intestines. J. M. Yang, S. Yang*, and E. Wozniak, *Cytzyme Laboratories Inc. (A Verdesian Life Sciences Company), Salt Lake City, UT, USA.*

Postbiotics produced from lactic acid bacteria consist of a wide range of molecules including peptidoglycans, teichoic acids, exopolysaccharides, cell surface proteins, secreted proteins (protein p40/p75, aggregation-promoting factor and bacteriocins), short-chain fatty acids, conjugated linoleic acid and neurotransmitters which play significant positive roles on the host biological processes such as immunomodulatory, prebiotic, antimicrobial, and gut barrier-preservation effects. Lumensa (AAFCO 36.12 Liquid *Lactobacillus acidophilus* Fermentation Product) applied to antibiotic-free diets has been shown to improve performance, reduce pathogenic bacteria and increase *Firmicutes* and *Bacteroidetes* ratio in cecum of broiler chickens exposed to heat stress. The objective of this study was to evaluate the effect of Lumensa on the growth of *Lactobacillus* strains from poultry and swine intestines in an in vitro model. Lumensa for Poultry was evaluated for bacterial growth performance of *L. reuteri* ATCC 55148 (isolated from chicken intestine), *L. gallinarum* ATCC 33199 (isolated from chicken crop) compared with non-treated control at 37°C under anaerobic condition (5.6% CO₂). Supplementation of Lumensa for Poultry (400 ppm) significantly increased cell density (OD_{650nm}, $P < 0.01$), bacterial counts ($P < 0.01$) and pH change ($P < 0.01$) after 24 h culture of *Lactobacillus* strains from poultry intestines compared with control. Lumensa for Swine was evaluated for bacterial growth performance of *L. acidophilus* ATCC 43121 (isolated from swine rectum), *L. reuteri* ATCC 53608 (isolated from swine intestine), and *L. amylovorus* ATCC 33198 (isolated from swine small intestine). Lumensa for Swine (400 ppm) significantly increased cell density (OD_{650nm}, $P < 0.01$), bacterial counts ($P < 0.01$) and pH change ($P < 0.01$) after 24 h culture of *Lactobacillus* strains from swine intestines compared with control. In conclusion, supplementation of Lumensa significantly increased the growth of beneficial *Lactobacillus* strains present in poultry and swine intestines in an in vitro model.

Key Words: *Lactobacillus* sp., Lumensa, postbiotic

P104 Immunofeed project: Searching the control of gut inflammation. J. Tarradas*¹, A. Perez de Rozas², A. Alberdi³, N. Tous¹, M. Viñas⁴, M. H. Kogut⁵, and J. Brufau¹, ¹*Animal Nutrition, IRTA, Constantí, Spain*, ²*CRESA, IRTA, Bellaterra, Spain*, ³*Section for Evolutionary Genomics, UCPH, Copenhagen, Denmark*, ⁴*Integral Management of Organic Waste, IRTA, Caldes de*

Montbui, Spain, ⁵*Southern Plains Agricultural Research Center, USDA-ARS, College Station, TX, USA.*

The objective of this project is the reduction of antibiotics dependence in poultry production inducing a robust homeostatic state in the intestine (promoting tolerance and avoiding inflammation) while the defensive capacity against pathogens is increased. For that purpose, the control of metabolic pathways that modulate the intestinal immune response (tolerance/inflammation/defense) is needed to induce tailored responses. Previous studies showed that a blend with different bacterial strains obtained from a cecal chicken isolate is able to reduce 99% of cecal *Salmonella* colonization in day-old chicks challenged with 10⁴ cfu of *S. typhimurium*. The study of these strains provides an extraordinary opportunity to understand their mechanisms of action and to detect altered immune pathways. The hypotheses of this project sustain that probiotic strains with a high concentration of CpG motifs in their genome have a greater immunomodulatory capacity due to their capacity to activate apical (but not basolateral) TLR21 inhibiting the NF-κB pathway and reducing intestinal inflammation. Moreover, the mode of action of probiotics includes a greater ability to synthesize SCFA, which could result in a better epithelial protection (synthesis of mucins from increased goblet cells and excretion of sIgA) and recruitment of Treg cells (increase of tolerance). Moreover, selected probiotics could be able to increase the expression of host defense peptides conferring a greater defense capacity against *Salmonella* infection and persistence. First results have demonstrated that this blend includes 16 strains (>1% of relative abundance obtained by NGS). The most abundant strains detected are *Shigella flexneri* (20.3%), *Pyramidobacter* sp. (16.5%), *Oscillibacter* sp. (13.6%), *Sutterella* sp. (9.1%), *Bacteroides fragilis* (5.8%), *Enterococcus faecalis* (5.4%), and *Bacteroides uniformis* (3.1%). The percentage of GC of these strains varies between 37.3% and 63.6%. These strains have been isolated and their antimicrobial activity and adequacy as probiotics are being characterized. The most promising strains will be assessed in in vivo trials to demonstrate the hypotheses of the project.

Key Words: probiotics, poultry, gut inflammation, nuclear factor-κB (NF-κB), toll-like receptor (TLR)21

P105 Different tissues from the chicken gut affect plasmid transfer in vitro. J. Jochum*, L. Ott, and M. Mellata, *Iowa State University, Ames, IA, USA.*

The emergence and spread of antibiotic resistance (AR) via bacterial plasmids lead to AR bacterial infections that pose a concern for animal and human health. The chicken gastrointestinal tract serves as a reservoir for AR gene transfer. An increasing incidence of resistance to last resort antibiotics in the gastrointestinal tract of chickens has been observed. An important aspect of the relationship between the gut microbiota and host health is the biogeography of the gut. However, the role of the gut environment in the transfer of AR genes remains unclear. We hypothesize that factors of the gut environment will affect the rate of plasmid transfer. Here we used chicken intestine explant models of the ilea, ceca, and colon to test plasmid transfer of antibiotic resistant plasmids from different incompatibility groups between *E. coli* strains. Our preliminary data show that chicken gut differentially promotes the transfer of plasmids from different incompatibility groups, and demonstrates the effect of



biogeography. Interestingly, we found that supernatant following exposure to AR *E. coli* in ceca explants significantly increased the incidence of Inc.F plasmid transfer in in vitro conjugation assays. The specific mechanism by which conjugation is stimulated in chicken ceca explant supernatant after exposure to bacterium is currently under investigation. Overall, we demonstrate the use of chicken gastrointestinal explants as a model to study and elucidate the unique role of gut tissue in bacterial plasmid transfer and antibiotic resistance spread.

