

SWINE SPECIES

1730 Probiotic treatment using *Bacillus subtilis* PB6 improves the growth performance, intestinal morphology, enzyme activities and barrier function in low birth weight piglets. L. Hu, L. Che**, X. Peng, Q. Xu, Z. Fang, S. Xu, Y. Lin, and D. Wu, *Institute of Animal Nutrition, Sichuan Agricultural University, Chengdu, China.*

This study aimed to investigate the effects of *Bacillus subtilis* PB6 supplementation in milk formula on growth performance, intestinal development, and immune function in low birth weight (LBW) piglets. Piglets with a birth weight near the mean litter birth weight (SD 0.5) were identified as normal birth weight (NBW), whereas those with at least 1.5 SD lower birth weight were defined as LBW. Fourteen pairs of NBW and LBW piglets (7 d old) were randomly assigned to receive the formula milk or formula milk with *Bacillus subtilis* PB6 for a period of 21 d. At Day 28, blood samples, intestinal tissues, and digesta were collected at necropsy and analyzed for morphology, digestive enzyme activities, immune cells, gene, and protein expressions as well as microbial population. Data were analyzed by SPSS software using the MIXED procedure. Regardless of the diet, LBW decreased the average daily dry matter intake (-31% , $P < 0.001$) and the average daily growth (-28% , $P < 0.001$). Moreover, LBW decreased plasma concentration of immunoglobulin A (-17% , $P < 0.001$), interleukin- 1β (-12% , $P = 0.006$), the count (-33% , $P = 0.021$) and percentage (-13% , $P = 0.025$) of blood lymphocytes compared to NBW piglets. LBW decreased the villous height (-8% , $P = 0.039$) and enzyme activity of maltase (-24% , $P = 0.011$), as well as the mRNA abundances of *Toll-like receptor 9* (-34% , $P = 0.020$) and *Toll-interacting protein* (-21% , $P = 0.001$) in ileum. Regardless of body weight, the supplementation of *Bacillus subtilis* PB6 markedly decreased the feed:gain ratio (-10% , $P = 0.034$), which could be related to the better intestinal morphology, increased enzyme activities of maltase ($+19\%$, $P = 0.082$) and sucrase ($+23\%$, $P = 0.095$) in jejunum. Moreover, the protein abundances of *Zonula occludens-1* and *Claudin-1* ($+33\sim 54\%$, $P < 0.05$) in ileum, as well as the copy number of *Bacillus* ($P = 0.01$) in colonic digesta were increased in piglets supplemented with *Bacillus subtilis* PB6 relative to piglets with control diet. Our results indicated that LBW impaired the growth and intestinal development as well as immunity of piglets, however, dietary supplementation of *Bacillus subtilis* PB6 improved the growth performance with better intestinal development and barrier function in both NBW and LBW piglets.

Key Words: immunity, low birth weight, probiotic

1731 Dietary nucleotides supplementation improves the intestinal development and immune function of low birth weight piglets. L. Hu, L. Che**, X. Peng, Q. Xu, Z. Fang, S. Xu, Y. Lin, and D. Wu, *Institute of Animal Nutrition, Sichuan Agricultural University, Chengdu, China.*

This study aimed to determine whether dietary nucleotides supplementation could improve growth performance, intestinal development, and immune function of low birth weight (LBW) piglets. Piglets with a birth weight near the mean litter birth weight (SD 0.5) were identified as normal birth weight (NBW), whereas those with at least 1.5 SD lower birth weight were defined as LBW. Fourteen pairs of NBW and LBW piglets (7 d old) were randomly assigned to receive a liquid milk-based control diet (CON diet) or diet supplemented with nucleotides (NT diet) for a period of 21 d. NT diet was formulated by adding 0.74% nucleotides in CON diet, the pattern of nucleotides (5'-AMP, CMP, GMP, IMP, UMP) was similar as that in sow milk. Data were analyzed by SPSS software using the MIXED procedure. Compared with NBW piglets, LBW piglets had significantly lower average daily dry matter intake ($P = 0.001$) and average daily gain ($P < 0.001$). Moreover, LBW decreased the villous height ($P = 0.008$) and villi: crypt ratio ($P = 0.014$) in duodenum, as well as maltase ($P = 0.033$) activity in jejunum. In addition, LBW decreased the serum concentrations of immunoglobulin A ($P < 0.001$), interleukin- 1β ($P = 0.017$) and interleukin-10 ($P = 0.008$), as well as the percentage of peripheral lymphocytes ($P = 0.015$). Meanwhile, the downregulation of innate immunity-related genes such as *Toll-interacting protein* (TOLLIP) ($P = 0.012$) and *Toll-like receptor* (TLR) 2 ($P = 0.073$) was observed in the ileum of LBW relative to NBW piglets. Regardless of birth weight, however, feeding NT diet decreased ($P = 0.001$) the feed:gain ratio, increased villous height in duodenum ($P = 0.036$), activities of lactase ($P = 0.019$) and maltase ($P = 0.055$) in jejunum, also increased count of peripheral leukocytes ($P = 0.039$), serum concentrations of immunoglobulin A ($P = 0.001$), and interleukin- 1β ($P = 0.019$) as well as gene expressions of *TLR-9*, *TLR-4*, and *TOLLIP* (all $P < 0.05$) in ileum. In addition, the protein expressions of *Claudin-1* and *Zonula occludens-1* ($P < 0.05$) in ileum were markedly increased by feeding NT diet relative to CON diet. Our results indicated that LBW impaired the growth performance, intestinal and immune function, but dietary supplementation of nucleotides improved the growth performance, digestive capability, and immunity.

