

# Comparative Gut Physiology

**W106 Effect of complex and prebiotic diets on intestinal health of nursery pigs inoculated to porcine circovirus 2 (PCV2).** Marco M. Lima<sup>\*1,2</sup>, Dana M. van Sambeek<sup>2</sup>, Huyen Tran<sup>2</sup>, Daniel C. Ciobanu<sup>2</sup>, Phillip S. Miller<sup>2</sup>, and Thomas E. Burkey<sup>2</sup>, <sup>1</sup>Univesidade Estadual Paulista, Jaboticabal, Sao Paulo, Brazil, <sup>2</sup>University of Nebraska, Lincoln, NE.

To investigate the effects of complex and prebiotic diets on nursery pigs inoculated for or vaccinated against porcine circovirus 2 (PCV2) on the intestinal health, 96 weaned barrows (age 27 to 40 d; BW 7.1 kg) were housed (4 pigs/pen) in an environmentally controlled nursery with ad libitum access to feed and water over a 28-d study. Forty-eight pigs were vaccinated (VAC) for PCV2 before arrival, while remaining pigs (PCV) were inoculated for PCV2 on d 0. Pigs were randomly assigned to 1 of 3 diets: complex (CO; lactose, spray-dried plasma, spray-dried whey), simple (SI; corn and SBM), or simple + 2.5% Grobiotic-S (GS). After 28 d of experiment, 1 pig per pen was euthanized by exposure to CO<sub>2</sub> for collection of samples. Two-cm segments of duodenum and ileum were collected for the determination of villous height (VH), villous area (VA), crypt depth (CD), and villous height: crypt depth (VH:CD) ratio. Images were recorded using an Olympus DP71 camera (Olympus, Center Valley, PA). The VH, CD, VH:CD ratio, and VA were measured using Cell Sense standard software (Olympus, Center Valley, PA). For each intestinal sample, a minimum of 10 to 15 full villi and crypts were measured and averaged for statistical analysis. All data were analyzed as a completely randomized design using the MIXED procedure of SAS. Pen was considered the experimental unit and the model included treatment as a fixed effect. All measurements were performed without treatment awareness. No significant PCV-status effects were observed in the duodenum histological measurements; however, a significant diet × PCV-status interaction ( $P = 0.0251$ ) on VH:CD in duodenal samples was observed. The highest VH:CD result observed was in pigs fed GS and inoculated with PCV. Diet had an effect ( $P = 0.0066$ ) on duodenal CD, with deeper crypts being observed for GS pigs. With respect to VH and CD, a tendency for a diet × PCV-status interaction ( $P < 0.07$ ) was observed whereby PCV inoculated pigs and fed simple or GS diets had greater CD and VH, respectively. No significant effects were observed for ileum histological measurements. Results indicate that diet complexity may affect duodenal health in pigs inoculated with PCV.

**Key Words:** diet, health, intestine

**W107 Mitotic and apoptosis rate of intestinal cells of nursery pigs fed with a blend of organic acids and medium chain fatty acids.** Marco M. Lima<sup>\*1</sup>, Maria C. Thomaz<sup>1</sup>, Fabricio F. Castro<sup>1</sup>, Rosemeire S. Filardi<sup>2</sup>, Daniela J. Rodrigues<sup>1</sup>, Maryane S. F. Oliveira<sup>1</sup>, Manuela V. Marujo<sup>1</sup>, Everton Daniel<sup>1</sup>, Antonio C. Laurentiz<sup>2</sup>, and Thomas E. Burkey<sup>3</sup>, <sup>1</sup>Univesidade Estadual Paulista, Jaboticabal, Sao Paulo, Brazil, <sup>2</sup>Univ Estadual Paulista, Ilha Solteira, Sao Paulo, Brazil, <sup>3</sup>University of Nebraska, Lincoln, NE.

To investigate the effects of a blend of organic acids and medium chain fatty acids on gut health, 96 weaned barrows (21 d; BW 5.2 kg) were housed (3 pigs/pen) with ad libitum access to feed and water over a 28-d study. The diets were comprised primarily of corn, soybean meal and a source of lactose, with inclusion of 0, 0.15, 0.30 and 0.45% of a mixture of acetic acid, citric acid, formic acid, lactic acid, caprylic acid and caproic acid (BLEND). Piglets ( $n = 4$  pigs/treatment/time point) were euthanized on d 14 and 28 for sample collection. Two-cm

segments of duodenal and jejunal tissue were collected for analysis of apoptotic and mitotic rates. Rate of apoptosis and mitosis were evaluated immunohistochemically in paraffin wax-embedded tissue sections using polyclonal antibodies (anti-Caspase 3 and anti-PCNA, respectively; Biocare Medical, Concord, CA). The immunohistochemical procedure was conducted per the manufacturer's instructions. Images were recorded using an Olympus BX41 camera. For each intestinal sample, a minimum of 20 to 30 full villi and crypts were measured. ANOVA was generated using the mixed-model procedure of SAS. Linear, quadratic, and cubic polynomials were used to detect the response to dietary inclusion of the BLEND. All measurements were performed without treatment awareness. A cubic effect was observed with respect to the number of cells in mitosis in duodenal ( $P < 0.0001$ ) and jejunal ( $P = 0.0062$ ) tissue segments obtained on d 14 with the greatest rate of mitosis observed in tissues obtained from pigs fed 0.30% BLEND. In addition, a quadratic effect in mitosis:apoptosis ( $P = 0.0171$ ) ratio was observed in duodenal tissue obtained from piglets on d 14 with minimal inflection point at 0.18% inclusion of BLEND. No significant effects were observed with respect to mitotic or apoptotic rates in tissues obtained on d 28. In conclusion, feeding a blend of organic acids and medium chain fatty acids may have a short-term positive effect on mitosis and apoptosis, possibly contributing to intestinal epithelial restitution and gut health.

**Key Words:** apoptosis, intestine, mitosis

**W108 Effects of organic acids and medium-chain fatty acids on gut health of nursery pigs.** Marco M. Lima<sup>\*1</sup>, Maria C. Thomaz<sup>1</sup>, Fabricio F. Castro<sup>1</sup>, Rosemeire S. Filardi<sup>3</sup>, Daniela J. Rodrigues<sup>1</sup>, Maryane S. F. Oliveira<sup>1</sup>, Manuela V. Marujo<sup>1</sup>, Dana M. van Sambeek<sup>2</sup>, and Thomas E. Burkey<sup>2</sup>, <sup>1</sup>Univesidade Estadual Paulista, Jaboticabal, Sao Paulo, Brazil, <sup>2</sup>University of Nebraska-Lincoln, Lincoln, NE, <sup>3</sup>Universidade Estadual Paulista, Ilha Solteira, Sao Paulo, Brazil.