Key Words: chicken, antibiotic resistance, plasmid transfer, gut tissue explant, biogeography

P106 Dietary 25OHD3 supplementation modulates intestinal inflammation and barrier integrity in young broiler chickens. G. A. Abascal-Ponciano*¹, S. F. Leiva¹, L. P. Avila¹, J. J. Flees¹, K. M. Sweeney², J. L. Wilson², J. D. Starkey¹, and C. W. Starkey¹, ¹Department of Poultry Science, Auburn University, Auburn, AL, USA, ²Department of Poultry Science, University of Georgia, Athens, GA, USA.

Vitamin D signaling is important for intestinal homeostasis. Increase of vitamin D receptor in immune cells can modulate cell phenotype and cytokine secretion. Cytokines regulate both pro-(interleukin 17; IL-17) and anti-inflammatory (IL-10) responses triggered by external stimuli. Inflammation in the gut can disrupt structure and remodeling of epithelial tight junction complexes, thus compromising the protective barrier. The objective of the study was to determine the impact of dietary supplementation with 25-hydroxycholecalciferol (25OHD3), hydroxylated metabolite of vitamin D, on the local immune response and epithelial barrier integrity over time in broilers. A randomized complete block design experiment was conducted to evaluate the effect of dietary 25OHD3 inclusion on relative protein expression of the cytokines IL-17 and IL-10, and tight junction proteins zona occludens 1 (ZO-1) and claudin 1 (CLD-1) in broiler chicken duodenum and ileum from 3 to 21 d post-hatch. On d 0, male chicks (n = 480) were randomly assigned to raised floor pens. The experimental corn-soybean meal-based treatments were (1) common starter diet containing 5,000 IU of D3 per kg of feed (D3) and (2) common starter diet containing 2,240 IU of D3 + 2,760 IU of 25OHD3 per kg of feed (25OHD3) fed from d 0 to 21. On d 3, 6, 9, 12, 15, 18, and 21, 12 birds per treatment were euthanized to collect tissue samples for quantitative, multiplex, fluorescent western blot analysis. Target proteins were quantified using Image Quant TL 8.1 and expressed relative to total protein. Feeding 25OHD3 post-hatch decreased ileal IL-10 (anti-inflammatory) protein expression in 21-d-old broilers compared with D3 only ($P = 0.0190$). Broilers fed only D3 post-hatch had greater IL-17 (pro-inflammatory) protein expression in the ileum at 18 and 21 d of age ($P = 0.0412$) than those fed 25OHD3. Dietary inclusion of 25OHD3 altered the abundance of key inflammatory cytokines and tight junction proteins in the ileum of young broilers.

Key Words: 25-hydroxycholecalciferol, cytokine, inflammatory response, interleukin

P107 Gut microbiome leads to immune response development in neonatal Holstein calves. V. Gomes*¹, C. Hoffmann¹, D. Irlanda Castro Tardon¹, F. C. Ramos Santos¹, and D. J. Hurley², ¹University of São Paulo, São Paulo, São Paulo, Brazil, ²University of Georgia, Athens, GA, USA.

We addressed whether gut microbiome development affected the developing immune response in neonatal calves. Twenty-eight Holstein cows and their female calves were included in this study. The calves received 3 to 6.5 L of fresh colostrum within 18 h of birth. Next, all calves were fed 6 L of milk replacer per day and calf starter ad libitum. Calf health was assessed immediately after birth and at 3, 7, 14, 21 and 28 d of age. Gut health was evaluated by fecal score and samples were harvested for laboratory analysis. The total DNA of all fecal samples were extracted using PowerSoil DNA Isolation kit. The V3-V4 region of 16S rDNA was amplified and sequenced by the Illumina MiSeq high-throughput sequencing platform. Sequences were analyzed using Qiime. The fraction of calves with diarrhea increased between 1 and 10 of age (peaking at 40%). Indicators of innate immunity demonstrated a decrease in the number of neutrophil and basophil on d 7 with a decrease in production of reactive oxygen species. It may be that granulocytes migrated to the gut at this time. Evidence of adaptive immunity indicated an initial decrease in ex vivo lymphocyte proliferation on d 7 then a gradual increase as the calves aged. The cytokines produced by ex vivo lymphocyte stimulation with bacteria or mitogen were minimal at d 3 but gradually increased for IL-17 and IFN-gamma as the calves aged. The early resident bacteria were predominantly *Staphylococcus*, *Escherichia coli*, and *Clostridia* spp. during the first 7 d. Subsequently, an increase in the number of *Faecalibacterium* and *Bacteroides* were observed over the rest of the study. Feces from healthy calves (fecal score 0) had an abundance of *Bifidobacterium* and *Lactobacillus*. In contrast, fecal samples from calves with diarrhea showed an abundance of *Fusobacteria* phylum. In conclusion, calves showed stronger innate responses early in life concurrent with initial bacterial colonization. As they aged, the adaptive immune elements showed signs of enhanced activity that may be associated with the establishment the bacterial community in the gut.

Key Words: innate immune response, adaptive immune response, diarrhea, *Faecalibacterium*, *Bacteroides*

P108 *Melissa officinalis* as gut contractility modifier in swine—An ex vivo study. S. Suor-Cherer^{1,2}, H. Bui*^{1,2}, M. el Amine Benarbia^{1,2}, and M. Mendel^{2,3}, ¹Labcom FeedInTech, Angers, France, ²Nor-Feed SAS, Angers, France, ³Institute of Veterinary Medicine, Warsaw University of Life Sciences, Warsaw, Poland.