Key Words: immunity, low birth weight, nucleotides

1732 Effect of supplemented mineral phosphorus and fermentable substrates on gut microbiota composition and metabolites, phytate hydrolysis, and health status of growing pigs. C. M. E. Heyer*, S. Schmucker, E. Weiss, M. Eklund, T. Aumiller, E. Graeter, T. Hofmann, M. Rodehutschord, L. E. Hoelzle, J. Seifert, V. Stefanski, and R. Mosenthin, *University of Hohenheim, Institute of Animal Science, Stuttgart, Germany.*

The present study examined the impact of diets with varying CaP levels and fermentable substrates on intestinal CaP concentration, phytate (*myo*-inositol hexakisphosphate, InsP₆) hydrolysis, the intestinal microbiota, and the immune system in pigs. In 2 consecutive experiments, 31 growing pigs (55 ± 4 kg) were allotted to a 2 × 2 factorial arrangement with 4 treatment groups, and were fed either a corn-soybean meal or a corn-pea based diet with differences in digestibility, each with 2 different CaP levels (low vs. high, supplemented with monocalcium phosphate). After 3 wks of adaptation to the diets, all pigs were immunized twice with keyhole limpet hemocyanin (KLH) (wk 4 and 6) and blood samples were taken 2 wks after the second immunization. In wk 8, the amount of anti-KLH IgG and anti-KLH IgM were analyzed in blood samples. After slaughtering in wk 9, jejunal and cecal digesta were analyzed for Ca, P, and inositol phosphate isomers, determination of 16S rRNA gene copy numbers by qPCR and bacterial metabolite analyses. Pigs fed the low-CaP diets showed lower plasma anti-KLH IgG concentrations ($P < 0.05$). The low-CaP level promoted jejunal *Bifidobacterium* spp. ($P < 0.01$). For the pea diets, jejunal *Lactobacillus* spp. were lower ($P < 0.05$). In the cecum, *Eubacterium rectale* and *Roseburia* spp. ($P < 0.05$) were lower for the low-CaP diets. For the pea diets, the caecal *Eubacterium rectale* and *Bifidobacterium* spp. ($P < 0.05$) were lower. In the cecum, total SCFA, acetate, and propionate ($P < 0.01$) were lower for the low-CaP diets. Acetate and butyrate ($P < 0.05$) in caecal digesta were lower for the pea diets. The P net absorption in the jejunum and cecum was lower ($P < 0.01$) for the low-CaP diets. In addition, the InsP₆ hydrolysis in digesta samples was not affected by the dietary treatment, nevertheless the InsP₆ concentration in the jejunum was lower for the pea ($P < 0.05$) and low-CaP diets ($P < 0.05$). In conclusion, the present study demonstrated that CaP and fermentable substrates modulate the adaptive immune response and the intestinal microbiota, and sufficiently high amounts of CaP may be required to support the adaptive immune response, beneficial saccharolytic bacteria and SCFA production. It needs to be further elucidated whether variations in P digestion and/or absorption might explain the complex relationship between P, the immune system, and the microbial ecosystem.

Key Words: immune system, intestinal microbiota, phosphorus, pig

1733 Sexual development and boar taint in male pigs selected for divergent residual feed intake. A. Prunier¹, S. Parois¹, N. Le Floc¹, and H. Gilbert², ¹PEGASE, *Agrocampus Ouest, INRA, Saint-Gilles, France*, ²GenPhySe, *Université de Toulouse, INRA, INPT, INPT-ENV, Castanet-Tolosan, France.*

Improving feed efficiency and rearing entire male pigs are relevant strategies to reduce feed cost and environmental waste in pig production. The major constraint for rearing entire male pigs being boar taint, an experiment was performed to determine the consequences of a divergent selection on residual feed intake (RFI: low RFI = LRFI; high RFI = HRFI) on pubertal development, and boar taint. Forty-one purebred French Large White male pigs in the course of a divergent selection experiment for RFI (10th generation of selection, $n = 20$ or 21 per line) were recruited. Blood samples were drawn at 125, 140, 154, and 168 ± 1 d of age (mean ± SD) for plasma estradiol (E2) and testosterone (T) determination by EIA. At slaughter at 177 ± 4 d of age (108 ± 14 kg live-weight), a backfat sample was collected in the neck for androsthenone and skatole determination by HPLC and genital tract was removed for testes and Cowper gland weighing after tissue trimming. All data were analyzed by ANOVA using R, including line as a fixed effect. Plasma E2 and T were log transformed for normalization and analyzed using a repeated in time model with nlme. Fat androsthenone and skatole were analyzed using a generalized mixed model with lme4. Other data were analyzed using lm. Growth rate, age, and live-weight did not differ between lines ($P > 0.1$). Testes weight was similar in both lines (LRFI: 527 ± 23 g; HRFI: 471 ± 33 g, $P > 0.1$) whereas Cowper glands were heavier in LRFI pigs (176 ± 10 g vs. 100 ± 8 g). Fat androsthenone (1.97 ± 0.31 vs. 0.56 ± 0.08 µg/g pure fat) and skatole (0.14 ± 0.02 vs. 0.05 ± 0.01 µg/g pure fat) were also higher in LRFI pigs ($P < 0.001$). The interaction age × line for E2 and T was not significant ($P > 0.1$). Across ages, plasma T (5.0 ± 0.9 vs. 2.7 ± 0.7 ng/mL plasma) and E (25.5 ± 2.9 vs. 11.4 ± 1.0 pg/mL plasma) were also higher in LRFI than in HRFI pigs ($P < 0.001$). In both lines, both hormones increased with age ($P < 0.001$). Overall, these data suggest a lower testicular activity in the HRFI than in the LRFI line which is positive for meat quality but may be detrimental to the reproductive function in the HRFI line.

Key Words: androsthenone, boar, estradiol, feed efficiency, testosterone

1734 Effects of dietary live yeast supplementation on growth and immunological parameters of weaned piglets challenged with *Escherichia coli* K88.

