

**92 Intramuscular administration of zinc metallothionein to preslaughter-stressed pigs improves anti-oxidative function and pork quality.** L. L. Li<sup>1</sup>, Z. P. Hou<sup>1</sup>, Y. H. Liu<sup>2</sup>, D. X. Hou<sup>3</sup>, B. Zhang<sup>2</sup>, G. Y. Wu<sup>1,4</sup>, C. B. Yang<sup>1</sup>, X. J. Yang<sup>1</sup>, Z. R. Tang<sup>1</sup>, Y. L. Yin<sup>\*1</sup>, and M. Z. Fan<sup>1,5</sup>, <sup>1</sup>*Institute of Subtropical Agriculture, The Chinese Academy of Sciences, Changsha, Hunan, P.R. China*, <sup>2</sup>*Hunan Agricultural University, Changsha, Hunan, P.R. China*, <sup>3</sup>*Kagoshima University, Kagoshima, Japan*, <sup>4</sup>*Texas A&M University, College Station*, <sup>5</sup>*University of Guelph, Guelph, Ontario, Canada*.

This study was conducted to determine the effects of exogenous zinc-metallothionein (Zn-MT) on anti-oxidative function in pork meat. After feeding a corn- and soybean meal-based diet for two weeks, 48 pigs (Duroc×Landrace×Chinese Black Pig) were assigned randomly into one of four treatment groups (12 pigs/group). Pigs in group 1 were maintained under non-stress conditions, whereas pigs in groups 2, 3 and 4 were aggressively handled for 25 min to produce stress. Then, pigs in groups 1 (control group) and 2 (negative control group)

received intramuscular administration of saline, while pigs in groups 3 (low dose group) and 4 (high dose group) received 0.8 and 1.6 mg rabbit liver Zn-MT per kg body weight, respectively. Pigs were slaughtered at 3 and 6 h post-injection. Zn-MT treatment increased ( $P < 0.05$ ) the activities of superoxide dismutase (SOD) and glutathione-peroxidase (GSH-PX) while decreasing the concentration of malondialdehyde (MDA) in the liver. These responses were greater ( $P < 0.05$ ) at 6 h than at 3 h post Zn-MT injection. Zn-MT treatment increased ( $P < 0.05$ ) hepatic SOD mRNA levels in a time- and dose-dependent manner, and decreased ( $P < 0.05$ ) blood activities of glutamate-pyruvate transaminase and lactate dehydrogenase (indicators of tissue integrity). Zn-MT administration decreased ( $P < 0.05$ ) lactic acid concentrations, thereby increasing ( $P < 0.05$ ) the pH and water-holding capacity of the meat. Collectively, our results indicate that intramuscular administration of Zn-MT to preslaughter-stressed pigs improves tissue anti-oxidative ability and pork quality. Supported by funds from the Chinese Academy of Sciences and China NSF.

**Key Words:** Stress, Metallothionein, Pork quality

## Nonruminant Nutrition: Nursery Nutrition - Swine

**93 Supplemental inulin affects digesta soluble Fe and sulfide concentrations in weanling pigs.** K. Yasuda<sup>\*1</sup>, K. R. Roneker<sup>1</sup>, D. D. Miller<sup>2</sup>, R. M. Welch<sup>3</sup>, and X. G. Lei<sup>1</sup>, <sup>1</sup>*Cornell University, Ithaca, NY*, <sup>2</sup>*Cornell University, Ithaca, NY*, <sup>3</sup>*USDA/ARS, U.S. Plant, Soil and Nutrition Laboratory, Ithaca, NY*.

Our laboratory has shown previously the improvement of bioavailability of dietary Fe for hemoglobin repletion by supplemental inulin in weanling pigs. The objective of this study was to determine the metabolic mechanisms for that improvement conferred by inulin. Twelve weanling pigs (BW = 7.70 ± 0.19 kg, n=6 per treatment,) were fed a corn-soybean meal based diet (BD, without inorganic Fe addition, 54 mg Fe/kg) or the BD + 4% inulin (Synergy 1, Orafiti, Tienen, Belgium) for 6 wk. Body weight gain and blood hemoglobin concentrations of individual pigs were measured weekly, and feed intake of individual pigs was recorded daily. All pigs were killed at the end of trial to collect digesta samples from stomach, duodenum, jejunum, cecum, and colon to assay for pH, phytase activity, and concentrations of total soluble Fe and sulfide. Compared with those fed the BD, pigs fed 4% inulin had higher ( $P < 0.05$ ) hemoglobin repletion efficiency (20.4 vs. 24.9%), soluble Fe concentration in colon digesta (1.2-1.6 vs. 2.1-2.9 μmol/g), and phytase activity in lower jejunum digesta (19.1 vs. 42.5 mU/g), but lower ( $P < 0.05$ ) sulfide concentration in distal colon digesta (4.8 vs. 3.3 μmol/g). There was no significant difference in growth performance, digesta pH, or digesta concentrations of total Fe between the two groups of pigs. In conclusion, supplemental inulin enhanced Fe solubility and decreased Fe binding compound sulfide in colon digesta. (Supported in part by a grant from Harvest-Plus, International Food Policy Research Institute, Washington DC).