Diarrheal symptom provoked by intestinal disorders is a significant problem causing huge economic loss in swine production, especially at weaning and post-weaning age. Among solutions, spasmolytic resulting in smoothing gastrointestinal tract musculature is generally considered as contributor to reduce diarrhea. This study aimed to evaluate the antispasmodic effects of a natural standardized *Melissa officinalis* extract (Nor-Balm) and its major active substances on swine intestine. The experiments were conducted on circular and longitudinal colon samples collected from routinely slaughtered pigs. The effect of the standardized *Melissa officinalis* extract, rosmarinic and lithospermic acids on spontaneous and ACh-induced activity was evaluated under isometric conditions. The results revealed significant and dose-dependent potency of *Melissa* extract to decrease the magnitude of acetylcholine-induced contraction. The impact was slightly stronger on longitudinal than circular



colon smooth muscle. Besides, the extract enhanced spontaneous contractility in longitudinal muscle layer. In case of rosmarinic and lithospermic acids the spontaneous colon motility was dose-dependently increased. Rosmarinic acid inhibited remarkably the contraction induced by ACh in both muscle types, whereas lithospermic caused increased and decreased response to ACh in circular and longitudinal colon muscles, respectively. The results of the performed study indicate that *Melissa officinalis* extract is efficient to control gastrointestinal motility. In which, rosmarinic acid seems contributing largely to the final effect of the plant extract. The ability to smooth intestinal muscle contraction revealed its potential in antidiarrheal effect in pigs. Further field studies should be carried to conform this assumption.

Key Words: *Melissa officinalis*, antispasmodic, diarrhea, lemon balm, anticontractility

P109 Microbiome and nutrient digestibility of pigs fed corn, soy, and corn distillers grains (DDGS) in the presence of a multicarbohydase complex. T. Dantas¹, R. Chaves¹, J. Barbi², N. Fagundes², M. Zangeronimo¹, and V. Cantarelli¹, ¹Universidade Federal de Lavras, Lavras, Minas Gerais, Brazil, ²Adisseo Brazil, São Paulo, São Paulo, Brazil.

The experiment aimed to evaluate performance, gut microbiota and digestibility of pigs fed corn, soy and corn distillers grain (DDGS) base diets with inclusion or not of a multicarbohydase complex (MC). Eighty-eight pigs were raised from 135 to 154 d of age, with 89.3 ± 2.8 kg of initial body weight, and distribution in a randomized block design into 4 treatments. A pen was considered an experimental unit and initial body weight a blocking factor. All treatment diets contained equal nutritional levels. The experimental treatments consisted of diets containing: 1 corn and soybean meal; 2 corn, soybean meal and MC; 3 corn, soybean meal and DDGS; 4 corn, soybean meal, DDGS and MC. DDGS was included at 25% and the MC nutrient matrix used in feed formulation considered digestible amino acids (e.g., 0.017% dig Lys) and net energy contents (50.5 kcal/kg). Fecal samples were collected per pen to determine apparent digestibility coefficients of nutrients by indirect method using a marker. At the slaughtering, cecal content were sampled to microbiota analysis. Pigs fed DDGS presented the worst digestibility coefficient, however, when MC was added, there was an improvement in nutrient digestibility ($P < 0.01$). Inclusion of DDGS in feed led to negative effect on gut biodiversity and microbial quality. Animals fed corn and soy presented higher level of beneficial bacteria such as *Lactobacillus*, *Megasphaera*, and *Bifidobacterium* ($P < 0.001$) compared with DDGS-fed pigs. Inclusion of DDGS in feed led to a significant increase in pathogenic bacteria such as *Streptococcus* ($P < 0.001$). When MC was included in DDGS diets, there was an increase in *Bifidobacterium* and a reduction in the *Streptococcus* genus. Regarding enteric microbiota diversity and using principal component analysis, benefit of inclusion of MC was achieved by improving similarity of diversity in either DDGS or corn soy diet. In conclusion, use of a multicarbohydase complex in pig diets containing corn DDGS might ameliorate microbiota quality and diversity, in addition to promote an upgrade in nutrient digestibility.

Key Words: microbiota, corn distillers grains (DDGS), digestibility, enteric biodiversity

P110 Advanced Digestion Enhancing Protein Plus Technology (ADEPPT) helps poultry gain body weight through modulating gut microbiome and cytokines. J. Talukder^{*1}, D. Dubourdieu¹, M. H. Talukder², A. Srivastava¹, and R. Lall¹, ¹Vets Plus Inc., Menomonie, WI, USA, ²Bangladesh Agricultural University, Mymensingh, Bangladesh.

ADEPPT, comprising a naturally derived polypeptide and polysaccharide complex, restores gut health and microbiome in pigs with diarrhea. It is not clearly known how the gut microbiome might play a role in body weight gain in poultry. The aim of this study was to determine the effects of ADEPPT on gut microbiome, immune system, and body weight gain in poultry. Day-old chickens ($n = 110$) were randomly segregated into groups. Different percentage (1, 0.5, and 0.1) of ADEPPT was added to diet of treated groups and replaced with starch for control. All birds were housed in standard conditions. Blood and feces were collected at the end of the 6-wk experiment. DNA was extracted from feces using the PowerSoil DNA extraction kit. The V4 variable region of the bacterial 16S rRNA gene was amplified and libraries were constructed using a dual index approach and sequenced on a MiSeq V3. Cytokines were measured in plasma by ELISA methods (Cusabio). All statistical analyses including α and β diversity, estimation, and indicator species were performed using various packages in the R statistical interface. A substantial body weight gain (13%, $P < 0.05$) was observed in 0.1% treated group as compared with control. Feces of all groups were negative of *Salmonella* and *E. coli*. Our preliminary microbiome studies showed beneficial differences in terms of bacterial community richness and Shannon index diversity in the ADEPPT-treated group compared with control. In addition, the microbiomes of the treated group were beneficially discriminated based on a Bray-Curtis distance PCoA. Indicator species analyses showed the bacterial species were positively discriminated between 0.1% treated and control groups. Blood serum analysis for cytokines showed the downregulation of IL-1 β (33%), IL-6 (55%), and IL-10 (20%), and upregulation of interferon- γ (11%). These findings suggest that ADEPPT significantly increases body weight gain through improving the gut microbiome and immune boosting response in chickens.