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This study aimed to investigate the effects of dietary live yeast (*Saccharomyces cerevisiae*, Phileo Lesaffre Animal Care, France) supplementation on growth performance and immunological parameters of piglets challenged with enterotoxigenic *Escherichia coli* K88. A total of 180 weaned piglets (6.39 ± 0.05 kg) were randomly allocated into 5 treatments with 6 pens and 6 piglets (3 barrows and 3 gilts) per pen, receiving the control (CON) diet, diets supplemented with antibiotics plus ZnO (ABT-ZnO:2250 mg/kg of ZnO, 20 mg/kg Colistin and 75 mg/kg Aureomycin), live yeast at 1 (LY1), 2.5 (LY2.5), or 5 g/kg (LY5) for a period of 2 wk. On Day 8, six piglets from CON group received sterilized Luria Broth as control ($n = 6$), while another 30 piglets from CON ($n = 6$), antibiotic plus ZnO ($n = 6$), LY1 ($n = 6$), LY2.5 ($n = 6$), and LY5 ($n = 6$) groups, were orally challenged with Luria Broth containing 1×10^{11} cfu of *E. Coli* K88. Body weights and pen feed disappearance were recorded weekly to determine ADG, ADFI, and F:G. On d 10, blood, ileum, and mesenteric lymph node (MLN) tissue samples were collected at necropsy and analyzed for immunological parameters. Data were analyzed by SPSS software using the GLM procedure. Pigs fed ABT-ZnO diet had higher ($P < 0.05$) ADG and ADFI than pigs fed CON, LY1, and LY5 diets during the first week, while ADFI and F:G were similar between pigs fed ABT-ZnO and LY2.5 diets. Moreover, the ADG of pigs fed LY1 diet was similar to pigs fed ABT-ZnO diet during the second week. Compared with the pigs fed ABT-ZnO diet and non-challenged pigs, pigs fed LY2.5 and LY5 diets had higher ($P < 0.05$) plasma concentration of immunoglobulin G. Relative to the non-challenged pigs, moreover, the plasma concentration of Pig Major Acute Phase Protein (PMAPP) was increased ($P < 0.05$) in the challenged pigs fed CON diet, but PMAPP had not been markedly affected in the pigs previously fed ABT-ZnO and LY5 diets. Relative to the non-challenged pigs, *E. coli* K88 challenge up-regulated ($P < 0.05$) the mRNA abundances of toll-like receptor 4 (TLR-4), toll-like receptor 9 (TLR-9), myeloid differentiation factor 88 (MyD88), tumor necrosis factor receptor-associated factor 6 (TRAF-6), and interleukin-6 (IL-6) in ileum, however, those genes were downregulated by feeding LY5 diet. In conclusion, pigs fed live yeast diet had similar ADFI and F:G as pigs fed ABT-ZnO diet during the first week, the higher inclusion of live yeast could improve immunological parameters of piglets challenged with *E. coli* K88.

Key Words: immunity, intestine, live yeast

1735 Assessment of the age of lesions on the pig carcass at the abattoir through spectrophotometric color assessment and gene expression analysis.

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The presence of skin lesions downgrades carcass value and indicates poor animal welfare preslaughter. The aim of this study was to assess the age of lesions on the carcass at slaughter through spectrophotometric color assessment and gene expression of the following genes involved in tissue inflammation and repair: CCL2, IL6, ITGA3, MMP1, and SERPINE1. A total of 96 barrows (100 ± 10kg), allotted into 8 pens of 12 pigs each, were used. Over a three day period, each pig was mixed four times: in the finishing pen 2 d before slaughter, at loading, and in the lairage pen at the abattoir. Fighting- and mounting-type lesions were selected through visual assessment and video validation. Twenty lesions and control skins (with no lesions) per age group (total of 80 lesions and control skins) were selected, with each group consisting of 1, 4, 24, and 48 h old lesions. Data and skin samples were collected at the abattoir. For gene expression analysis, a skin biopsy of 4 mm was taken on each lesion and control skin at bleeding. After extraction, RNA was analyzed by qPCR to evaluate gene expression involved in tissue inflammation and repair. In the cooler, the color of each lesions and control skin was assessed through Minolta spectrophotometer. Delta values for each lesion were calculated between color and gene expression values obtained from the lesioned and control skin. Statistical analyses were performed using the mixing procedure of SAS, with log transformation applied to gene expression data. The time of infliction had an effect on Minolta L* and a* values ($P < 0.01$ for both), with 1 h old lesions being darker (higher-DL* value) than 4 and 24–48 h old ones ($P < 0.05$) and redder (higher Da* value; $P < 0.01$) than 24–48 h old lesions. The different lesions age resulted in a different expression of CCL2 and IL6 cytokines ($P < 0.001$), and other genes involved in tissue repair and remodeling (MMP1, ITGA3, SERPINE1) whose genetic expression was greater ($P < 0.01$) in 1 h old lesions compared with 24–48 h old ones. Furthermore, when compared with 4 h old lesions, 1 h old lesions presented a greater expression of CCL2 and ITGA3 ($P < 0.01$), and MMP1 ($P < 0.05$). To conclude, the spectrophotometric color assessment and the analysis of inflammatory and tissue repair gene expression in the carcass lesions at slaughter may be reliable methods to discriminate between fresh and older lesions at the abattoir.

Key Words: age, pigs, skin lesions

1736 Blood plasma replacement by hydrolyzed yeast in weaned piglets' diets. J. A. Rivera*¹, L. F. Araújo², R. L. D. C. Barbalho³, M. A. Bonato³, L. A. Vitagliano⁴, G. D. Santos³, and M. L. Cuadros⁵, ¹Faculdade de Medicina Veterinária e Zootecnia–VNP/FMVZ/USP, Pirassununga, Brazil, ²University of Sao Paulo, Pirassununga, Brazil, ³ICC Brazil, Sao Paulo, Brazil, ⁴Universidade de São Paulo, Pirassununga, Brazil, ⁵Veterinary Medical, Universidad Peruana Cayetano Heredia, Lima, Peru.