To investigate the effects of a blend of organic acids and medium chain fatty acids on gut health, 96 weaned barrows (21 d; BW 5.2 kg) were housed (3 pigs/pen) with ad libitum access to feed and water over a 28-d study. The diets were comprised primarily of corn, soybean meal and a source of lactose, with inclusion of 0, 0.15, 0.30 and 0.45% of blend (acetic acid, citric acid, formic acid, lactic acid, caprylic acid and caproic acid). For sample collection, piglets ( $n = 16$ ) were euthanized at 14 and 28-d study. Two-cm segments of duodenum and jejunum were collected for the determination of villous height (VH), crypt depth (CD), villous height: crypt (VH:CD) depth ratio and count goblet cell by methods of Schiff-PAS and Alcian Blue. Images were recorded using an Olympus BX41 camera. Cell Sense standard software was used for measurement of the respective morphological aspects. For each intestinal sample, a minimum of 20 to 30 full villi and crypts were measured and in assessing the number of goblet cells, 15 counts were performed. ANOVA was generated using the mixed-model procedure of SAS. Linear, quadratic and cubic polynomials were used to detect the response to dietary inclusion of the blend. Was observed a cubic effect in duodenal VH:CD ( $P < 0.0001$ ) ratio and jejunal goblet cell count ( $P = 0.0034$ ) by method of Schiff-PAS at 14-d study. Was observed a cubic effect on CD ( $P = 0.0009$ ), goblet cell count ( $P = 0.0014$ ) by method of Schiff-PAS, goblet cell count ( $P = 0.006$ ) by method of Alcian Blue, and an increasing linear effect on the VH:CD ( $P = 0.0006$ ) ratio in jejunum of pigs at 28-d study. Results indicate the blend had little effect at 14-d study; however,

positive effects of blend were observed at 28-d of study. In conclusion, the blend may contribute to intestinal restitution.

**Key Words:** health, organic acid, pig

**W109 Effect of turmeric, ginger and garlic extracts on performance, microbial load, and gut morphology of weaned pigs.**

Olufemi A. Adebisi<sup>1</sup>, Isaac A. Adejumo<sup>2</sup>, Oluremi A. Adeniji<sup>1</sup>, Olusegun D. Oshibanjo<sup>1</sup>, and Muyiwa B. Falana-Williams<sup>1</sup>, <sup>1</sup>*Department of Animal Science, University of Ibadan, Ibadan, Nigeria*, <sup>2</sup>*Department of Animal Science, Landmark University, Omu Aran, Kwara state, Nigeria*.

Producing swine without in-feed antibiotics requires a combination of different strategies. Some of the approaches that are available to improve the pigs ability to reduce the impact of intestinal pathogens are phytogetic, which improve intestinal health and promote productivity. Therefore, the objective of this experiment was to assess the effect of turmeric, ginger and garlic extracts on performance, microbial loads and gut morphology of weaned pigs. A total number of 20 weaned pigs were randomly allotted into 4 treatments with 5 replicates arranged in a completely randomized design. The treatments are: T1 (control), T2 (2g turmeric extract/kg feed), T3 (2g ginger extract/kg), T4 (2g garlic extract/kg). The feed was formulated to contain 19% crude protein and 2950 kcal/kg ME which meets the nutritional requirements of the weaner pigs. The experiment lasted for 49 d. No significant ( $P < 0.05$ ) difference was observed in the performance attributes of the weaned pig that were fed the different diets. The feed conversion ratio ranges from 3.59 in pigs fed T2 diet to 3.92 in pigs fed the control diet. Enterobacter count was significantly ( $P < 0.05$ ) higher in pigs fed T1 (6.38 cfu), T2 (6.29 cfu) and T3 (6.27 cfu) diets, compared with their counterpart on T4 (5.12 cfu). The least value of 6.63 cfu for total bacteria count was also observed in pigs fed T4 (garlic extract) diet. The ileum section of the gastro-intestinal tract of the pigs revealed significant ( $P < 0.05$ ) increase in the villus height for pigs on T4 (1419.75  $\mu$ m) than what was observed on pigs fed other diets (709.25  $\mu$ m, 1156.50  $\mu$ m and 1068.00  $\mu$ m in T1, T2 and T3 respectively). However, no significant ( $P > 0.05$ ) variations was observed in the villus width and crypt depth despite the different treatments. It can be concluded that inclusion of garlic extract at 2g/kg feed resulted in improved intestinal morphology and reduction in the microbial load in weaned pig.

**Key Words:** pig, extract, performance

**W110 Effect of heat stress on endogenous intestinal loss of amino acids in growing pigs.**

Adriana Morales<sup>1</sup>, Lorenzo Buenabad<sup>1</sup>, Lisbeth Hernández<sup>1</sup>, Misael Pérez<sup>1</sup>, Pedro Castro<sup>1</sup>, Gilberto Castillo<sup>1</sup>, Lance Baumgard<sup>2</sup>, and Miguel Cervantes<sup>1</sup>, <sup>1</sup>*ICA, Universidad Autónoma de Baja California, Mexicali, BC, México*, <sup>2</sup>*Department of Animal Science, Iowa State University, Ames, IA*.

Heat stress (HS) appears to increase intestinal cell death in pigs, which in turn may increase endogenous intestinal losses (EIL) of proteins and amino acids (AA). Experimental objectives were to analyze the effect of HS on the AA composition of intestinal endogenous proteins and the EIL of AA in pigs. Eight pigs (24 kg initial BW) were surgically implanted with T-type cannulas at the end of the small intestine. After surgery recovery, all pigs were adapted to a protein-AA-free diet and trained to consume the same amount of feed twice a day for 7d in thermo-neutral (TN) conditions (22  $\pm$  2°C). On d 8 of TN conditions ileal content was collected during 12 consecutive h. On d 9 pigs were exposed to natural HS conditions (31 to 37°C) for 8 d. During the HS period ileal content

was collected again on d2 (HSd2) and d8 (HSd8). Chromic oxide was used as indicator of the intestinal digesta flow. Data were analyzed using PROC MIXED of SAS; the model considered the TN pigs as no HS and the fixed effect of HS-sampling day was used to compare TN with HSd2 and HSd8. The AA composition of endogenous intestinal protein was not affected by HS ( $P > 0.10$ ). The EIL of indispensable AA of TN, HSd2 and HSd8 pigs were: Arg, 314, 345, 335; His, 144, 163, 153; Ile, 169, 196, 173; Leu, 378, 434, 387; Lys, 238, 275, 250; Met, 099, 113, 110; Phe, 298, 337, 296; Thr, 489, 533, 481; Val, 335, 354, 343 mg/d, respectively. The EIL of dispensable AA of TN, HSd2 and HSd8 pigs were: Ala, 377, 423, 383; Asp, 639, 684, 621; Glu, 478, 553, 509; Gly, 977, 838, 872; Pro, 763, 892, 1,941; Ser, 375, 394, 422; Tyr, 219, 251, 227 mg/d, respectively. The EIL of Thr and Phe tended to be increased ( $P \leq 0.10$ ), and Arg and His were enhanced at HSd2 ( $P < 0.05$ ), and Pro increased at HSd8 ( $P = 0.01$ ) compared with TN conditions. The EIL of the remainder AA was not affected by HS. Although HS increased the EIL of Arg and His within the first 2 d, it appears that normal EIL of AA is quickly reestablished. In summary, HS does not appear to affect the AA composition of intestinal endogenous proteins and suggest that the EIL of AA may not be critical in chronic HS pigs.