Key Words: digestion, gut health, microbiome, immune booster, nutraceutical

P111 Salmonella carriage in peripheral lymph nodes and feces of cattle at slaughter. L. Wottlin^{*}, T. Edrington, R. Anderson, and D. Nisbet, U.S. Department of Agriculture, Agricultural Research Service, Food and Feed Safety Research Unit, College Station, TX, USA.

Salmonella represents a primary food safety concern in retail beef, and some contamination is thought to occur through fecal contamination of the carcass and inclusion of contaminated lymph nodes in ground beef. Surveillance in processing plants assists producers and packers in risk management of *Salmonella* by understanding seasonal trends and risks of differing cattle types. In this study, fecal samples ($n = 1,840$) and subiliac lymph nodes (LN; $n = 1,550$) were collected from cattle sourced from 5 different production systems across 5 geographic regions and 3 seasons to better characterize trends in *Salmonella* burden. Cattle types were cull beef, cull dairy, conventionally fed, grass-



fed, or natural-fed. The 5 regions were the High Plains, Southern Plains, Southcentral, Southwest, and Western Plains of the United States. Fecal samples and LN were cultured quantitatively and qualitatively for *Salmonella*, in addition to screening for antimicrobial susceptibility on isolates. Conventionally-fed and cull dairy cattle had the greatest qualitative prevalence rates in both LN (32% and 18%, respectively) and feces (37% and 49%, respectively), while natural-fed cattle had the lowest prevalence in LN (3%) and feces (7%). Conventionally fed cattle had the greatest *Salmonella* concentration (1.17 log₁₀ cfu/g) in the LN, while cull dairy had the greatest *Salmonella* concentration (1.96 log₁₀ cfu/g) in the fecal samples. Seasonal effects differed, but winter consistently presented lowest *Salmonella* burden. Region 4 (Southwest) presented greater prevalence than other regions for LN and feces. Only 21 *Salmonella* isolates in this study were identified as MDR, and cull dairy and cull beef cattle were the primary sources (86%). These compelling results suggest that different production schemes may result in varying degrees of hindgut health which could affect ability of *Salmonella* to reach the LN, though the mechanisms of *Salmonella* prevalence in LN is far from elucidated. On-farm and in-abattoir *Salmonella* surveillance remains necessary to better understand production source, seasonal, and regional risks.

Key Words: cattle, lymph nodes, *Salmonella*

P112 Cecal microbiota transplantation: Unique influence of the donor line on growth, gut health, stress, and immune parameters of recipient chickens. Y. Fu^{*1}, J. Hu¹, and H.

Cheng², ¹Department of Animal Sciences, Purdue University, West Lafayette, IN, USA, ²Livestock Behavior Research Unit, USDA-ARS, West Lafayette, IN, USA.

Fecal microbiota transplantation is a promising therapeutic method in treating patients with gastrointestinal disorders such as inflammatory bowel diseases. The aim of this study was to examine if cecal microbiota transplantation (CMT) presents similar efficiency in improving the health status of egg-laying chickens. Cecal contents were collected from the diversely selected 6₃ and 7₂ lines based on resistance or susceptibility to Marek's disease, resulting in line's unique physiological characteristics and stress adaptive capacity. Cecal samples were diluted 1:10 in gut microbiome media; and transplantation was conducted through oral gavage daily at the first 10 d and then boosted weekly from wk 3 to 5. Eighty-four day-old male chicks of Dekalb XL strain were randomly assigned into 3 treatments with 7 replicates per treatment and 4 birds per replicate: Control (saline), 6₃-CMT (cecal solution of line 6₃), and 7₂-CMT (cecal solution of line 7₂). One bird per replicate was sacrificed to detect CMT-induced changes at wk 5 and 16, respectively. The results indicated that 7₂-CMT birds had the highest body weight and ileal villus/crypt ratios among treatments at wk 5 ($P < 0.05$); and higher heterophil/lymphocyte ratios than that of 6₃-CMT birds at wk 16 ($P < 0.05$). However, there were no treatment effects on the levels of corticosterone and testosterone at wk 16 ($P > 0.05$). 7₂-CMT birds also had higher levels of plasma immunoglobulin (Ig) G and interleukin (IL)-6 at wk 16, while 6₃-CMT birds had higher concentrations of ileal mucosal secretory IgA at wk 5 and plasma IL-10 at wk 16 ($P < 0.05$). In addition, 7₂-CMT birds tended to have the lowest serotonin concentrations ($P = 0.07$) with the highest serotonin turnover in the ileum among treatments at wk

5 ($P < 0.05$). In conclusion, early postnatal CMT shows line-correlated effects on the growth and health status of recipients via the regulation of ileal morphological structures, gut-derived serotonergic activities, peripheral cytokines, and antibody production in egg-laying chickens.

Key Words: cecal microbiota transplantation, egg-laying chicken, gut health, immune parameter

P113 Effects of *Fusarium* mycotoxins on broiler gut cytoprotective capacity. E. Griela¹, V. Paraskeuas¹, D. Bouziotis¹, K. Fegeros¹, G. Antonissen², and K. Mountzouris^{*1}, ¹Agricultural University of Athens, Athens, Attica, Greece, ²Ghent University, Ghent, Flanders, Belgium.