The aim of this study was to evaluate partial levels or complete substitution of blood plasma by hydrolyzed yeast as a source of nucleotides in piglets' diets. For this, 1600 weaned piglets (± 21 d of age) Agrocere PIC® distributed in a randomized block design with 4 treatments and 10 replicates of 40 animals each. The nursery phase was divided in four: pre-initial I: 22 to 28 d; pre-initial II: 29 to 35 d; initial I: 36 to 47 d; and initial II: 48 to 63 d. The treatments consisted of different inclusions of plasma and hydrolyzed yeast (*Saccharomyces cerevisiae*) [HY] (Hilyses®-from ICC Brazil Company): 1- Control–conventional diet provided at the farm, with normal levels of plasma (6, 4, 2, and 0% in the respective phases); 2- Diet with plasma reduction (3, 2, 1, 0) + HY (4, 3, 2, and 0%); 3- Diet with plasma reduction (1.5, 1, 0.5 and 0%) + HY (6, 4.5, 3, and 0%); 4- Diet without plasma + HY (8, 6, 4, and 0%). The piglets begin receiving the experimental diets after weaning until the end of this phase (± 66 d). The feed intake (FI) and body weight were measured at the end of each phase. Based on this, FI (g/d), body weight gain (BWG, g/d) and feed conversion ratio (FCR, g/g) were calculated. Mortality were daily observed and noted. Data obtained were analyzed with GLM (SAS) procedure and means were compared by Tukey test ($P = 0.05$). In phase pre-initial 1 the control treatment (no replacement) resulted in better ($P < 0.05$) FI and BWG, when compared to other treatments. However, during phase pre-initial 2, treatments with the larger proportion of HY (3 and 4) showed an increase ($P < 0.05$) in FI (26.3 and 13.7%, respectively); in phase initial 1, improved ($P < 0.05$) BWG (30.8%, for both treatments) and FCR (-17.4 and -17.3% , respectively). Considering the total period, the treatment 3 improved numerically (not statistically) FI (4.1%), BWG (8%), FCR (-2.3%), and mortality (-83.3%). The analysis of the data allow us to conclude that, in commercial farm conditions, the replacement of blood plasma by hydrolyzed yeast as a source of nucleotides is a viable alternative, and may even improve FI, BWG, FCR, and mortality.

Key Words: nucleotides, nursery, nutrition, *Saccharomyces cerevisiae*

1737 Effects of dietary energy on muscle growth of low birth weight neonatal pigs. Y. Chen*, S. R. McCauley, K. R. Oliver, R. P. Rhoads, and S. W. El-Kadi, Virginia Tech, Blacksburg.

Increasing the efficiency of nutrient utilization in farm animals remains one of the most important means to increasing profitability. It is well documented that increasing energy intake increases insulin-like growth factor I (IGF-I) concentration in animals. In addition, our previous data suggest that IGF-I signaling is compromised in muscle of low birth weight (LBWT) compared to normal birth weight (NBWT) neonatal pigs. We hypothesized that LBWT pigs have a higher energy requirement compared to their NBWT siblings. Twelve pairs of 7-d old, sex matched LBWT (1.73 ± 0.24 kg) and NBWT (2.42 ± 0.29 kg) pigs from the same litters were used. Pigs were fed either a low (LE) or high energy (HE) isonitrogenous diets, that contained 80 or 100% of NRC metabolizable energy requirement for 14 d. Body composition was determined by dual energy X-ray absorptiometry before and 13 d after initiation of feeding. On the last day of the study, pigs were euthanized to collect blood, and weigh and sample muscles. Plasma IGF-I concentration was measured using a commercial ELISA kit, and muscle mRNA expression by real-time PCR. Body weight was lower for LBWT than NBWT pigs throughout the study ($P \leq 0.05$). Lean and fat deposition increased with feeding in both LBWT and NBWT pigs, but was lower in LBWT compared with their NBWT littermates ($P \leq 0.05$). Longissimus dorsi (LD), gastrocnemius, semitendinosus and soleus muscle weights were lower in LBWT compared to NBWT pigs ($P \leq 0.05$). However, there was no effect of diet energy content on body composition and muscle weights. Plasma IGF-I concentration in LBWT pigs was lower than NBWT when pigs were fed LE diet, but increased to similar level as the NBWT group when pigs were fed the HE diet ($P \leq 0.05$). Gene expression of IGF-I, IGF-I receptor, and IGF binding protein 3 and 5 were lower in the LD muscle of LBWT compared with NBWT pigs fed the LE diet, while the mRNA abundance of these proteins was similar in LBWT and NBWT pigs fed the HE diet ($P \leq 0.05$). These results suggest that although increasing dietary energy content increased plasma IGF-I concentration and muscle mRNA expression of IGF-I and IGF binding protein 3 and 5 in LBWT pigs, the increase in growth was only modest indicating that other macronutrients may be limiting growth.

Key Words: dietary energy, LBWT, muscle growth

1738 Prediction of the concentration of androstenone in backfat from boar carcasses using indicators of sexual development. A. Prunier¹, S. Parois¹, A. Faouën¹, and C. Larzul², ¹PEGASE, *Agrocampus Ouest, INRA, Saint-Gilles, France*, ²GenPhyse, *Université de Toulouse, INRA, INPT, INPT-ENV, Castanet-Tolosan, France*.

Predicting fat androstenone concentration using a rapid and cheap method applied to live pigs is needed for efficient genetic selection against boar taint. Piétrain x (Large White x Landrace) boars were slaughtered either at 119 ± 4 kg live weight and 168 ± 1 d of age (S1, $n = 48$) or at 116 ± 4 kg and 174 ± 1 d of age (S2, $n = 42$). Blood and saliva samples were collected on D 0 (S1: 29 d, S2: 35 d before slaughter) and D 27 (S1: 2 d, S2: 8 d before slaughter) to measure plasma concentrations of estradiol and testosterone and salivary concentration of estrone by EIA. A backfat sample was collected on live pigs by biopsy on D 27 and on carcasses at slaughter to measure concentration of androstenone by HPLC. Testes and Cowper glands were weighed at slaughter after tissue trimming. Data were analyzed using the R MASS package. When necessary, variables were log or square root transformed for normalization. Predictive models of fat androstenone at slaughter were established with the modlin function. Plasma estradiol and fat androstenone on D 27, taken separately, were good predictors of fat androstenone at slaughter (mean R^2 between measured and predicted values was 0.48 and 0.43, respectively for each predictor) in S1 pigs. The quality of the prediction decreased between S1 and S2 pigs despite inclusion of salivary estrone in the equation with estradiol. To conclude, plasma estradiol can be considered as a good predictor of fat androstenone at slaughter if the delay between blood collection and slaughter is short.

Key Words: estradiol, estrone, genital tract

1739 Effects of dietary ramie (*Boehmeria nivea*) powder at different levels on carcass traits, muscle fiber characteristics, and muscular free amino acid profile of Chinese indigenous finishing pigs. Y. Tang*, *Institute of Subtropical Agriculture, Chinese Academy of Sciences, Changsha, China*.

