W344 Effect of glutamic acid plus glutamine on the intestinal morphology of piglets. D. Lescano[1], L. Albino[1], M. Hannas[1], S. Salguero[1], M. Kutschenko[2], E. Nogueira[2], and H. Rostagno*[1], *[1]Federal University of Viçosa, Viçosa, MG, Brazil, [2]Ajinomoto of Brazil Ajinomoto Animal Nutrition, São Paulo, SP, Brazil.*

Weaning of piglets affects intestinal morphology directly and indirectly. Glutamine has synergistic effect with glutamic acid, play key roles for the maintenance of the functional structure of the small intestine. A study was conducted to evaluate the utilization of 4 dietary levels of a commercial product containing glutamic acid plus glutamine (min 95%) in diets for weanling pigs from (18 d) to 25 d old. A total of 24 piglets were used and euthanized 7 d after weaning for sampling. The animals were randomly assigned in a completely randomized design into 4 treatments, 6 replicates and 1 animal per experimental unit. The treatments were: T1- 0.0%; T2- 0.4%; T3- 0.8% and T4- 1.2% glutamic acid (Glu) plus glutamine (Gln). Diets were based on corn, soybean meal, precooked corn, dairy products, blood plasma, L-lysine, L-threonine and DL-methionine. Small intestine histological parameters were measured such as villi height, crypt depth and villous: crypt ratio. The addition of Glu plus Gln improved linearly ($P < 0.05$) duodenum villus height (DV), ileum villus height (IV) and the villus height: crypt depth ratio in the duodenum (DV: DC), jejunum (JV: JC) and ileum (IV: IC). There were also linear and quadratic effects ($P < 0.05$) in duodenal crypt depth (CD) (Table 1). It is concluded that the dietary utilization of 1.2% Glu plus Gln is beneficial to ameliorate the detrimental effects of weaning on morphological parameters in the small intestine of weanling piglets from 18 to 25 d of age.

Table 1. Mean of the intestinal histological parameters of piglets at 25 days of age

	Glu plus Gln (%)				Regression		
Parameter	0.0	0.4	0.8	1.2	Linear	Quadratic	CV (%)
DV (µm)	376	372	418	462	<0.01	NS	14.6
DC (µm)	254	171	175	166	<0.0003	<0.009	16.0
DV: DC	1.7	3	3.1	3.8	<0.0002	NS	24.0
JV (µm)	339	353	321	365	NS	NS	19.2
JC (µm)	183	177	189	157	NS	NS	11.4
JV: JC	2	2.3	1.8	2.8	<0.04	NS	22.1
IV (µm)	240	299	313	367	<0.0001	NS	13.6
IC (µm)	199	197	188	200	NS	NS	7.8
IV: IC	1.3	1.7	1.8	2	<0.00001	NS	11.9

Key Words: piglet, intestinal histology, glutamic acid plus glutamine

W345 Intestinal health of weaned piglets fed diets containing purified cellulose. M. V. Marujo, M. C. Thomaz, V. V. Almeida*, M. M. Lima, E. Daniel, D. J. Rodrigues, F. R. Castelini, M. S. F. Oliveira, and Y. V. S. Guillen, *FCAV/UNESP, Jaboticabal, SP, Brazil.*