**Key Words:** pig, heat stress, endogenous amino acids loss

**W111 Effect of dietary fiber and a multicarbohydrase enzyme blend on net glucose and lactate fluxes, insulin production, and oxygen consumption by the portal-drained viscera and by the whole animal in growing pigs.**

Atta K. Agyekum<sup>1</sup>, Elijah Kiarie<sup>2,1</sup>, and Charles M. Nyachoti<sup>1</sup>, <sup>1</sup>*Department of Animal Science, University of Manitoba, Winnipeg, MB, Canada*, <sup>2</sup>*DuPont Industrial Biosciences, Marlborough, Wiltshire, UK*.

The objective was to determine the effects of supplementing a high-fiber (HF) diet with a multicarbohydrase enzyme (MC; 4000 units/g xylanase, 1000 units/g  $\alpha$ -amylase, 500 units/g protease, 150 units/g  $\beta$ -glucanase) on net portal fluxes of glucose and lactate, insulin production and oxygen consumption by the portal-drained viscera (PDV) and whole animal (WAOC) in growing pigs. Three isocaloric/nitrogenous diets based on corn and soybean meal (SBM) with either 0% (CTRL) or 30% distillers dried grains with solubles (DDGS; 1:1 corn and wheat mixture; HF) were used; the third diet was supplemented with MC in addition to the 30% DDGS (HF+MC). Five 22.8  $\pm$  1.6 kg gilts fitted with permanent catheters in the portal vein, ileal vein (to infuse para-amino hippuric acid to measure blood flow rate) and carotid artery were fed the 3 diets at 4% BW once daily at 0900 h for 7 d in a replicated 3  $\times$  3 Latin square design. On d 7, pigs were placed in an open-circuit indirect calorimeter to measure WAOC and sample blood for 7 h postprandial. Net glucose and insulin production were calculated from portal-arterial differences  $\times$  flow and PDV O<sub>2</sub> consumption was calculated as arterial-portal O<sub>2</sub> differences  $\times$  flow. Diet had no effect ( $P > 0.10$ ) on postprandial WAOC, flow rate, and lactate flux. Also, diet had no effect ( $P > 0.10$ ) on overall postprandial PDV O<sub>2</sub> consumption, but altered ( $P < 0.05$ ) postprandial PDV O<sub>2</sub> consumption from 240 to 360 min postprandial. Pigs fed CTRL had higher ( $P < 0.05$ ) portal insulin and glucose fluxes, from 90 to 300 min, and net glucose flux from 90 to 240 min postprandial. However, pigs fed CTRL and HF+MC had similar ( $P > 0.10$ ) postprandial net glucose flux, which was higher ( $P < 0.05$ ) than pigs fed HF. Therefore, it was concluded that adding MC to the HF diet improved net glucose portal flux in pigs.

**Key Words:** high-fiber diet, multicarbohydrase, net portal flux

**W112 Effect of a post-weaning diet supplemented with gut health-enhancing feed additives on ileum transcriptome activity and serum cytokines in piglets challenged with lipopolysaccharides (LPS).** Nathalie Bissonnette\*<sup>1</sup>, Xian-Ren Jiang<sup>1,4</sup>, Jacques J. Matte<sup>1</sup>, Guylaine Talbot<sup>1</sup>, Frédéric Guay<sup>2</sup>, Joshua Gong<sup>3</sup>, Qi Wang<sup>3</sup>, Valentino Bontempo<sup>4</sup>, and Martin Lessard<sup>1</sup>, <sup>1</sup>Dairy & Swine Research and Development Centre Agriculture and Agri-Food Canada, Sherbrooke, Quebec, Canada, <sup>2</sup>Département des Sciences Animales, Université Laval, Québec, Québec, Canada, <sup>3</sup>Guelph Food Research Centre, Agriculture and Agri-Food Canada, Guelph, Ontario, Canada, <sup>4</sup>Department of Health, Animal Science and Food Safety, University of Milan, Milan, Italy.

This study aimed to evaluate the impact of dietary feed additives with supplemental vitamins and trace minerals (DS) on the ileum and on systemic immune responses to a LPS challenge in low- (LW) and high-weight (HW) weaned piglets. At 20 ± 1 d of age (weaning), litters (12 piglet each) from 32 sows were randomly assigned to 4 dietary groups: control diet (CTL), CTL diet + chlortetracycline (ATB) or + DS, or DS + bovine colostrum instead of spray-dried animal plasma (DS-BC). Within each litter, 2 LW, 2 medium-weight (MW) and 2 HW piglets were identified. At 37 d, LW and HW piglets received intra-peritoneal LPS injection (200 µg). Piglets were bled before the injection (T0) and at slaughter, 4 h (T4; 1 LW and 1 HW) and 18 h (T18; 1 LW and 1 HW) post-injection. Microarray analysis was performed on LW, MW, and HW ileal tissues. The dietary feed treatments had no effect on the basal transcriptome level of the in MW piglets or on blood concentrations at T0 of tumor necrosis factor-α (TNF-α), IL-8, and IL-10. At T4, LW piglets secreted more TNF-α ( $P = 0.05$ ) and more (tendency) IL-8 ( $P = 0.11$ ) and IL-10 ( $P = 0.10$ ) than HW piglets. LPS altered the expression of 3,078 ileal genes with the false discovery rate (FDR) at 0.05.

There was no diet × LPS interaction on ileal gene expression on T4 vs T18 vs unchallenged MW piglets. However, a diet effect was observed on gene expression for LW piglets using fold change > 1.5 for the T4/MW ratio. Confirmed by QPCR, T4/MW in DS+BC ileal tissue of the apoptotic *CD163* gene was lower than in ATB's for LW piglets ( $P = 0.02$ ), whereas the corresponding effect in HW was a tendency ( $P = 0.07$ ). The T4/MW ratio of the acute phase (*SAA2* and *S100A12*), *SOD2*, and heat shock protein (*DNAJB1* and *HSP90AA1*) genes was also lower in DS than ATB ( $P < 0.05$ ) for LW piglets. The chemokine (*CXCL9*) T4/MW ratio was lower in both DS and DS+BC than ATB's ( $P < 0.02$ ) for LW and HW piglets. In conclusion, LW piglets developed a more pronounced inflammatory response than HW piglets and dietary feed additives supplemented with micronutrients attenuated the ileal gene response to LPS challenge.