The experiment was conducted to investigate the effects of containing different levels of ramie powder in finishing pig diets on carcass traits, muscle fiber characteristics, and muscular free amino acid (FAA) profile. A total of 150 Xiangcun Black pigs, a Chinese local breed, with initial body weight (70.71 ± 1.21 kg) were used in a 50-d feeding study. Pigs were randomly allotted to 1 of 5 isonitrogenous and isoenergetic diets (corn-soybean meal-based) containing 0, 3, 6, 9, or 12% ramie. There are 6 replicate pens per treatment with 5 pigs per pen. On d 50, a subsample of 40 pigs (8 pigs per treatment) was harvested and carcass traits were calculated.

Measurements of diameter and density of myofibers in longissimus dorsi muscle (LM) were taken. Muscle samples including LM and biceps femoris muscle (BM) were analyzed for myosin heavy chain (MyHC) mRNA expression level and FAA profile. The data were analyzed by SPSS 18.0 software with ANOVA analysis. Polynomial contrasts were performed to determine linear and quadratic effects. The level of $P < 0.05$ was the criterion for statistical significance. Overall, increasing dietary ramie reduced (linear, $P < 0.05$; 34.09 to 25.02 mm) the backfat thickness and increased (linear, $P < 0.05$; 23.46 to 32.38 cm²) the loin-eye area of the finishing pigs. A quadratic effect of MyHC IIB mRNA expression level in the LM was also observed as the dietary ramie added ($P < 0.05$), and the lowest value (0.77) was noted in 9% ramie group, along with the increased ($P < 0.05$) density of myofibers with a quadratic effect, but diameter of myofibers in the LM was linearly reduced ($P < 0.05$, 74.06 to 67.07 μ m). Inclusion of ramie powder in the diet could up-regulate MyHC I mRNA expression level in the BM (quadratic, $P < 0.05$), with the highest point (1.77) in 9% ramie group. In addition, increasing dietary ramie linearly lowered ($P < 0.05$) the contents of essential amino acid (EAA) and total amino acid (TAA) in the LM, while linearly heightened ($P < 0.05$) both contents in the BM. In conclusion, these results suggested that ramie is an effective and unconventional feed crop to improve carcass traits and muscle fiber characteristics, and the underlying mechanism may be partly due to the alteration in MyHC gene expression levels and muscular FAA profile induced by dietary ramie.

Key Words: carcass trait, finishing pig, free amino acid, myofiber, ramie

1740 Effects of different sources and routes of administration of copper and vitamins A and D on gut volatile fatty acids and gene expression involved in regulation of innate and acquired immunity in piglets. L. Lo Verso^{*1}, J. J. Matte¹, G. Talbot¹, J. Lapointe¹, N. Bissonnette¹, F. Guay², N. Gagnon¹, B. Ouattara¹, and M. Lessard¹, ¹*Agriculture and Agri-Food Canada, Sherbrooke Research and Development Centre, Sherbrooke, Canada*, ²*Université Laval, Québec City, Canada*.

Placental and colostral transfers of copper and vitamins A and D are limited in pig species (Matte et al., 2014, JAS 92-Suppl. 2:153). Because these micronutrients can influence intestinal microbiota and development of immunocompetence, the aim of the study was to evaluate the influence of different neonatal supplementation strategies on volatile fatty acid (VFA) concentration, pH, and modulation of cytokine gene expression in piglets' gut. Within each litter from 5 sows, 10 newborn piglets were allocated to one of the following combinations of sources and routes of micronutrient administrations: oral vitamin D₃, retinol-acetate and CuSO₄ (T1); oral

25-OH-D3, β -carotene and Cu-yeast (T2); exposure to UVB light (20 min every second day), oral retinol-palmitate and Cu-gluconate (T3); intramuscular vitamin D3 and retinol-propionate and oral Cu-acetate (T4); oral saline (CTL). Oral or intramuscular provisions corresponded to 12 mg of copper and 70 and 12 MIU of vitamins A and D, respectively. This design was repeated with 5 other sows fed daily supplements of 25-OH-D3 (4 MIU), β -carotene (24 MIU), and Cu-yeast (45 mg) from 90 d of gestation to 21 d of lactation. At 23 d of age, 2 d after weaning, 5 repetitions of a combination of sow and piglet factorial treatments were sacrificed: caecal pH was recorded and digesta samples from cecum and mid-colon were taken to measure VFA concentrations. Mesenteric lymph nodes and jejunal and ileal mucosal samples were collected for measurement of cytokine gene expression by quantitative real-time PCR. Supplementation to sows significantly reduced caecal pH ($P < 0.01$) and increased both caecal ($P < 0.05$) and colonic ($P < 0.01$) VFA concentrations. Within piglet treatments, caecal VFA concentration was higher in T3 than in T4 ($P < 0.05$), but no difference was detected among other groups. For cytokine gene expression, jejunal IL-10 expression was reduced in T2 compared to T1, T3, or T4 groups ($P < 0.05$), while supplementation to sows increased gene expression of IL-22 ($P < 0.01$), IL-1 β ($P < 0.05$), and IL-8 ($P < 0.05$) in the mesenteric lymph nodes. These results indicated that sow supplementation in combination with exposure to UVB light and oral supplementation of vitamins D and A and copper was an efficient administration method to modulate intestinal production of VFA by microbiota and cytokine gene expression compared to CTL. These results are in line with data indicating that copper and vitamins A and D statuses of neonatal piglets are increased by oral supplementation or UVB light (results not shown).

Key Words: copper, gut, piglets, retinol, vitamin D

1741 Comparison of transport characteristics of ferrous sulfate and iron glycine chelate across IPEC-J2 cell monolayers. S. Fang*, College of Animal Science, Zhejiang University, HangZhou, China.