This study aimed to evaluate the effect of deoxynivalenol (DON) and fumonisins (FUM) on metabolic pathways related to detoxification, antioxidant response, inflammation, and barrier integrity, along broiler intestine. For this purpose, 378 day-old male Ross 308 broiler chickens were randomly divided into 3 treatments, each with 7 replicate pens. The experimental treatments were: predisposing dysbiosis diet (PDD), PDD supplemented with DON at 5 mg/kg of diet (DON), and PDD supplemented with FUM at 20 mg /kg of diet (FUM). Sampling was performed on d 39. Effects of DON and FUM on relative gene expression levels were evaluated by quantitative real-time PCR. The results showed that DON increased ($P < 0.05$) the expression of aryl hydrocarbon receptor 1 and 2 (AhR1, AhR2), cytochrome P450 1B1 (CYP1B1) and nuclear transcription factor- κ B (NF- κ B) and decreased ($P < 0.05$) mucin 2 (MUC2), at the duodenum. At the jejunum, DON upregulated ($P < 0.05$) cytochrome P450 1A1 (CYP1A1). At ileal level, DON induced ($P < 0.05$) the expression of aryl hydrocarbon receptor nuclear translocator (ARNT), hepatitis B virus X-associated protein (XAP2) Kelch-like ECH-associated protein 1 (Keap1) and heat shock protein 90 (HSP90) and decreased ($P < 0.05$) glutathione peroxidase 2 (GPX2) and claudin 1 (CLDN1). Furthermore, DON increased ($P < 0.05$) expression levels of Keap1 and HSP90, at ceca. On the other hand, at the duodenum, FUM upregulated ($P < 0.05$) heat shock protein 70 (HSP70), toll-like receptor 4 (TLR4) and NF- κ B and downregulated ($P < 0.05$) glutathione S-transferase A2 (GSTA2) and MUC2 expression. At the ileum, FUM increased ($P < 0.05$) CYP1A2 and lowered ($P < 0.05$) GPX2 and CLDN1. The expression levels of CYP1A2, Keap1, and HSP70 were increased ($P < 0.05$) and NAD(P)H dehydrogenase [quinone] 1 (NQO1) was downregulated ($P < 0.05$) by FUM, at the ceca. Our findings revealed that the impact of DON and FUM on broiler gut cytoprotective responses were shown to be mycotoxin- and intestinal site-specific. Furthermore, these results could be highly relevant for the assessment of various dietary bioactive components in broiler diets, for protection against mycotoxins.

Key Words: mycotoxin, broiler, gut health, detoxification, antioxidant response

P114 Effects of nutritional-induction of chronic inflammation on broiler gut health and performance. G. Cardoso Dal Pont^{*1}, A. Lee¹, C. Bortoluzzi¹, C. Eyng², C. Gougoulis³, and M. Kogut⁴, ¹Department of Poultry Science, Texas A&M Agrilife Research, College Station, TX, USA, ²Department of Animal Science, Western Parana State University, Marechal C. Rondon, PR, Brazil, ³Innovad NV/SA, Essen, Belgium, ⁴USDA-ARS,



Southern Plains Agricultural Research Center, College Station, TX, USA.

We have previously observed that feeding a diet with 30% of rice bran to broilers induced a low-grade chronic intestinal inflammation. Moreover, ingredient quality also can interfere in the animal's gut health. Therefore, the current experiment focused on further evaluating the broiler response to diets with high rice bran and with/or rancid oil inclusion. For that 1,344 Cobb male by-product day-of-hatch chickens were raised to 22 d of age and randomly assigned to 6 treatments. The treatments were (1) negative control (NC, corn and soybean diet); (2) NC diet + bacitracin; (3) diet with rancid oil (7.2 mEqO₂); (4) diet formulated with 20% rice bran + rancid oil; (5) diet with 20% rice bran inclusion and (6) diet with 30% rice bran. At 15 and 22 d, necropsies were conducted to evaluate gastrointestinal (GI) gross lesions, histological examination of the jejunum through microscopic I See Inside (ISI), and performance (feed intake, weight gain and feed conversion) were calculated. No differences in GI tract gross lesions between treatments were observed at either 15 or 22 d. The rancid oil did not affect performance or produce histologic alterations in the jejunum. However, broiler performance was negatively affected by both rice bran diet inclusions at both days ($P < 0.01$) with the worse performance throughout the experiment observed in the animals fed with the 30% rice bran diet. Moreover, at 15 d, the broilers in the rice bran groups presented an increase in lamina propria thickness ($P = 0.002$), goblet cells ($P = 0.003$), and inflammatory infiltration ($P = 0.0005$), and an increase in total ISI score. At 22 d, the jejunum of birds fed with rice diets presented an increase in goblet cells ($P < 0.001$) and congestion ($P = 0.040$) compared with NC. The inclusion of 30% rice bran, also increased epithelial thickness ($P = 0.021$) and proliferation of enterocytes ($P = 0.004$) compared with the bacitracin-fed animals. In conclusion, high inclusion of rice bran in the broiler feed reduced intestinal health and induced chronic intestinal inflammation, which had a detrimental effect on performance.

Key Words: intestinal inflammation, rice bran, intestine

P115 Effect of artificial colostrum supplementation in nursery pigs. H. J. Park*, V. Sampath, J. H. Song, W. J. Seok, and I. H. Kim, *Department of Animal Resource & Science, Dankook University, Cheonan, South Korea.*

The first 24 h after the birth of piglets is a crucial period in pig production as they are born with low body energy stores and, without immunoglobulins. Colostrum intake within few hours after birth helps the piglets to build their immunity for lifetime performance. Thus, the intention of this study was to evaluate the effect of artificial colostrum supplement on the growth performance and blood profile of piglets. At d 115 of lactation, 15 multiparous sows ($n = 5/\text{treatment}$) with their 195 offspring were blocked according to parity. Sows were offered a lactation diet, while litters were allocated into 1 of 3 dietary treatments: CON- only sow colostrum, (SC- intake depends on $\text{ADG} \times 3$), TRT1-SC+ 160 mL artificial colostrum (AC) (one time/day), and TRT2-SC+ 180 mL AC (2 times/day). Artificial colostrum powder was commercially purchased from Deahan Co. Ltd. (South Korea), mixed with hot water, and offered to piglets from the day of parturition and continued until weaning (21 d), while sows were offered a lactation diet. AC powder contains

53.25% of protein, 1.65% of fat, 3.30% of moisture, and 12.60% of immunoglobulin (IgG). The bodyweight (individual) of the piglets was measured at the initial, wk 1, weaning, and the end of the experiment to calculate ADG. Blood samples were collected from 12 piglets/treatment at the initial, wk 1, weaning, and the end of the experiment. Experimental data were analyzed (complete randomized design) using the GLM procedure of SAS. Piglets that received both sow colostrum and AC showed higher ($P < 0.05$) body weight and average daily gain, also increased ($P < 0.05$) lymphocyte population and immunoglobulin (IgG) concentration compared with piglets that received only sow colostrum. Although piglets fed sow colostrum were protected, fine, and grew well, providing AC had more significant benefits. We recommend that provision of AC twice a day along with SC could be more beneficial to enhance piglet immunity.