**Key Words:** weaned swine feeding, gut health-enhancing feed additive, intestinal disease

**W113 Chitoooligosaccharide improves intestinal barrier function in the jejunum of weaning piglets.** Y. Yao\*, G. Tian, D. W. Chen, B. Yu, X. H. Song, J. Yu, P. Zheng, X. B. Mao, J. He, and Z. Q. Huang, *Animal Nutrition Institute, Sichuan Agricultural University, Chengdu, Sichuan, China.*

The recognition that chitoooligosaccharide (COS) possess potent anti-inflammatory, antioxidant and antimicrobial properties has prompted studies investigating its efficacy for animal growth and intestinal health. The objective of this study was to examine the effect of COS on growth and jejunal barrier function of weaning piglets. A total of 18 piglets (6.55 ± 0.32 kg) at 21 d of age, were randomly assigned to 1 of 3 groups (n = 6/group). Piglets in group 1 continued to be nursed by

sows, while piglets in groups 2 and 3 were weaned to a corn and soybean meal-based diet that was supplemented with 0 mL or 10 mL COS (5 ml/time, 2 times/d). At 28 d of age, growth performance, jejunal structure and epithelial integrity were examined. Data were analyzed by ANOVA procedure of SPSS. Differences between means were determined by using the Duncan multiple comparison method. The results indicated that final BW and ADG were markedly reduced in weaning piglets when compared with suckling piglets ( $P < 0.05$ ), while supplementation with COS restored ADFI, final BW and ADG in the weaned piglets ( $P < 0.05$ ). Weaning stress did not affect villous height but increased crypt depth and decreased the ration of villous height: crypt depth ( $P < 0.05$ ), whereas, this alteration can't be reversed by COS supplementation. Peripheral D-lactate concentration and diamine oxidase activities were not affected by weaning stress or COS supplementation. Weaning stress led to greater jejunal cell apoptosis index and sIgA content ( $P < 0.05$ ), and COS supplementation partially restored this changes ( $P < 0.05$ ). Jejunal gene abundance of occludin was not affected by weaning or COS supplementation, while the weaning-induced decrease in jejunal ZO1 ( $P < 0.05$ ) and ZO2 mRNA levels were elevated by COS supplementation ( $P < 0.05$ ). Collectively, our results support an important role of COS in regulating jejunal barrier function of weaning piglets.

**Key Words:** chitoooligosaccharide, weaning stress, piglet

**W114 Exogenous enzymes blend (DigeGrain Delta) improve growth performance and gut health of weaning pigs fed corn-soybean based diet in absence of antibiotic growth promoters.** Y. H. Kim<sup>1</sup>, S. L. Ingale\*<sup>2</sup>, P. C. Rath<sup>2</sup>, S. H. Lee<sup>1</sup>, and B. J. Chae<sup>1</sup>, <sup>1</sup>College of Animal Life Sciences, Kangwon National University, Chuncheon, Gangwon-do, Republic of Korea, <sup>2</sup>Advanced Enzyme Technologies Ltd., Thane, Maharashtra, India.

The present study investigated the effects of dietary supplementation of an exogenous enzyme blend (DigeGrain Delta; a blend of amylase, protease, β-mannanase, xylanase and phytase) on growth performance, apparent total-tract digestibility (ATTD) of nutrients, and gut health of weaning pigs. A total of 192 weaned piglets (Landrace × Yorkshire × Duroc, initial body weight: 7.3 ± 0.7 kg) were randomly allotted to 4 treatments on the basis of body weight (4 pens per treatment with 12 pigs in each pen). The dietary treatments included corn-SBM based basal diet supplemented with 0 (control), 0.025, 0.050, or 0.075% exogenous enzyme blend. The experimental diets were fed in a meal form for 2 phases (d 0–14, phase I and d 14–28, phase II). Pigs fed dietary increasing levels of enzyme blend had linear improvement ( $P < 0.05$ ) in overall (d 0–28) average daily gain (ADG), gain:feed (G:F), and ATTD of dry matter, gross energy, and crude protein. Also, overall ADG and G:F of pigs fed diets supplemented with 0.050 and 0.075% enzyme blend were greater ( $P < 0.05$ ) than pigs fed the control diet. The ATTD of Ca and P was tended to increase ( $P < 0.10$ ) with dietary increase in enzyme blend. At d 21, pigs fed dietary increasing levels of enzyme blend had greater (linear,  $P < 0.05$ ) *Lactobacillus* spp. (ileum and cecum) and fewer (linear,  $P < 0.05$ ) *Clostridium* spp. (ileum and cecum) and coliform (ileum) populations. On d 28, villus height of the jejunum and ileum were linearly increased ( $P < 0.05$ ) with dietary increase in enzyme blend. In addition, crypt depth (duodenum and ileum) and villus height: crypt depth (duodenum, jejunum and ileum) tended to increase (linear;  $P < 0.10$ ) with increase in dietary level of enzyme blend. Results obtained in the present study indicates that dietary supplementation of amylase, protease, β-mannanase, xylanase, and phytase blend had potential to improve the growth performance, ATTD of nutrients, and

gut health of weanling pigs fed a corn-SBM based diet in the absence of antibiotics growth promoters.

**Key Words:** exogenous enzyme blend, performance, weanling pig

**W115 Endoplasmic reticulum stress pathway is involved in weaning stress induced jejunum cell apoptosis in piglets.** Y. Yao\*, G. Tian, D. W. Chen, B. Yu, X. H. Song, J. Yu, P. Zheng, X. B. Mao, J. He, and Z. Q. Huang, *Animal Nutrition Institute, Sichuan Agricultural University, Chengdu, Sichuan, China.*