The study was conducted to compare the transport characteristics of ferrous sulfate (FeSO_4) and iron glycine chelate (Fe-Gly) across porcine jejunal cell line (IPEC-J2) monolayers. IPEC-J2 cells were seeded onto the 6-well transwell collagen-coated PTFE filters and evaluated for study use on the 19–22th days. The trans-epithelial electrical resistance (TEER) value of $7510.92 \pm 1586.44 \Omega \cdot \text{cm}^2$ was observed, a transportation percentage (0.92%) of fluorescein sodium could meet the requirements of tightness. The AKP activity in the apical side (AP) had significant higher than the basolateral side (BL) ($p < 0.01$), which means the IPEC-J2 cells has well polarity. These cell monolayers were used for the transport studies. For transport study, sample solutions containing different iron concentrations (5, 10, and 20 $\mu\text{mol/L}$) were

added to AP and a buffer was added to BL. Different times (0–120 min) and temperatures (37°C, 4°C) were designed to study the effects on transportation in the same iron concentration (10 $\mu\text{mol/L}$). Samples were removed from the buffer and the iron concentrations were analyzed by atomic absorption spectrophotometer. Triplicate wells were used for each treatment. The results showed that transports of Fe-Gly and FeSO_4 across IPEC-J2 cell monolayers are linear increased as time went on ($R^2 = 0.9518$, $R^2 = 0.9428$, respectively). Iron transport amount of Fe-Gly and FeSO_4 under 37°C are significant higher than those under 4°C ($P < 0.05$), so did the apparent permeability coefficient (*Papp*). These results suggest that the absorption of Fe-Gly and FeSO_4 in IPEC-J2 cells may through active transport. However, no concentration-dependent iron transport was found, at concentration of 5 and 10 $\mu\text{mol/L}$, iron transport in Fe-Gly treatment was higher than FeSO_4 , at concentration of 20 $\mu\text{mol/L}$, transport amount of both iron sources significantly reduced ($P < 0.05$), iron transport amount in Fe-Gly treatment was significant lower than FeSO_4 ($P < 0.05$). Distinct absorption mechanism may account for the transport difference between these two iron sources at different concentrations.

Key Words: IPEC-J2; absorption; ferrous sulfate; iron glycine chelate; active transport

1742 Studing of population structure of European wild boar (*Sus scrofa*) and its subspecies, inhabiting Russia. A. A. Traspov¹, O. V. Kostyunina¹, I. A. Domsy², A. V. Ekonomov², A. A. Sermyagin^{*1}, and N. A. Zinovieva¹, ¹L.K.Ernst Institute of Animal Husbandry, Moscow, Russian Federation, ²Institute of Hunting and Fur-farming named after professor B.M. Zhitkov, Kirov, Russian Federation.

Genetic studies help to shed a light on the topic but it embraces various aspects including economic, social, and technical issues. Genetic structure of wild boars from Russia can represent flexible territorial clusterization on large geographical areas. In this study, we performed whole-genome SNP analysis of wild boars inhabiting the Russian Federation. Forty animals represent 11 regional subpopulations of the wild boars. They were genotyped using Porcine 60K BeadChip (Illumina Inc., USA). All populations belong to European part of Russia, including Arkhangelsk, Chelyabinsk, Kirov, Krasnodar, Kurgan, Novgorod, Smolensk, Tumen, Udmurtia, Vladimir, and Volgograd regions. We used PLINK v1.09 to obtain Multi-Dimensions Scaling matrix (MDS) and pairwise clustering based on IBS distances. Neighbor Joining tree provided by MEGA v.7 software, based on Tamura-Nei model. In addition, we evaluated population structure of wild boars using ADMIXTURE 1.20 package and calculated pairwise differences and F-statistics between subpopulations. Visualization of data was performed by R. Analysis of spatial distribution showed that at least four groups of animals, which belong

to Arkhangelsk, Kirov, Novgorod, and Vladimir subpopulations, performed separated clustering. Another seven subpopulations have formed a huge single group. We could observe the exchange of single animals between Smolensk and Arkhangelsk subpopulations. The same result was shown by NJ-tree dendrogram and IBS-clustering matrix—most part of animals formed main core with minor branches. Analysis of admixture was performed for the number of clusters (K) from 2 to 7. Analysis of population structure performed for the clusters number K = 2 and 3 according to obtained lowest values of CV errors (0.76395 and 1.42878, respectively) and showed high divergence of the Arkhangelsk subpopulation among all other subpopulations. The presence of clusters may probably indicate the existence of wild boar subspecies. There are no Asian subspecies of wild boar in the European territory of Russia, so we can presume that Arkhangelsk wild boar subpopulation belongs to European-Caucasian subspecies of wild boar. This is the first large-scale analysis of the Russian wild boars performed on whole-genome level. Studies will be continued with involving wild boars inhabiting the whole area of distribution of this species in Russia.

Key Words: phylogenetic, population studies, wild boar

1743 Supplementation with a blend of capsicum and artificial sweetener improves performance of growing and finishing pigs. C. Ionescu*, C. Soulet, C. Bruneau, and E. H. Wall, *Pancosma, Geneva, Switzerland.*

Supplementation of piglets with the artificial sweetener SUCRAM® increases intestinal expression of sodium-glucose co-transporter-1, glucose uptake, and mucosal growth. Both SUCRAM® and capsicum oleoresin improve efficiency of growth in pigs; however, responses to the two additives fed in combination have not been described. The objective of this experiment was to determine the effects of such a blend on feed intake and performance of growing and finishing pigs exposed to a dietary energy challenge. Pigs (PIC380 x Large White/Landrace; $n = 252$ barrows & 252 gilts) were housed in 24 pens under 12-h artificial lighting, were blocked by BW and gender, and were randomly assigned to two treatments ($n = 21$ pigs per pen; 12 pens per treatment) during grower and finishing phases (Grower 1: 25–50 kg; Grower 2: 50–75 kg; Grower 3: 75–100 kg; Finisher: 100–129 kg). Dietary treatments were: 1) Low-NE which was a standard diet formulated to meet NRC recommendations, with wheat millrun added to decrease net energy by 100 kcal NE/kg; and 2) Low-NE + supplementation with a blend of capsicum oleoresin and SUCRAM® (CAPS-SUC; 75 g/ton; TakTik® X-Hit; Pancosma, Geneva, Switzerland). Diets were fed ad libitum as mash feed and disappearance of feed was measured by a robotic recording system. Pigs and remaining feed were weighed at the end of each feeding phase to calculate daily gain and daily feed

intake, respectively. Mortality, pulls, and health records were monitored; growth performance, days to market weight, and carcass characteristics were measured. Inclusion of CAPS-SUC in the Low-NE diet increased daily gain in both the Grower 1 (949 vs. 974 g/d; $P < 0.05$) and Finisher phases (921 vs. 938 g/d; $P < 0.05$). This appeared to be partly driven by feed intake, which was numerically increased with CAPS-SUC when all phases were considered (2.70 vs. 2.85 g/d; $P < 0.20$). Feed ÷ gain was not affected by treatment across all phases (2.98 vs. 2.97; $P > 0.80$). Removals and deaths were not affected by treatment ($P > 0.50$). Carcass weight was increased (101.7 vs. 102.5 kg; $P \leq 0.05$) and days to slaughter were decreased (18.2 vs. 16.7; $P \leq 0.10$) with CAPS-SUC. Feed costs were not affected by treatment (\$0.72 vs. \$0.73/kg; $P > 0.20$). The results of this study indicate that CAPS-SUC can improve performance of growing and finishing pigs when a dietary challenge is introduced.