The study was conducted to evaluate the effects of purified cellulose inclusion in the diets of newly weaned piglets on intestinal morphology and bacterial enumeration. Thirty-two barrows weaned at 21 d of age were blocked by initial BW (6.68 ± 1.79 kg) and randomly allotted to 1 of 4 treatments, with 8 replicates per treatment and 1 pig per pen. Treatments consisted of corn-soybean meal-based diets formulated to contain 0.0, 1.5, 3.0, or 4.5% purified cellulose. Lactose was added to all diets as an energy source. On d 14 and d 29 post-weaning, piglets were slaughtered and tissues samples were collected from duodenum and jejunum to determine villus height (VH), crypt depth (CD), villus-to-crypt ratio (VH:CD), and number of goblet cells (GC). *Lactobacillus* spp., *E. coli*, and *Clostridium perfringens* counts were determined in digesta samples from the distal portion of the small intestine using plate counts. Statistical analyses were performed using the GLM procedure of SAS. On d 14 post-weaning, increasing purified cellulose level had no effect on duodenal VH, CD, and GC, but resulted in a linear increase in duodenal VH:CD (1.05, 1.09, 1.04, and 1.27 ± 0.28 ; $P < 0.05$) and in a quadratic response in VH (311.99, 293.35, 318.78, and 339.12 ± 0.29 µm; $P < 0.01$) and VH:CD (1.21, 1.06, 1.05, and 1.21 ± 0.27; $P < 0.01$) in the jejunum. On d 29 post-weaning, increasing dietary fiber level had no effect on duodenal morphology, but resulted in a quadratic effect on VH (339.88, 332.06, 308.80, and 380.79 ± 0.27 µm; $P < 0.05$), CD (306.41, 325.89, 295.26, and 270.64 ± 0.27 µm; $P < 0.05$), and VH:CD (1.12, 1.02, 1.05, and 1.42 ± 0.29; $P < 0.05$) in the jejunum. There was a quadratic effect of purified cellulose inclusion on *Lactobacillus* spp. population (7.92, 7.39, 7.30, and 8.09 ± 0.28 log UFC/g; $P < 0.05$) only on d 29 after weaning. Counts of *E. coli* and *Clostridium perfringens* were not affected by treatments on d 14 or 29 post-weaning. In conclusion, adding 4.5% of purified cellulose to the diets of newly weaned piglets improved intestinal health by increasing mucosal membrane integrity and Lactobacillus spp. counts.

Key Words: dietary fiber, piglet, weaning

W346 Effects of nucleotides on growth performance, blood profiles, and fecal microflora in weanling pigs. Z. F. Zhang[1], A. V. Rolando[2], and I. H. Kim*[1], *[1]Department of Animal Resource & Science, Dankook University, Cheonan, Choognam, South Korea, [2]DSM Nutritional Products Philippines Inc., Bonifacio Global City, Taguig, Philippines.*

A total of 140 weanling pigs [(Landrace × Yorkshire) × Duroc; BW = 7.50 ± 0.71 kg; 21 d of age] were used in this 42-d feeding trial to evaluate the effect of nucleotides (NU) as an alternative of antibiotics on growth performance, blood profiles, and fecal microflora which related to post-weaning applicability in weanling pigs. Pigs were randomly distributed into 1 of 4 treatments on the basis of BW and litter (7 replicate pens per treatment with 5 pigs per pen). Dietary treatments were (1) T1, control diet; (2) T2, T1 + 150 g/ton NU; (3) T3, T1 + 220 g/ton NU; (4) T4, T1 + 275 g/ton NU. NU (Rovimax NX) contains at least 80% nucleotides, half of which are free NU. At d 1, 14, 28, 42, BW and feed intake were recorded to calculate the ADG, ADFI and G:F, 2 pigs were randomly chosen from each pen and bled via jugular venipuncture to obtain blood samples, then, fecal *Lactobacillus* and *E. coli* shedding were measured by using MacConkey agar plates and lactobacilli medium III agar plates. All data were subjected to the GLM procedures of SAS (1996) as a randomized complete block design, with pen as the experimental unit. During d 1 to 14, pigs fed T3 diet had higher ($P < 0.05$) ADG than pigs fed T1 diet. During d 29 to 42, pigs fed the T3 diet increased ($P < 0.05$) ADG and G:F compared with pigs fed the T1 diet. During d 15 to 28 ADG and G:F of pigs fed the T2, T3 and T4 diets was higher ($P < 0.05$) than those fed the T1 diet. During d 1 to 42, ADG and G:F of pigs fed the T2, T3 and T4 diets was higher ($P < 0.05$) than those fed the T1 diet. The IgG concentration in T3 and T4 was increased ($P < 0.05$) compared with T1 at d 28 and 42. The fecal Lactobacillus counts in T2, T3 and T4 was higher ($P < 0.05$) than that in T1 at d 28 and 42. In conclusion, dietary supplementation with 150,

220, and 275 g/ton NU could improve growth performance and increase fecal *Lactobacillus* population, moreover, inclusion of 220 and 275 g/ton NU could increase blood IgG centration in weanling pigs.