Unresolved endoplasmic reticulum (ER) stress can lead to cell apoptosis. We therefore tested the role of ER stress in intestinal epithelial barrier disruption in piglets post-weaning. A total of 24 piglets (21 d of age and  $6.52 \pm 0.29$  kg) from 4 litters were randomly continued to be nursed by sows (suckling piglets, 3 piglets/sow) or weaned to a corn and soybean meal-based diet. On d 3 and 7 post-weaning, blood and jejunum tissue were collected at necropsy. Thus, this produced 4 experimental groups (management/time) as suckling/3 d, suckling/7 d, weaning/3 d and weaning/7 d ( $n = 6$ /group). Data were analyzed by ANOVA procedure of SPSS including management, time, interaction between management and time as the main factors. Differences between means were determined by using the Duncan multiple comparison method. Weaning stress induced significant elevations in plasma cortisol level, D-lactate content and diamine oxidase (DAO) activity ( $P < 0.001$ ). Moreover, this management-related increase in blood index was higher in 3 d than in 7 d ( $P = 0.03$  for cortisol,  $P = 0.03$  for D-lactate and  $P = 0.02$  for DAO). Enterocyte apoptosis index in jejunum was increased in weaning piglets ( $P < 0.001$ ), this alteration was accompanied by increasing jejunal gene expression of caspase3 ( $P = 0.03$ ), without any difference between piglets at different time. Weaning stress did not affect Bcl-2 expression but decreased caspase9 expression ( $P = 0.04$ ). Meanwhile, weaning stress upregulated mRNA expression of fas and caspase8 that were related to death receptor signal ( $P = 0.03$  and  $P < 0.001$ ). Marked weaning modifications were also observed for gene expression of ER stress pathway (glucose regulated protein 78kDa, +16%,  $P = 0.02$ ; eukaryotic translation initiation factor 2-subunit 1  $\alpha$ , +17%,  $P = 0.02$ ; activating transcription factor 4, +16%,  $P = 0.002$ ; x-box binding protein1, -19%,  $P = 0.004$ ; ER degradation enhance- mannosidase  $\alpha$  like 2, -11%,  $P = 0.10$ ). However, most of these genes were not affected by time or interaction between management and time. In conclusion, weaning stress induced jejunal enterocyte apoptosis and barrier disruption possibly via regulation of ER stress pathway and death receptor signal.

**Key Words:** endoplasmic reticulum stress, weaning stress, apoptosis

**W116 The expression of genes encoding gastrointestinal enzymes, microbial populations, and volatile fatty acids in pigs differing in feed efficiency.** Stafford Vigors\*, Torres Sweeney, Cormac J. O'Shea, and John V. O'Doherty, *College of Agriculture, Food Science and Veterinary Medicine, Dublin, Ireland.*

The objective of this study was to examine the effect of divergent selection for feed efficiency using residual feed intake (RFI) as a model on nutrient digestibility, bacterial populations, enzyme gene expression and volatile fatty acid (VFA) production. Male pigs ( $n = 75$ ; initial BW 22.4 kg) were fed a standard finishing diet (9.21 g/kg of standard ileal digestible lysine and 14 MJ/kg digestible energy) for 43 d before slaughter to evaluate feed intake and growth for the purpose of calculating RFI. Phenotypic RFI was calculated as the residuals from a regression model regressing average daily feed intake (ADFI) on average daily gain (ADG) and mid-test metabolic BW0.75 (MWT). Data were

analyzed using the GLM procedure of SAS. Sixteen pigs (85 kg, SEM 2.84 kg), designated as high RFI (HRFI;  $n = 8$ ) and 8 low RFI (LRFI) were killed and digesta was collected from the cecum and colon to determine microbial populations and VFAs. Digesta was collected from the ileum and rectum to measure coefficient of apparent ileal (CAID) and total-tract nutrient digestibility (CATTD). Mucosal scrapings from the duodenum, jejunum and ileum were used for RNA extraction and subsequent analysis of mRNA expression of several enzymes using RT-PCR. As expected LRFI pigs had lower ADFI (2.44kg vs. 1.87kg, + 0.07) and improved feed conversion ratio (1.96 vs. 2.48, SEM 0.02) than HRFI pigs ( $P < 0.001$ ) with no difference in ADG or MWT. The LRFI pigs had improved CAID of GE ( $P < 0.05$ ). Similarly, LRFI pigs had improved CATTD of GE, while also having improved CATTD of nitrogen and dry matter ( $P < 0.05$ ). In the jejunum RFI was correlated ( $r = -0.46$ ;  $P < 0.10$ ) with the gene expression of the enzyme sucrase-isomaltase which is located in the intestinal brush border cells. In the colon HRFI pigs had increased concentration of acetic acid ( $P < 0.05$ ). In the cecum LRFI pigs had increased molar proportions of butyric acid ( $P < 0.10$ ). LRFI pigs had increased cecal lactobacillus ( $P < 0.05$ ) compared with HRFI pigs. In conclusion differences in GE digestibility, sucrase-isomaltase gene expression, and populations of lactobacillus may contribute to differences in feed efficiency between RFI groups.

**Key Words:** feed efficiency, pig, RFI

**W117 Diets containing flaxseed-meal and oat hulls modulate fat digestibility, production, and excretion of bile acids and neutral sterols in growing pigs.** Saymore P. Ndou\*<sup>1</sup>, Elijah Kiarie<sup>1,2</sup>, Sijo J. Thandapilly<sup>3</sup>, Nancy Ames<sup>3</sup>, and Charles M. Nyachoti<sup>1</sup>, <sup>1</sup>Department of Animal Science, University of Manitoba, Winnipeg, MB, Canada, <sup>2</sup>DuPont Industrial Biosciences-Danisco Animal Nutrition, Marlborough, Wiltshire, United Kingdom, <sup>3</sup>Richardson Centre for Functional Foods and Nutraceuticals, Agriculture and Agri-Food Canada, Winnipeg, MB, Canada.

Effects of dietary fiber type on fat digestibility, intestinal and fecal concentrations of bile acids and plant sterols were determined. Forty-eight Genesus [(Yorkshire-Landrace)  $\times$  Duroc] barrows ( $25.0 \pm 0.32$  kg BW) were housed in pairs and assigned to 3 diets; corn-soybean meal-based diet (control), 12% flaxseed meal (FM)- and 10% oat hulls (OH)-containing diets. All diets were replicated 8 times in a completely randomized design. Titanium oxide was added in the diets as an indigestible marker. Diets were formulated to be iso-energetic; FM and OH were used as sources of soluble and insoluble fiber, respectively. The analyzed dietary NDF content (% as fed) was 9.4, 18.0 and 18.7% in the control, FH and OH, respectively. After 28 d of ad libitum feeding, fecal samples were collected from each pen, and then pigs were slaughtered to sample ileal and cecal digesta for the assessment of fat, bile acids and sterols concentrations. Fat digestibility in pigs fed FM-based diets was 24% lower ( $P = 0.02$ ) than the control, whereas that of OH-based diets fed pigs was intermediate. The ileal deoxycholic acid concentrations in pigs fed OH- and FM-containing diets were increased ( $P < 0.01$ ) by 46.3% and 30.1%, respectively, compared with the control. In the cecal contents, the total bile acids concentration was increased ( $P < 0.01$ ) by 114 and 75% in pigs fed FM- and OH-containing diets, respectively. The total bile acids excreted in feces of pigs fed FM- and OH-rich diets were respectively 2.47- and 2.03-fold higher than in control fed pigs. Compared with the control, intestinal bioconversion of cholesterol (coprostanol: cholesterol) was enhanced more in pigs fed FM- and OH-containing diets ( $P = 0.05$ ). Pigs fed FM- and OH-containing diets had higher cecal ( $P < 0.01$ ) and fecal ( $P = 0.002$ ) cholesterol concentrations than control fed pigs. In summary, soluble fiber reduces fat digestibility

more than insoluble fiber, and malabsorption of fat can be attributed to deconjugation of bile acids.