Key Words: feed additive, phytonutrient, Sucram

1744 Effects of different sources and routes of administration of copper and vitamins A and D on piglets gut microbiota. G. Talbot¹, M. Lessard^{*1}, E. Yergeau², N. Gagnon¹, L. Lo Verso¹, J. Lapointe¹, N. Bissonnette¹, D. Bueno Dalto¹, B. Ouattara¹, F. Guay³, and J. J. Matte¹, ¹*Agriculture and Agri-Food Canada, Sherbrooke Research and Development Centre, Sherbrooke, Canada,* ²*Université du Québec, Centre INRS-Institut Armand-Frappier, Laval, Canada,* ³*Université Laval, Québec City, Canada.*

Placental and colostrum transfers of copper and vitamins A and D micronutrients from dams to neonates are limited in pig species (Matte et al., 2014, JAS 92-Suppl. 2:153). The aim of the study was to evaluate the influence of different perinatal micronutrient supplementation strategies on piglets' gut microbiota. Within each litter from 5 sows, 10 newborn piglets were allocated to one of the following combinations of sources and routes of micronutrient administrations: oral vitamin D3, retinol-acetate and CuSO₄ (T1); oral 25-OH-vitamin D3, β-carotene and Cu-yeast (T2); exposure to UVB light (20 min every second day), oral retinol-palmitate and Cu-gluconate (T3); intramuscular vitamin D3 and retinol-propionate and oral Cu-acetate (T4); oral saline (CTL). Oral or intramuscular provisions corresponded to 12 mg of copper and 70 and 12 MIU of vitamins A and D, respectively. This design was repeated with 5 other sows fed daily extra supplements of 25-OH-vitamin D3 (4 MIU), β-carotene (24 MIU) and Cu-yeast (45 mg) from 90 d of gestation to 21 d of lactation. At 21 d of age, feces were collected and piglets were weaned. At 23 d of age, 5 repetitions of a combination of sow and piglet factorial treatments were sacrificed and feces and content from mid-jejunum, ileum, mid-colon, and rectum were collected to characterize gut microbiota. Bacterial communities were analyzed by sequencing the V3-V4 regions of

16S rRNA genes on an Illumina MiSeq. Bioinformatic analyses were performed on our internal data analysis pipeline and statistics were performed in R. The analysis of bacterial community composition at the class level revealed that sow supplementation significantly increased the relative abundance of *Bacilli* in feces at d 21 ($P = 0.04$) but not at d 23. Gut microbiota diversity significantly differed ($P = 0.03$) according to supplemental treatments provided to piglets. However there was no piglet treatment effect on gut microbiota based on PCoA analyses. The Shannon diversity of jejunal and ileal microbiota was significantly ($P < 0.05$) decreased when supplementation was given to sows. Sow supplementation also significantly increased *Bacilli* in both jejunum and ileum ($P < 0.001$, both). The study demonstrated that piglet gut microbiota can be modulated by daily extra supplementation of vitamins A and D and organic copper to sows during late pregnancy and lactation periods. Further studies are thus warranted to study mechanisms of action explaining the impact of such maternal micronutrient supplementation on bacterial colonization in piglets gut.

Key Words: copper, gut microbiota, piglets, retinol, vitamin D

1745 Diurnal heat stress reduces nursery-grower pig performance and intestinal integrity.

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Heat stress negatively affects performance and intestinal integrity of livestock. Our objective was to characterize the effects of diurnal heat stress on nursery-grower pig performance and intestinal integrity. Forty-eight individually penned crossbred gilts (21 ± 2.0 kg BW) were randomly assigned across two environmental treatments (thermal neutral (TN) or diurnal heat stress (HS), $n = 24/\text{trt}$) at the Iowa State University Swine Nutrition Farm. All pigs were allowed ad libitum access to water and a corn-soybean diet that met or exceeded NRC (2012) requirements. After a thermal neutral acclimation period, 24 pigs (HS) were exposed to 3 d of diurnal heat stress with 6 h in HS conditions (38°C ; 40–60% humidity) and 18 h in thermal neutral conditions (32°C ; 40–60% humidity). The remaining 24 TN pigs were maintained for these 3 d under thermal neutral conditions (28°C ; 40–60% humidity). Pig rectal temperature (Tr), respiration rates (RR), BW changes, and feed disappearance were recorded over the environmental treatment. Blood samples were collected at the end of the 3 d environmental treatment and metabolites, endotoxin, cytokines, and acute phase proteins were evaluated. All pigs were sacrificed after the 3 d environmental treatment and ex vivo ileum integrity was assessed in Ussing chambers

by measuring transepithelial resistance (TER), FITC-dextran (FD4), and FITC-LPS permeability. As expected, HS pig Tr were increased on average 2°C over the 3 d period ($P < 0.05$) and RR increased from 50 to 150 breathes per min (TN verses HS, respectively, $P < 0.01$). Compared to TN, HS pigs had a 30% reduction in ADFI and a 76% reduction in ADG over the 3 d environmental treatment ($P < 0.05$). Gain to feed was also reduced due to HS compared to TN (0.16 verses 0.55, $P = 0.016$). Ileum TER was significantly decreased ($P = 0.04$), FTIC-LPS ($P < 0.01$) and FD4 ($P = 0.015$) permeability increased due to HS compared to TN pigs. Serum endotoxin was significantly elevated due to HS ($P = 0.031$) and there was a reduction in LPS-binding protein ($P = 0.06$) and tumor necrosis factor α ($P = 0.04$) in HS compared to TN pigs. Overall, HS reduced blood insulin concentrations by 50% ($P = 0.02$), but did not affect blood glucose concentrations ($P = 0.47$). Altogether, short exposure to diurnal heat stress significantly reduced pig performance and intestinal integrity compared to those exposed to thermal neutral conditions.