Key Words: colostrum, growth performance, immunoglobulin, piglet

P116 Lactating sows fed whey protein diet improved the blood profile of weaning pigs. J. H. Song*, V. Sampath, H. J. Park, and I. H. Kim, *Department of Animal Resource & Science, Dankook University, Cheonan, South Korea.*

Dietary milk components such as, whey protein concentrate (WPC) and whey protein hydrolysate (WPH) have been widely used in piglet diets. To date no literature has been presented on the application of whey protein additive in sow diet. This study aims to evaluate the efficacy of WPC and WPH supplementation in sows during lactation and the litter performance. At d 115, of lactation, 21 multi-parous sows ($n = 7$ per treatment) with their offspring were blocked according to parity and allocated to 1 of 3 dietary treatments: CON- (basal diet), TRT 1-CON + 0.047% WPC, and TRT2- CON + 0.02% WPH. The designated diets WPC and WPH powders were obtained from AT Feed Co. Ltd. (South Korea) and mixed in sow diet from lactation and continued until weaning, whereas dam milk was the only feed source to the piglets. During pre- and post-farrowing, and at weaning (d 21) individual sows body weight (BW), body condition score, and backfat thickness were measured. Piglets were weighed at birth and at weaning and the coefficient of variation was calculated. Individual piglet's BW was measured at birth and at weaning. Overall average daily gain (ADG) was also recorded. Blood samples were collected from 7 sows and 12 piglets /treatment. Individual sow and their litter were used as an experimental unit. Difference among the treatment means were determined using the Duncan multiple range test. The reproduction performance of sows was not affected by experimental diets. However, piglets born to sows fed WPC and WPH diet had a higher ($P < 0.05$) ADG. Sows fed WPC and WPH diet showed lower red blood cell (RBC) count and total iron-binding count (TIBC) after farrowing. But, the piglets born to sows fed diet containing WPC had increased ($P < 0.05$) RBC, iron, hemoglobin, and TIBC. Though there were no significant differences observed on the reproductive performance of sows' neither in WPC nor the WPH groups the body weight and blood profile of piglets were highly improved in piglets born to sows fed WPC and WPH diets. We infer that 0.047% of WPC and 0.02% of WPH in sow diets could be beneficial to improve the blood profile of piglets

Key Words: whey protein, piglet, growth performance, blood profile

**P117 Effects of synergistic blend of organic acids supplementation in late gestating sows on litter performance.** V.Sampath*¹, L. Pineda², Y. Han², and I. H. Kim¹, ¹*Department of Animal Resource & Science, Dankook University, Cheonan, South Korea*, ²*Trouw Nutrition R&D, Boxmeer, the Netherlands*.

This study aims to investigate the effects of in-feed additive based on a synergistic blend of short and-medium chain organic acids (SGG) supplementation in sows during gestation and lactation on litter performance. At d 107 of gestation, 150 multiparous sows (n = 50/treatment) were blocked according to parity and allocated to 1 of 3 dietary treatments: (1) CON (basal diet), (2) SGG-Low – CON + 1 kg/T SGG, and (3) SGG-High – CON + 3 kg/T SGG. The sows' body weight (BW), body condition score, and backfat thickness (BF) were measured at pre- and post-farrowing, and at weaning (d 21). Piglets were individually weighed at birth and at weaning and the coefficient of variation (CV) was calculated. The litter size was standardized to 12 piglets by cross-fostering within 24 h post-farrowing. On a weekly basis, piglet BW, FI, and FCR were measured. The fecal samples were collected from 8 sows per treatment at pre- and post-farrowing and at d 7 in lactation, and in litters at d 7 and 21 in lactation for *Lactobacillus*, *E. coli*, and *C. perfringens* counts. Data were checked for normality and analyzed using the MIXED procedure in SAS. Sows supplemented with SGG-High consumed more lactation feed than sows fed the CON diets ($P = 0.04$). The BW and BF losses were lower in sows fed with SGG-Low and SGG-High ($P < 0.05$). Also, sows fed SGG-Low and SGG-High diets had a reduced number of mummified piglets ($P = 0.04$) and improved birthweight CV and survivability of piglets during the first 24 h after birth ($P = 0.04$). Piglets born to sows fed SGG-Low and SGG-High had higher BW and ADG and grew from 2.8% to 4.1% faster during the first 21 d of life compared with piglets born to sows fed the CON diets ($P < 0.05$). At the time of weaning, litter weight was higher in pigs born to sows fed SGG-High (+3.1 kg, $P = 0.002$). The *Lactobacillus* and *E. coli* counts were not affected by the dietary treatments. However, SGG-Low and SGG-High reduced the *C. perfringens* counts in feces of sows on d 7 of lactation ($P < 0.05$). We infer that SGG supplementation in sows can support optimum sow productivity and improve birthweight uniformity and preweaning growth rate of pigs

Key Words: organic acid, sow productivity, preweaning growth

P118 Supplementing quercetin extracted from the flower of *Sophora japonica* improves growth performance, apparent nutrient digestibility, and cecal microbiota in broiler chicks.J. H. Song*, D. X. Dang, J. Ahn, and I. H. Kim, *Department of Animal Resource & Science, Dankook University, Cheonan, South Korea*.