**Key Words:** dietary fiber, fat digestibility, bile acids

**W118 The gut and vaginal microbiota profile of pregnant sows and their contribution to neonatal piglet gut microbiota development.** Alessi A. Kwawukume\*, Hein M. Tun, Martin C. Nyachoti, and Ehsan Khafipour, *University of Manitoba, Winnipeg, Manitoba, Canada.*

The establishment of an initial gut microbiota is identified as a critical stage in neonatal development and is believed to influence health throughout life. Neonates are believed to receive their first bacterial colonizers while passing through the birth canal, from the environment as well as from milk during suckling; however, the relationship between maternal microbiota and development of neonatal gut microbiota is not clearly understood. To establish the contribution of maternal microbiota (gut and vaginal) to neonatal gut microbiota development, swab samples were taken from the posterior and anterior vagina 4 d before expected farrowing in pregnant sows housed on concrete slatted floors (CSF) (n = 12) and on straw (ASF) (n = 15). Fecal samples were obtained from sows at the same time as vaginal sampling, and from 5 piglets born to each sow (n = 135 piglets) on d 0, 1 and 3 after birth. DNA was extracted and subjected to V3-V4 bacterial 16S rRNA Illumina sequencing. Firmicutes (46.5%) and Bacteroidetes (24.8%) dominated the vaginal bacterial community of pregnant sows while Proteobacteria were in low numbers (14.5%). Among Firmicutes, Clostridia (34.6%) were found to predominate while Lactobacilli (3.8%) were few. No differences in  $\beta$ -diversity ( $P = 0.447$ ) of bacterial communities were observed between the anterior and posterior vagina in sows from the 2 housing types. Firmicutes and Bacteroidetes dominated sows fecal microbiota (48.7% and 37.13% respectively) with relatively low numbers of Proteobacteria (0.9%). Fecal samples of piglets differed in percent composition during the first 3 d after birth. Proteobacteria were found to be predominant on d 0 (63.8%), Firmicutes on d 1 (55.2%), and Firmicutes and Bacteroidetes on d 3 (60.1% and 15.15% respectively). Although piglet fecal microbiota was significantly different from both sow vaginal, and fecal microbiota ( $P = 0.001$ ), the principal coordinate analysis showed a moving trend of piglet microbiota toward the sow vaginal microbiota as piglets grew from d 1 to d 3. Results indicate that maternal microbiota may contribute to piglet gut microbiota development.

**Key Words:** piglet, sow, vaginal and fecal microbiota

**W119 Enteral bile acids modulate intestinal immune response and gut microbiota in early-weaned piglets challenged with LPS.** Alessandro Mereu\*, Nuria de Diego-Cabero<sup>2</sup>, Jose Javier Pastor Porras<sup>1</sup>, David Menoyo<sup>2</sup>, and Ignacio Ipharraguerre<sup>3,1</sup>, <sup>1</sup>*Lucta SA, Montornés del Valles, Barcelona, Spain*, <sup>2</sup>*Departamento de Producción Animal, Universidad Politécnica de Madrid, ETS Ingenieros Agrónomos, Madrid, Spain*, <sup>3</sup>*Institute of Human Nutrition and Food Science, University of Kiel, Kiel, Germany.*

Bile acids (BA) have recently emerged as regulators of intestinal immune homeostasis and mucosal integrity. We examined the effects of administering enterally deoxycholic acid (DCA) to early-weaned pigs challenged with lipopolysaccharide (LPS) on gut BA profile, immune response and microbiota. Twenty-four piglets were weaned at 21 d, acclimatized for 14 d, and subsequently grouped (n = 8) to be intragastrically infused with either deionized water (C+, C-) or 15 mg of DCA·kg<sup>-1</sup> initial BW (DCA) daily during 14 d. On d 28, C+ and

DCA piglets were injected i.p. with 150  $\mu$ g LPS·kg<sup>-1</sup> BW. Three h later, all animals were bled and killed for organ measurement and sampling. Blood samples were analyzed for endotoxin (EDT), interleukin (IL)-6, and tumor necrosis factor  $\alpha$  (TNF- $\alpha$ ). Expression of occludin, IL-6 and IL-10 genes and the concentration of individual BA were measured in the ileal mucosa. Colonic microbiota was characterized by sequencing bacterial 16S ribosomal-RNA. Individual BW and feed intake were recorded weekly. Data were analyzed with a mixed-effects model in which pig was treated as random effect and treatment as fixed effect. Compared with C-, LPS decreased total BA concentration ( $P < 0.01$ ) and increased plasma TNF- $\alpha$  ( $P < 0.01$ ) and EDT ( $P < 0.02$ ) as well as hepatic ( $P < 0.01$ ) and intestinal ( $P < 0.03$ ) weight. Interestingly, DCA infusion increased the proportion of BA with the greatest ability to induce BA-signaling pathways ( $P < 0.05$ ), prevented alterations ( $P > 0.10$ ) in plasma EDT and intestinal weight, decreased expression of IL genes ( $P < 0.04$ ) in the ileum, and enhanced ( $P < 0.05$ ) feed intake. In addition, treating pigs with DCA increased ( $P < 0.05$ ) *Peptostreptococcaceae* and *Clostridiaceae* whereas decreased ( $P < 0.05$ ) *Lactobacillaceae* in the colon. In conclusion, DCA acted locally to prevent LPS-induced inflammation and barrier disruption of the intestinal mucosa. These effects were associated with changes in the intestinal BA signature.