Key Words: growth performance, nucleotides, weanling pig

W347 Dietary supplementation with a novel *Lactobacillus acidophilus* fermentation prototype improved nursery pig performance and gut health. J. W. Frank*, A. Brainard, M. Wright, and M. Scott, *Diamond V, Cedar Rapids, IA.*

Two experiments were conducted to evaluate the effects of a novel Lactobacillus acidophilus fermentation prototype (SGX; SynGenX, Diamond V) on nursery pig growth and health. In experiment 1, 180 pigs weaned at 19 d of age and weighing 6.7 kg were fed 1 of 6 treatments for 30 d. Pigs were housed 2/pen with 15 replicates/treatment. Treatments were control (CON), XPC (1 g/kg; Original XPC, Diamond V), and SGX at 0.5, 1, 1.5, and 2 g/kg. The control diet contained antibiotics and pharmacological levels of copper and zinc with XPC and SGX treatments added to the control diet. Pig BW and feed intake were recorded, as well as number of injectable medications administered to the pigs to treat health problems. Pigs supplemented with XPC or SGX had improved G:F compared with CON ($P = 0.04$). Final BW of CON, XPC, and the 4 levels of SGX were 15.9, 16.6, 16.7, 17.1, 17.3, and 17.3 kg, respectively ($P = 0.57$). The total number of medications administered to the pigs were 33, 34, 28, 24, 13, and 5 for CON, XPC, and the 4 levels of SGX, respectively ($P = 0.12$). In experiment 2, 1040 pigs weaned at 19–21 d of age and weighing 6.4 kg were fed 1 of 4 treatments for 22 d. Treatments were control (CON) or 1, 2, and 3 g/kg of SGX. The control diet contained antibiotics and pharmacological levels of copper and zinc with SGX treatments added to the control diet. Pigs were housed 26/pen with 10 replicates/treatment. Pig BW and feed intake were recorded. Composite fecal samples were collected from each pen on d 8 to measure Bifidobacteria and Lactobacillus levels using quantitative PCR. Fecal Bifidobacteria ($P = 0.05$) and Lactobacillus ($P = 0.02$) levels were greater in pigs fed SGX at 2 g/kg compared with CON. Final BW for CON and 1, 2, and 3 g/kg of SGX were 11.7, 11.9, 12.4, and 11.9 kg, respectively ($P = 0.25$). The results of these experiments demonstrate that feeding SynGenX, a novel *Lactobacillus acidophilus* fermentation prototype, can improve growth performance and increase the presence of beneficial bacteria in the gut of pigs.

Key Words: pig, lactobacillus, growth

W348 Eugenol affects the integrity of the mucus layer and susceptibility to enteric pathogens. M. Wlodarska[1,2], B. B. Finlay[1,2], and D. M. Bravo*[3], *[1]Michael Smith Laboratories, University of British Columbia, Vancouver, BC, Canada, [2]Department of Microbiology and Immunology, University of British Columbia, Vancouver, BC, Canada, [3]Pancosma, Geneva, Switzerland.*

Phytonutrients are gaining interest for their use as health promoting feed additives in animal production however their ability to alter mucosal immune response in the intestine is still unknown. Due to its potential beneficial use in the feed industry, we characterized the immunomodulatory function of eugenol, a phytonutrient extracted from cloves. Eugenol is a phenolic compound with previously described functions as an antimicrobial and anti-inflammatory agent when used at high concentrations. We explored the effect of eugenol on the large intestine in terms of changes to the microbial ecosystem, mucosal defenses, and stimulation of innate immunity. Mucus secretion and thickness is thought to play a major role in both health and disease by providing a protective yet permeable barrier between intestinal contents and host tissue. The mucus layer in the large intestine consists of 2 stratified layers, mainly composed of the secreted mucin, Muc2. The inner layer is of dense composition and devoid of commensal bacteria, while the outer layer is built as a loose matrix housing commensal bacteria. Eugenol was evaluated in C57Bl/6 mice for its effect on the mucus layer, microbial composition, and colitis induced by enteric pathogens, including *Citrobacter rodentium* (*C. rodentium*), *Salmonella typhimurium*, and *Trichuris muris*. Eugenol was given to mice through their drinking water for 7 d. Eugenol-fed mice were found to have increased Muc2 expression ($P = 0.06$) and a significantly thicker inner mucus layer ($P = 0.02$) in the large intestine compared with untreated mice. We hypothesize that the thickening of the inner mucus layer mediated by eugenol treatment is dependent on the activation of specific immune signaling pathways. Further, we show that eugenol-fed mice were less susceptible to initial *C. rodentium* colonization in the large intestine 3 d post infection ($P = 0.0341$). These results suggest that eugenol acts to strengthen the mucosal barrier by increasing the thickness of the inner mucus layer, which protects against invading pathogens and intestinal inflammation.