Quercetin is a kind of flavonoid compound that is widely found in fruits or vegetables. Quercetin has been widely reported for its excellent biological properties such as antibacterial, antioxidant, gut health improver, growth promoter, and immunomodulatory. However, there were no studies to evaluate the effects of dietary supplementation of quercetin extracted from the flower of *Sophora japonica* (QS) on growth performance and productive performance in broiler chicks. Thus, this study aimed to evaluate the effects of supplementing quercetin extracted from the flower of *Sophora japonica* (QS) to the diet of broiler chicks on their

growth performance, apparent nutrient digestibility, cecal microbiota, serum lipid profiles, relative organ weight, and breast muscle quality. A total of 1088 1-d-old broiler chicks (mixed sex) were randomly assigned to 4 groups based on the initial body weight (43.00 ± 0.29 g). The trial period was 35 d (starter, d 1–7; grower, d 8–21; finisher, d 22–35). There were 17 replicate cages per treatment and 16 birds per cage. Dietary treatments consisted of basal diet without quercetin as the control group and treatment groups consisted of basal diet supplemented with 0.2, 0.4, or 0.6 g/kg QS. With the increase of the QS dosage, body weight gain during d 1–7 ($P = 0.021$), 8–21 ($P = 0.010$), and 1–35 ($P = 0.045$), feed intake during d 1–7 ($P = 0.037$) and 1–35 ($P = 0.025$), apparent dry matter digestibility ($P < 0.05$), apparent energy retention ($P < 0.05$), cecal lactic acid bacteria counts ($P < 0.05$), the relative weight of breast muscle ($P < 0.05$), pH value of breast muscle ($P < 0.001$), and the WHC of breast muscle ($P = 0.012$) increased linearly, whereas breast muscle drip loss ($P = 0.001$) decreased linearly. The addition of QS in the diet of broiler chicks has positive effects on the breast muscle yield and breast muscle quality, and could improve the apparent nutrient digestibility by increasing cecal beneficial bacteria counts, thus improving growth performance. Dietary level of QS in 0.6 g/kg was a suitable dose.

Key Words: quercetin, broiler, gut health

P119 Effects of feeding weaning pigs with a diet containing tributyrin and coated anise complexes on growth performance, nutrient digestibility, fecal noxious gas emission, fecal bacteria counts, fecal score, intestinal villus length, and serum hematology. D. X. Dang*, Q. Q. Zhang, J. M. Ahn, and I. H. Kim, *Department of Animal Resource & Science, Dankook University, Cheonan, South Korea*.

Nutrients such as butyrate have been used as regulators to repair the damaged intestinal barrier, improve intestinal mucose integrity, and ameliorate intestinal microbiota disorder. Anise as a plant-derived substance has been reported to play an important role in attenuation of enterotoxigenic *Escherichia coli*-induced intestinal barrier disruption and intestinal inflammation. However, no study has investigated the effects of tributyrin and anise supplementation on performance of weaning pigs. We conducted this study to evaluate the effects of dietary supplementation of tributyrin and coated anise complexes (TCC) on growth performance, nutrient digestibility, fecal noxious gas emission, fecal bacteria counts, fecal score, intestinal villus length, and serum hematology in weaning pigs. A total of 150 21-d-old weaning pigs [(Landrace × Yorkshire) × Duroc] were randomly allotted to 3 treatments according to initial body weight (6.19 ± 0.29 kg) for a 42-d trial (phase 1, d 1–7; phase 2, d 8–21; phase 3, d 22–42). Each treatment had 10 replicate pens with 5 pigs (mixed sex) per pen. There were 3 diet conditions: (1) CON, corn-soybean-wheat basal diet; (2) TRT1, CON + 0.075% TCC; and (3) TRT2, CON + 0.15% TCC. We found that final body weight, average daily gain during d 8–21, 22–42, and 1–42, average daily feed intake during d 22–42 and 1–42, feed efficiency during d 1–42, apparent dry matter and nitrogen digestibility, apparent energy retention on d 7 and 42, and intestinal villus length increased linearly with the dose of TCC increased, whereas fecal amino emission on d 42 decreased linearly. Therefore, the TCC supplementation could increase villus length with subsequent improvement in nutrient



digestibility, and further improving growth performance and reducing fecal noxious gas emission in weaning pigs.

Key Words: anise, tributyrin, fecal bacteria count, weaning pig

P120 *Escherichia coli*-expressed human lysozyme supplementation improves growth performance, apparent nutrient digestibility, and fecal microbiota in weaning pigs. D.

X. Dang*, W. J. Seok, H. J. Park, and I. H. Kim, *Department of Animal Resource & Science, Dankook University, Cheonan, South Korea.*

The *Escherichia coli*-expressed human lysozyme (EHL), a new source of lysozyme that is different from egg white lysozyme and the human lysozyme expressed in the milk of transgenic animals, has not been investigated extensively. We evaluated the effects of dietary supplementation of EHL on growth performance, nutrient digestibility, fecal microbiota, fecal score, and hematology indicators in weaning pigs. A total of 150 21-d-old weaning pigs [(Landrace × Yorkshire) × Duroc] were randomly allotted to 3 treatments according to the initial body weight (6.73 ± 0.01 kg) for a 35-d trial (phase 1, d 1–7; phase 2, d 8–21; phase 3, d 22–35). Each treatment had 10 replicate pens with 5 pigs (mixed sex) per pen. Dietary treatments consisted of a basal diet (CON), and a basal diet supplemented with 2.5 mg/kg antibiotic growth promoter complexes (AGP) or 1 g/kg EHL. Body weight on d 35 ($P = 0.001$), average daily gain during d 22–35 ($P < 0.001$) and 1–35 ($P = 0.001$), gain to feed ratio during d 22–35 ($P < 0.001$), growth rate during d 22–35 ($P < 0.001$) and 1–35 ($P = 0.002$), and apparent dry matter digestibility ($P = 0.044$) in feeding weaning pigs with AGP or EHL containing diet were higher, whereas fecal score during d 1–7 ($P = 0.002$) and fecal coliform bacteria counts ($P = 0.022$) were lower than those fed with the control diet. Moreover, weaning pigs fed the diet supplemented with EHL had a higher gain to feed ratio during d 1–35 ($P = 0.030$) than the CON group. Supplementing AGP to the diet of weaning pigs led to a decrease of fecal lactic acid bacteria counts ($P < 0.001$) compared with those fed with EHL containing diet or the control diet. However, hematology indicators did not differ among all dietary groups. Therefore, EHL has the potential to be used as an alternative to antibiotics due to the comparable effects with AGP on the growth performance, nutrient digestibility, hematology indicators, fecal score, and fecal coliform bacteria counts, however, unlike AGP, EHL did not inhibit fecal lactic acid bacteria counts.