Key Words: heat stress, intestine, pig

1746 Effect of diet composition on piglet growth and digestibility responses to a high dietary canola content.

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Soybean meal (SBM) and canola meal (CM) are the most extensively used protein supplements in the feed industry, whereas corn and wheat are the main sources of energy in swine diets in North America. Although recent studies show that piglets can handle relatively high levels of CM, it is unclear whether this ability depends on the cereal base the diet. Thus, the aim of the study was to determine whether the composition of the main feed ingredients in the basal diet influences pig response to high dietary CM inclusion as indicated by growth performance and apparent total tract digestibility (ATTD) measurements. Ninety-six pigs [(Yorkshire-Landrace) x Duroc] with an initial BW of 6.63 ± 0.028 kg (barrows) and 6.78 ± 0.036 kg (gilts) were used in this 28-d feeding study. There were 8 replicate pens per treatment each with 3 pigs. Pigs were randomly allotted to one of four dietary treatment: 1) Corn-SBM; a corn-SBM based diet, 2) Corn+20%CM; a corn-SBM diet with SBM partially replaced by 20% CM, 3) Wheat-SBM; a wheat-SBM based diet, and 4) Wheat+20% CM, a wheat-SBM diet with SBM partially replaced by 20% of CM. A two phase feeding program was used (phase 1, 1 to 14 d post-weaning and phase 2, 15 to 28 d post-weaning). Average daily gain (ADG), average daily feed intake (ADFI), and feed efficiency (G:F) were recorded weekly. Freshly voided fecal samples were collected on d 21 and 27 to determine ATTD of CP and energy. Data were analyzed as a randomized complete block design using MIXED procedure of SAS. No significant differences were observed in ADFI, ADG, and FBW among treatments ($P > 0.10$). Pigs

fed on the wheat + 20% CM diet had higher G:F ratio compared with those fed on the corn-SBM diet (0.95 vs. 0.79, $P < 0.01$) during phase 1. However, the corn-SBM diet had higher ATTD of CP and energy compared with piglets fed the corn+20% CM, wheat-SBM, and wheat+20% CM diets (96.6 vs. 89.0, 90.9, and 87.2%; and, 95.3 vs. 89.6, 90.8, and 86.9%, $P < 0.01$) during phase 2. In conclusion, results indicated that the composition of the main feed ingredients in the basal diet influences feed efficiency, likewise protein and energy digestibility when CM is included at 20% level without affecting voluntary feed intake and ADG.

Key Words: canola meal, diet composition, digestibility

TEACHING UNDERGRADUATE AND GRADUATE EDUCATION

1747 Increase in demand for hands-on instruction in animal science curriculum. R. Woiwode*, Colorado State University, Fort Collins.

In animal science programs across the United States, the fraction of undergraduate students that have livestock experience before entering college is diminishing. Students in many programs clamor for hands-on experiences with animals and livestock, as it is relevant to their program of study, and may provide a competitive advantage in applying to a veterinary program. An experimental course was proposed for two primary purposes; first to address the specific demand encountered in the Department of Animal Sciences at Colorado State University, and second to provide greater pre-employment training and experience in course development and instruction for a doctoral student wishing to pursue an academic path. With guidance from the department head, a course description, outline, and schedule were constructed and presented to the departmental curriculum committee. Upon receiving authorization for the course to be listed on an experimental basis, registration was made available to the first ten students to enroll. The three credit course consisted of two lectures per week and one lab. Students were guided through an introduction to classical behaviorism and ethology, moving on to species specific behaviors of the major livestock species. Information was presented first in lecture, and reinforced through lab exercises. In labs, students were introduced to concepts through expert demonstration of animal handling or management techniques, and then practiced the skill with close supervision. Students had several opportunities to increase their proficiency with specific skills before they were given a practical assessment. Students were assessed on their assimilation of lecture material through traditional written exams, as well as in class and take home quizzes. Evaluation of the course was conducted with questions

ranked in a 5-point Likert scale to assess student perceptions and effectiveness of the course to achieve university learning goals. Students felt this course was an important part of their academic experience, and indicated that the exposure to the livestock species and various sectors of the livestock industry they were exposed to in this course was an invaluable experience. Finally, students felt that the size of the class provided optimum opportunity for students to receive instruction, practice, and demonstrate proficiencies.

Key Words: hands-on instruction, livestock experience, livestock handling, proficiency

1748 Adding a student-generated summary of main points to a lecture as a learning tool in an advanced nutrition course. S. L. Hansen*, Iowa State University, Ames.

Learning-centered classrooms encourage students to focus on the thinking required to master a concept. Previous work has suggested that increasing the number of focused engagement activities such as Turn To Your Partner (TTYTP) within a class period enhances student retention of information in an advanced animal science course. The TTYTP activity allows at least 3 opportunities to think about the learning, as the student generates his/her own answer, discusses it with a partner, and participates in whole class discussion. Starting each class period with a defined set of learning outcomes provides focus to the lecture and provides an outline from which students can study. Similarly, a structured ending to a class period that includes a review of the most salient points from a lecture could be beneficial to student learning. Students in a senior level animal nutrition course ($n = 34$ students) were asked to generate overall summary statements at the end of lecture ($n = 23$ lectures in the semester). During the last 5 min of class, students were asked to compile summary points from the lecture using the TTYTP format. Students were given approximately 2 min to generate a list of 3 to 5 primary summary points from the day's lecture material or discussion. They were then allowed to work with a partner for another minute, and then brought back to group discussion. Students were held accountable for their learning by being called on at random to share what they and their partner had identified as a critical summary point for the day's material. This continued until all points were exhausted. Critical opportunities for student development included the opportunity for the instructor to correct misconceptions, and for students to develop better note taking and summarizing skills. Students gave feedback halfway through the semester and 80% specifically mentioned that summary point generation was a factor in class that positively affected their learning. Twenty-three students completed the final anonymous course evaluation, and 87% replied to the question "what helped your learning most in this class"? Of those replies, 100% indicated the TTYTP and summary exercise were beneficial in their learning. Including