Key Words: phytonutrient, enteric disease, mucus

W349 Effect of dietary resistant starch content on nutrient digestibility, fecal microbial diversity and body weight in piglets. H. Lu*[1], H. Yan[1], R. Potu[1], M. G. Ward[1], C. C. Pelkman[2], C. H. Nakatsu[1], O. Adeola[1], and K. M. Ajuwon[1], *[1]Purdue University, West Lafayette, IN, [2]Ingredion Incorporated, Bridgewater, NJ.*

Resistant starch (RS), a major component of amylose corn, is considered a prebiotic. The utilization of RS rich substrates leads to enrichment of the hind gut with beneficial bacteria and increased production of short chain fatty acids (SCFA). The effect of consuming diets with different amounts of RS during gestation and lactation on birth and weaning weights, concentrations of maternal blood metabolites such as triglycerides (TG), glucose and free fatty acids (FFA) and hormones (IGF-1 and insulin) and milk composition (ether fat, protein, ash and total solids) was evaluated. Two corn-soybean diets (65.8% of control corn or high amylose corn) were fed to 16 sows (8 sows per diet) from D 60 of gestation to farrowing (D 114) and during the lactation period (up to 21 d after farrowing). The control and amylose corn diets had RS contents of 23.5 and 54.5%, respectively. Fecal microbial composition of sows on the 2 diets was determined by PCR-DGGE analysis. Ileal digestibility and total tract nutrient utilization were also determined in ileal-cannulated pigs, (35 kg BW, 5 per diet) in a 7-d digestibility trial. Feeding amylose corn during gestation diet tended ($P < 0.1$) to result in piglets with lower birth weight than control (1.5 vs. 1.7 kg) but with similar weaning weights (6.5 ± 0.2 vs. 6.6 ± 0.2 kg). Serum hormone and metabolite concentrations were not different ($P > 0.05$). Milk from sows on amylose corn diet had higher ($P < 0.05$) total solids (20.6 vs.18.9%) and tended ($P < 0.09$) to have a higher ether fat (9.3 vs.7.8%) than those on the control corn diet. Apparent ileal digestibility of DM, N, energy, Ca and P were not different. Hind gut digestibility was higher ($P < 0.05$) in the amylose vs. control diet for DM (0.56 vs. 0.42) and energy (0.49 vs. 0.36). Amylose diet also resulted in higher ($P < 0.05$) total SCFA concentration than control (142.5 vs. 96.7 m*M*). Analysis of DGGE band profile showed greater microbial diversity in the amylose corn diet than control. Consumption of amylose corn rich diet may be a strategy to enhance sow milk lipid concentration and increase hindgut microbial diversity.

Key Words: maternal, amylose, piglet

W350 Influence of whole wheat feeding on the development of coccidiosis in broilers. Y. Singh, T.J. Wester, A. L. Molan, G. Ravindran, and V. Ravindran*, *Massey University, Palmerston North, New Zealand.*