**Key Words:** Inulin, Pigs, Iron

**94 Additivity of effects of copper and zinc in diets for weaned piglets on a commercial farm.** V. G. Perez-Mendoza<sup>\*1</sup>, M. U. Steidinger<sup>2</sup>, G. R. Hollis<sup>1</sup>, T. M. Fakler<sup>3</sup>, and J. E. Pettigrew<sup>1</sup>, <sup>1</sup>*University of Illinois, Urbana-Champaign*, <sup>2</sup>*Swine Nutrition Services Inc, Anchor, IL*, <sup>3</sup>*Zinpro Corporation, Eden Prairie, MN*.

A total of 1008 newly weaned pigs (21 d old; 5.25±1.0 kg) were used in a commercial farm to test whether the performance effects of

organic copper (Availa-Cu) are additive to the performance effects of zinc oxide (ZnO). This was a RCBD with 4 dietary treatments in a 2x2 factorial arrangement of Availa-Cu (0 vs. 100 ppm Cu) and ZnO (0 vs. 3000 ppm Zn); pigs were blocked by weight and room (3 wt categories and 4 rooms). Pens were experimental units with 21 pigs; gender distribution was equal within blocks. Copper was added throughout the entire experiment (6 wk) and ZnO only during the first 2 wk; these high levels of Cu and Zn were in addition to the nutrient levels provided by the standard trace mineral premix. This was a 4-stage feeding program with decreasing diet complexity: 1, 1, 2 and 2 wk per phase. Diets used in phases 1 and 2 were in mini-pellet form, and phases 3 and 4 were in meal form. The only interaction ( $P=0.05$ ) between Cu and Zn was in ADFI during the first week, which was increased by Zn in the absence (106 vs. 134 g;  $P < 0.01$ ), but not in the presence (130 vs. 132 g; SEM=6.5;  $P=0.88$ ) of Cu. During the entire 6-wk period both Cu and Zn increased ( $P < 0.001$ ) ADG and ADFI: Availa-Cu increased ADG by 33 g in the absence of Zn (250 vs. 283 g;  $P < 0.001$ ), and by 15 g in the presence of Zn (300 vs. 315 g; SEM=12.3;  $P < 0.09$ ); there was not an interaction ( $P=0.14$ ). Availa-Cu increased ADFI by 44 g in the absence of Zn (401 vs. 445 g;  $P < 0.001$ ), and by 22 g in the presence of Zn (459 vs. 481 g; SEM=17.1;  $P < 0.06$ ); there was not an interaction ( $P=0.18$ ). An outbreak of diarrhea due to *E. coli* caused a high rate of pig removal (including mortality), which was reduced ( $P < 0.001$ ) by Zn (17.1 vs. 6.6%; SEM=2.1). These results show beneficial effects of both Availa-Cu and zinc oxide, and the lack of significant interaction suggest that the effects are at least partially additive. These results also confirm the protective effect of ZnO against enteric infections.

**Key Words:** Organic copper, Zinc oxide, Weaned pigs

**95 Importance of vitamin B<sub>12</sub> enterohepatic cycle in growing pigs.** D. P. Prévêraud<sup>\*1,2</sup>, C. L. Girard<sup>1</sup>, F. Guay<sup>2</sup>, N. Le Floc<sup>3</sup>, and J. J. Matte<sup>1</sup>, <sup>1</sup>*Agriculture and Agri-Food Canada, Lennoxville, Qc, Canada*, <sup>2</sup>*Laval University, Ste-Foy, Qc, Canada*, <sup>3</sup>*INRA, St-Gilles, France*.