**Key Words:** deoxycholic acid, bile acid signaling, gut permeability

**W120 Impact of xylanases on gut microbiome of growing pigs fed with corn-based and wheat-based diets.** H. M. Tun\*, R. Li<sup>1</sup>, E. Kiarie<sup>1,2</sup>, M. Nyachoti<sup>1</sup>, and E. Khafipour<sup>1</sup>, <sup>1</sup>*University of Manitoba, Winnipeg, MB, Canada*, <sup>2</sup>*DuPont Industrial Biosciences-Danisco Animal Nutrition, Marlborough, Wiltshire, UK.*

This study was carried out to assess the effects of exogenous xylanases on production performance and gastrointestinal microbiota of growing gilts fed corn-based or wheat-based diets. A total of 96 individually penned gilts (22.7  $\pm$  0.65 kg initial BW) were used in a CRD experiment with 2  $\times$  6 factorial arrangement and fed experimental diets for 42 d. Gilts (n = 8 per treatment) received one of the 2 basal diets: (a) corn with 40% corn distillers dried grains, or (b) wheat with 25% wheat co-products, each without or with one of the 5 xylanases (XA, XB, XC, XD and XE). Xylanases were supplemented at 75 mg/kg of feed and all diets contained phytase. All xylanases were produced by different fungal organisms, except for xylanase-C, which originated from bacteria. On d 42, all pigs were euthanized to obtain ileal and cecum digesta for microbiome analysis using pyrosequencing of V1-V3 regions of 16S rRNA and downstream bioinformatic analyses using QIIME. Spearman's correlation was used to correlate microbiome composition data with performance characteristics, apparent total-tract digestibility (ATTD), and colon digesta volatile fatty acids (VFA) concentration. The XA yielded the best growth performance in both corn and wheat based diets ( $P < 0.05$ ) when compared with other xylanases. Based on PERMANOVA analysis on UniFrac distances, XA significantly affected the  $\beta$ -diversity of ileum microbiota compared with other xylanases and controls ( $P < 0.05$ ). Furthermore, xylanases influenced ATTD and colonic digester volatile fatty acids diet dependently ( $P < 0.05$ ). The XA increased *Lactobacillus* species in the cecum in both diets, whereas other xylanases drastically decreased *Lactobacillus* species when compared with control ( $P < 0.05$ ). In the wheat-based diet with xylanases, cecal bacterial community composition changes significantly correlated with ATTD of DM ( $r = -0.5$ ), gross energy digestibility ( $r = -0.49$ ) and colon VFA concentrations ( $r = -0.67$ ) ( $P < 0.02$ ). However, in the corn-based diet with xylanases, ileal bacterial community changes correlated with ATTD of DM ( $r = -0.4$ ) and gross energy digestibility ( $r = -0.43$ ), whereas cecal bacterial community changes correlated with

ATTD of fat digestibility ( $r = -0.58$ ) and colon VFA concentration ( $r = -0.41$ ) ( $P < 0.03$ ).

**Key Words:** pig, xylanases, gut microbiome

**W121 Effects of sulfur amino acids to lysine ratio on the expression of selected genes from piglets challenged with enterotoxigenic *Escherichia coli* K88.** Roseline Kahindi\*<sup>1</sup>, Alemu Regassa<sup>1</sup>, John Htoo<sup>2</sup>, and Martin Nyachoti<sup>1</sup>, <sup>1</sup>University of Manitoba, Winnipeg, MB, Canada, <sup>2</sup>Evonik Industries AG.

The sulfur AA (SAA; methionine and cysteine):Lys ratio for protein accretion is 55% for 7 to 11 kg pigs (NRC, 2012). The use of SAA to support immunity in addition to accretion of lean tissue may exert additional requirements in immune stimulated pigs. Moreover, due to negative whole body protein balance resulting from muscle wasting during an immune challenge, performance responses may not be suitable response criteria for determining SAA requirements. A study was conducted to determine the standardized ileal digestible (SID) SAA:Lys ratio of weaned pigs under an enterotoxigenic *Escherichia coli* (ETEC) challenge using gene expressions of methionine adenosyltransferase 1 and 2- $\alpha$  (MAT1A and 2A), 5-methyltetrahydrofolate-homocysteine methyltransferase (MTR), and cystathionine  $\gamma$ -lyase (CTH) as response criteria. Thirty-five [Duroc  $\times$  Yorkshire  $\times$  Landrace], 7-kg piglets were assigned to 5 dietary treatments in a completely randomized design. The corn-wheat-soybean-meal based antibiotic-free diets had graded SID SAA:Lys ratios (48, 54, 60, 66, and 72%) and 1.18% SID Lys. Feed was offered at 4% BW and fed twice a day at 08.00 and 16.00 h. Piglets had a 6-d diet adaptation period and were all orally challenged with 6 and 15 mL of ciprofloxacin-resistant ETEC K88+ ( $5 \times 10^9$  cfu/mL) on d 7 and 10, respectively. Blood samples were collected before and after challenge. On d 13 all pigs were killed to collect liver and ileal tissues for gene expression of MAT1A and 2A, MTR, and CTH using quantitative real-time PCR. Serum TNF- $\alpha$  concentration 6 h after inoculation was higher ( $P < 0.05$ ) than pre-challenge and was improved with increasing SAA:Lys ratio. Data were subjected to ANOVA using Proc Mixed of SAS 9.2. Increasing SAA:Lys ratio linearly decreased ( $P < 0.01$ ) liver MTR, while quadratically increasing ( $P < 0.01$ ) CTH and MAT1A gene expression. Ileal expression of MTR and MAT2A linearly increased, whereas, CTH and MAT2A were quadratically increased ( $P < 0.05$ ) with increasing SAA:Lys ratio. Maximum transmethylation, transsulfuration, and remethylation was at SAA:Lys ratio of 60% indicating that this ratio was enough to support piglets during an immune challenge.

**Key Words:** pig, *Escherichia coli* K88, SAA:Lys ratio

**W122 Messenger ribonucleic acid abundance of intestinal enzymes and nutrient transporters in chickens fed with vitamin D<sub>3</sub> and 1,25-dihydroxycholecalciferol.** Cristiane R. A. Duarte\*, Alice E. Murakami, Ana F. Q. M. Guerra, and Iván C. Ospina-Rojas, Departamento de Zootecnia, Universidade Estadual de Maringá, Maringá, Paraná, Brazil.

Vitamin D plays an essential role in regulating the bone formation and mineral balance in chickens and it is also related to functional development of the small intestine in rats. This study compared the effects of cholecalciferol and 1,25-dihydroxycholecalciferol on gene expression of vitamin D receptor, intestinal enzymes and nutrient transporters in chickens in the starter phase (1 to 21 d). A total of 1,008 1-d-old male Cobb chicks were used, distributed in a completely randomized factorial design 2  $\times$  3 (2 sources of vitamin D<sub>3</sub>: D<sub>3</sub> and 1,25(OH)<sub>2</sub>D<sub>3</sub>  $\times$  3 levels: 200; 950; 1,700 IU/kg feed) with 6 replicates and 28 birds