A study was conducted to assess the effect of whole wheat (WW) feeding on performance, gizzard development, oocyst yield and intestinal lesion score of male broilers (Ross 308) experimentally challenged with *Eimeria acervulina*, *E. maxima*, and *E. tenella*, and to test the hypothesis that the inclusion of whole grain in the diet will reduce the severity of coccidial infection. Diets (finely ground wheat (GW) and 300g/kg WW replacing GW either before or after pelleting) were offered ad libitum from d 1 to d 28 post-hatching. At 21 d of age, each dietary treatment was divided into 2 groups, one unchallenged control and the other inoculated with mixed species of coccidia. No differences ($P > 0.05$) between dietary treatments were observed in weight gain and feed per gain during the pre-challenge period (1 to 21 d), but feed intake was lower ($P < 0.05$) in WW fed birds. After the inoculation (21 to 28 d), challenged birds had reduced ($P < 0.05$) weight gain and feed intake, and higher ($P < 0.05$) feed per gain compared with unchallenged birds. Mortality in challenged birds was highest in those fed diets with WW post-pelleting, followed by pre-pelleted WW and GW (58, 35, and 17%, respectively; $P < 0.05$). Relative gizzard weights were heavier ($P < 0.05$) in WW fed birds, irrespective of the method of inclusion, compared with those fed GW in both challenged and unchallenged groups. Total lesion scores of challenged birds were not influenced ($P > 0.05$) by dietary treatments. Lesion scores were, however, lower ($P < 0.05$) in the duodenum and jejunum, and higher ($P < 0.05$) in the ceca in WW fed birds, irrespective of the method of inclusion. Total oocyst counts in the excreta of challenged birds were higher ($P < 0.05$) in birds fed WW, irrespective of the method of inclusion. No mortality, intestinal lesion and excreta oocyst shedding were observed in unchallenged treatments. Based on increased mortality, it can be concluded that WW feeding exacerbated the severity of coccidiosis infection, possibly via a mechanism involving enhanced gizzard development.

Key Words: whole wheat, coccidiosis, broiler

W351 Effects of whey protein on intestinal integrity in heat-stressed growing pigs. M. V. Sanz-Fernandez*[1], S. C. Pearce[1], V. Mani[1], N. K. Gabler[1], D. C. Beitz[1], L. Metzger[2], J. F. Patience[1], R.P. Rhoads[3], and L. H. Baumgard[1], *[1]Iowa State University, Ames, [2]South Dakota State University, Brookings, [3]Virginia Polytechnic Institute and State University, Blacksburg.*

Heat stress (HS) decreases livestock productivity and this may in part be mediated by reduced intestinal integrity or "leaky gut." Dairy products improve intestinal integrity in a variety of human and small animal models. Consequently, we hypothesized that dietary bovine colostrum (CL) and whey protein (WP) would mitigate HS-induced leaky gut in pigs. Crossbred gilts (39 ± 3 kg BW) were ad libitum fed 1 of 4 dietary treatments (n = 8 pigs/treatment): (1) control (CT), (2) diet A, containing test product A (98% WP, 2% CL); (3) diet B, containing test product B (80% WP, 20% CL); and (4) diet C, containing test product C (100% WP). Diets were formulated to provide 100 g/d of protein from the test products. After 7d (Period 1, P1) on experimental diets, all pigs were exposed to constant HS conditions for 24 h (P2; 32°C, ≈26% relative humidity). Production parameters and body temperature indices were recorded throughout the experiment, and P2 measurements were compared with P1. At the end of the study, pigs were euthanized and fresh ileum and colon sections were isolated and mounted into modified Ussing chambers for ex vivo assessment of intestinal integrity. There were no differences in growth or feed efficiency during P1. Prior to HS, diet C-fed pigs had a slightly increased ($P < 0.05$; 0.1°C) rectal temperature (Tr), but respiration rates (RR) were not different between treatments. As expected, during P2, both Tr ($P < 0.01$; 40.29 vs. 39.43°C) and RR ($P < 0.01$; 116 vs. 40 breath/min) increased, but no treatment differences were detected. Heat stress markedly reduced feed intake ($P < 0.01$; 44%), and none of the treatments ameliorated this decrease. After 24 h of HS, pigs in all treatments lost a similar amount of BW (−0.5 kg). When compared with CT, ileal transepithelial electrical resistance was decreased ($P = 0.02$; 37%) and tended to be decreased ($P = 0.10$; 27%) in B and C diet-fed pigs, respectively. No differences were detected in any of the remaining intestinal integrity variables. These data demonstrate that supplementing CL and WP in the proportions present in the test products augmented HS-induced leaky gut in pigs.

Key Words: heat stress, whey protein