Key Words: *Escherichia coli*-expressed human lysozyme, fecal microbiota, weaning pig

P121 Use of pronutrients (plant-based molecules) alone and combined with butyrate and probiotics to improve performance in broilers though improving gut health. T. Chowdhury¹, S. Halder², D. Diez⁴, C. Domenech⁴, and J. Pie^{*4,3}, ¹*Doctor's Agrovet Ltd., Dhaka, Bangladesh*, ²*Agrivet Consultancy Pvt. Ltd., Kolkata, Bangladesh*, ³*IFTA USA, Raleigh, NC, USA*, ⁴*Biovet S.A., Contantí, Tarragona, Spain*.

Pronutrients are active molecules from plant extracts that optimize the functioning of the organs. Intestinal conditioners are the ones that target the enterocytes and improve the status of the gut mucosa to improve performance and gut health. Butyrate is another solution intended to improve performance in poultry

production. A trial was conducted to study the effects of intestinal conditioner pronutrients (PRO), alone or in combination with butyrate, on performance. Three hundred twenty male broilers (Vencobb 430) were distributed in 4 treatments with 8 replicates each. The litter was 50% reused and served as a moderate challenge. Treatments were T1 without growth promoters; T2 with pronutrients; T3 with calcium butyrate (CaBu); and T4 with pronutrients and CaBu. Pronutrients were included at 500 g/t and CaBu at 300 g/t. Performance parameters were evaluated weekly and carcass yield at the end of the trial. Data were statistically analyzed with multi-variate ANOVA version 26.0 and diets used as the grouping factor. P -values < 0.05 were considered statistically significant. Values were compared using Tukey's test. Results showed that weight was significantly different at the end of the trial, only. T4 obtained the best result (2335.1 g) and was significantly different from T3, which obtained the lowest weight (2232.6 g). No differences were observed between the other groups. No significant differences were observed in feed intake. Feed conversion rate was improved in all supplemented groups compared with T1 ($P < 0.05$). This improvement was 4.8% in T2, 1.3% in T3, and 2.7% in T4. No significant differences were observed in livability and efficiency index, even though they were numerically higher in T2 and T3 compared with T1. Carcass yield was significantly improved in T3 and numerically improved in T2 compared with the control (T1). In conclusion, pronutrients improved productive performance when used alone and in combination with butyrate and were more effective than butyrate alone. They can be combined with butyrate without any negative consequence.

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Key Words: natural additive, pronutrient, chicken, butyrate, gut health

P122 Modified fluorescein isothiocyanate dextran assay procedure to determine intestinal permeability in samples containing high natural or synthetic pigments. C. N. Vuong,

G. J. Mullenix, M. T. Kidd, W. G. Bottje, B. M. Hargis, and G. Tellez-Isaias*, *Division of Agriculture, University of Arkansas, Fayetteville, AR, USA.*

Orally administered fluorescein isothiocyanate dextran (FITC-d) has been used as an indicator for intestinal permeability in poultry research for several years. Under healthy conditions, tight junctions in the intestinal wall will not allow the large (4–6 kDa) FITC-d to enter the bloodstream. Disruption of these enteric tight junctions can occur from infections, stress responses, chronic inflammation, or even feed components. Detection of FITC-d in serum (1-h post-oral administration of FITC-d) has proven to be a reliable indicator of leaky gut syndrome (increased intestinal inflammation and tight junction damage). Administration of supplementary products in feed, particularly those high in β -carotene levels or other pigments, has resulted in strong serum background fluorescence, which can render this assay unreliable. To account for this increase in background autofluorescence, the FITC-d assay procedure has been modified to accommodate these particular serum samples.

Key Words: leaky gut, fluorescein isothiocyanate dextran (FITC-d), pigment, serum, poultry

P123 Implications of psychobiotics and the gut–brain axis in livestock and performance animals: A meta-analysis.



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Psychobiotics are a type of probiotic that affect cognitive and behavioral functions in the host, have an effect via the gut–brain axis. Proposed mechanisms of psychobiotic effects include modulation via the hypothalamus–pituitary–adrenal axis, direct immune effects, and various neural, hormonal, and metabolic pathways affecting the balance of the gut microbiome. Growing evidence demonstrates that certain psychobiotic strains such as various *Lactobacillus*, *Bifidobacterium*, and *Streptococcus* species confer benefits for treatment or prevention of mental disorders such as depression, anxiety, and different altered mood or emotional states in humans. Many diseases and health problems exist in the production animal, which is often related to stress conditions or events such as weaning, transport, and

castration. There is a potential for psychobiotics to reduce the stress experience of these animals, subsequently improving immune function and development, performance parameters, and encouraging desired mental states in livestock and performance animals. Over 100 relevant studies were found in the literature detailing psychobiotic and probiotic usage in humans and animals for neuropsychiatric benefit. Despite some probiotic trials analyzing the effects of psychobiotics on behavior and welfare in mice and human models, no studies to date have been performed to indicate the potential use of psychobiotics in livestock and performance animals for enhanced health and productivity measures. This presentation will evaluate the potential of psychobiotic administration in swine, pre-ruminants, and equids to promote the resolution of stereotypies, stress-induced disordered function, and improved production parameters based on suggested evidence in animal models used to date.

Key Words: psychobiotics, gut health, mental health, gut–brain axis, livestock



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