each one. Relative mRNA abundance of vitamin D receptor (VDR), aminopeptidase N (APN), maltase, sucrase-isomaltase (SI) complex, vitamin D-1- $\alpha$ -hydroxylase, sodium/glucose cotransporter 1 (SGLT1), glucose transporter 2 (GLUT2), peptide transporter 1 (PEPT1), sodium/phosphate cotransporter type IIb (NaPi-IIb), plasma membrane Ca<sup>2+</sup> ATPase (PMCA-1b) were assayed using real-time PCR. All data were analyzed by SAS GLM and differences among means were separated using Tukey's multiple range tests. There was an interaction ( $P < 0.05$ ) between sources and levels of vitamin D<sub>3</sub> only for mRNA abundance of SI. The mRNA abundance of maltase, NaPi-IIb, PMCA-1b, PEPT1 and GLUT2 were higher ( $P < 0.05$ ) in jejunal mucosa of animals fed with vitamin D<sub>3</sub>, while the mRNA abundance of 1- $\alpha$ -hydroxylase and SGLT1 were lower ( $P < 0.05$ ) in these animals. The levels of vitamin D (independently of source) affected the mRNA abundance of 1- $\alpha$ -hydroxylase, PEPT1 and SGLT1. The mRNA abundance of 1- $\alpha$ -hydroxylase in jejunal mucosa of animals fed with 200 IU/kg feed of vitamin D was higher ( $P < 0.05$ ) compared with 950 IU/kg feed. The mRNA abundance of PEPT1 was higher ( $P < 0.05$ ) with 200 IU/kg feed of vitamin D compared with other levels, while the mRNA abundance of SGLT1 was higher ( $P < 0.05$ ) in animals fed with 200 IU/kg feed of vitamin D compared with 1,700 IU/kg feed. It can be concluded that vitamin D and 1,25(OH)<sub>2</sub>D<sub>3</sub> can differently influence the gene expression of intestinal enzymes and nutrient transporters in chicken.

**Key Words:** cholecalciferol, gene expression, intestine

**W123 Early supplementation of alfalfa to starter diets altered electrophysiological properties and permeability of the gastrointestinal tracts in growing lambs.** Bin Yang\*<sup>1</sup>, Shan-shan Wang<sup>1</sup>, Bo He<sup>1</sup>, Jian-xin Liu<sup>1,2</sup>, and Jia-kun Wang<sup>1</sup>, <sup>1</sup>Institute of Dairy Science, Hangzhou, Zhejiang, China, <sup>2</sup>Zhejiang University, Hangzhou, Zhejiang, China.

To investigate the effects of early supplementation of starter pellets with alfalfa in pre-weaning period on the permeability, expressions of tight junction (TJ) proteins and cytokines of gastrointestinal tract during the pre- and post-weaning period, 6 of 66 male Hu lambs at the age of 10 d were slaughtered as control, and the other 60 lambs were randomly allocated to 2 dietary treatments: milk replacer and starter pellets without (STA) or with free-choice provision of chopped alfalfa (S-ALF). The animals were offered 300-g/d concentrate mixture and had free access to alfalfa after weaning at the end of wk 4 (age of 38 d). The plasma concentrations of D-lactic acid, lipopolysaccharides, IgA, IgM and IgG were measured by ELISA kit (RB). Ruminal epithelium and duodenal mucosa were subjected to Ussing chamber to measure the transepithelial electrical resistance (TER) and conductance. The mRNA expressions of TJ proteins and cytokines of gastrointestinal tract were determined with qRT-PCR. Results were analyzed as a completely randomized design. All data were analyzed by 2-way ANOVA using PROC GLM SAS (version 9.2; SAS Institute Inc., Cary, NC). Data of TER and conductance showed that alfalfa supplementation increased or decreased permeability of ruminal epithelium and duodenal mucosa numerically in pre- or post-weaning period, respectively, while the plasma concentrations and the morphological appearance of duodenum were not different between 2 treatments ( $P > 0.05$ ). Compared with STA group, alfalfa supplementation increased ( $P = 0.057$ ) the ruminal occludin expression, enhanced ( $P < 0.01$ ) the duodenal expression of claudin-1, and numerically enhanced ileal expression of claudin-1 and claudin-4 during the pre-weaning period, and inhibited ( $P < 0.05$ ) the weaning-caused compensatory increase in ruminal epithelial expression of claudin-4. The change in ruminal expression of TNF- $\alpha$  with weaning was similar to claudin-4. In summary, early supplementation of alfalfa

to starter diet could maintain the normal function of the gastrointestinal barrier, and helped to release the stress from weaning and feed transition in growing lambs.

**Key Words:** alfalfa, weaning, gastrointestinal tract

**W124 Heat-treated colostrum feeding promotes beneficial bacteria colonization in the small intestine of neonatal calves.** Nilusha Malmuthuge\*, Guanxiang Liang, Yanhong Chen, Laksiri Goonewardene, and Le L. Guan, *University of Alberta, Edmonton, AB, Canada.*

The feeding of heat-treated colostrum is a common practice to increase passive transfer of immunity and decrease enteric infections in calves. However, its influence on gut microbial colonization has not been well studied. The present study investigated the effect of heat-treated colostrum feeding on the bacterial colonization in calf small intestine, within the first 12 h of life. Newborn Holstein bull calves (n = 32) were removed from dams and fed with either fresh colostrum (FC, n = 12) or heat-treated colostrum (HC, n = 12) soon after birth, while the control (NC, n = 8) group did not receive colostrum. Small intestinal samples (tissue and contents) were collected from proximal jejunum, distal jejunum and ileum at 6 and 12 h after birth, following euthanasia.

Quantitative real time PCR was used to explore the colonization of total bacteria, lactobacilli, and bifidobacteria. The feeding of colostrum soon after birth increased total bacteria density (FC- $1.4 \pm 0.7 \times 10^{10}$  16S rRNA copy/g of sample, HC- $9.8 \pm 3.4 \times 10^9$  16S rRNA copy/g of sample) in calf gut within the first 12 h compared with NC ( $5.3 \pm 2.2 \times 10^8$  16S rRNA copy/g of sample). Although there were bacteria in FC ( $1.8 \times 10^3$  16S rRNA gene copy/mL), bacteria were not detectable in HC. In contrast, the prevalence of lactobacilli was lower in HC ( $0.007 \pm 0.004\%$ ) and FC ( $0.014 \pm 0.008\%$ ), comparing to NC ( $0.031 \pm 0.015\%$ ). Remarkable changes in the prevalence of small intestinal tissue-attached bifidobacteria were observed with the feeding of HC soon after birth, but not that in gut contents. The prevalence of bifidobacteria was 3.2-fold and 5.2-fold higher in HC ( $28.6 \pm 10.3\%$ ) than FC ( $8.9 \pm 2.5\%$ ) and NC ( $5.5 \pm 1.5\%$ ), respectively, at 6 h. The feeding of FC increased the prevalence of tissue-attached bifidobacteria gradually, reaching to that of HC at 12 h. Thus, the present study suggests that feeding of HC enhances the colonization of bifidobacteria on small intestinal tissue immediately postpartum compared with that of FC and NC, which may prevent the colonization of enteric pathogens, and thereby decrease enteric infections in neonatal calves.

**Key Words:** newborn calves, gut colonization, bifidobacteria