Endogenous B<sub>12</sub> in the small intestine originates from the enterohepatic cycle (EHC) and from the low bioavailable B<sub>12</sub> vitamers synthesized

by enteric bacteria. This EHC allows the release of B<sub>12</sub> from the liver into the duodenum through the bile secretion and its reabsorption further in the small intestine. Although the concept is well known, its physiological importance for B<sub>12</sub> homeostasis remains to be established. This study aimed to estimate the absorption of intestinal endogenous B<sub>12</sub> in pigs. Six pigs (32.4 ± 2.8 kg BW) fed a B<sub>12</sub> free diet since weaning at 21 d of age were surgically equipped with catheters in the portal vein and in a carotid; an ultrasonic flow probe was also installed around the portal vein. Blood samples were collected simultaneously from the 2 catheters for B<sub>12</sub> determination and portal flow measurements were recorded every 45 min for the first 3 h post-feeding, and every hour for the following 21 h. The portal net flux of B<sub>12</sub> was calculated at each sampling time and the area under that curve represented the total daily amount of B<sub>12</sub> reaching the portal circulation. For a 24 h period, the mean value (±SE) was 1.1 ± 1.0 µg and, globally, did not differ from 0 (P=0.35). During the first 6 h post-feeding, the portal net flux of B<sub>12</sub> was negative, possibly due to B<sub>12</sub> utilization by the intestinal wall. From 12 to 18 h post-feeding, the portal net flux of B<sub>12</sub> became positive and different from 0 (P<0.05) suggesting then a late but small net absorption of B<sub>12</sub>. Using the B<sub>12</sub> content measured in bile and its volume produced daily (Juste, 1982. INRA publ.12:155-73), the estimated total B<sub>12</sub> released through the bile was 1.3 µg/d. Based on this value, a maximum of 85.4 % of the amount of biliary B<sub>12</sub> would be reabsorbed in the ileum assuming that the enteric provision of bacterial B<sub>12</sub> is negligible. Such value was similar to what was estimated in humans. In conclusion, it appears that B<sub>12</sub> from the EHC, although apparently highly bioavailable, represents a small pool of B<sub>12</sub> and is unlikely to interfere with the evaluation of B<sub>12</sub> absorption when pigs are fed dietary levels of ±15 µg/kg as recommended by NRC (1998).

**Key Words:** Vitamin B<sub>12</sub>, Enterohepatic cycle, Pigs

**96 Bioavailability of dietary cyanocobalamin (vitamin B<sub>12</sub>) in growing pigs.** J. J. Matte\*<sup>1</sup>, D. P. Prévraud<sup>1,2</sup>, F. Guay<sup>2</sup>, and C. L. Girard<sup>1</sup>, <sup>1</sup>*Agriculture and Agri-Food Canada, Lennoxville, QC, Canada*, <sup>2</sup>*Université Laval, Québec, QC, Canada*.

There are few data on bioavailability of vitamin B<sub>12</sub> in pigs; isotope tracer methods were used in the 70's (Ford et al, 1975, Br. J. Nutr.34:469-92) with suckling piglets. There is no reference value for older pigs. The present study aimed to generate such information using body deposition of the vitamin as the criterion in growing pigs. Piglets were fed a diet without supplemental B<sub>12</sub> from 3 (weaning) up to 8 wk of age. Blood samples were collected in order to determine plasma B<sub>12</sub>. Fifteen repetitions of 3 pigs were formed according to their B<sub>12</sub> status evaluated from the plasma B<sub>12</sub> and plasma volume (estimated at 4 % of BW, 31.7 ± 0.5 kg). Then, one pig (IN) from each repetition (n = 15) was sacrificed. Liver, empty digestive tract and carcass were weighed, frozen and minced. Representative samples were collected and analysed for B<sub>12</sub> concentration. The remaining 2 piglets, in each repetition, were transferred to metabolic cages and fed for 8 d, 25 or 250 µg of cyanocobalamin per day (corresponding to 20 or 200 ppb, respectively). Urine was collected and sampled twice a day during the whole period. At the end of the collection period, the pigs were sacrificed as for pig IN of each repetition. Results are summarized in the Table. Although affected by the dietary treatments (P<0.01), it appears that urine is a negligible pool of B<sub>12</sub> (<1 %). The total content of B<sub>12</sub> in the carcass and intestinal tract rose (P≤0.01) as dietary B<sub>12</sub> increased. The additional amount of B<sub>12</sub> transferred in the carcass (vs 0 ppb) was 58.4 % higher (P<0.01) with 200 ppb (75.4 ± 7.9 µg) than with 20 ppb (47.6 ± 7.0 µg). For the intestinal tract, the pool was small

at ± 5 % of the whole body. In liver, the B<sub>12</sub> content tended (P<.07) to increase with the level of dietary B<sub>12</sub>. For the whole body, the B<sub>12</sub> content increased (P<0.01) with the level of dietary B<sub>12</sub>, the effect being more marked, as for liver, between 0 and 20 ppb. In conclusion, the bioavailability of B<sub>12</sub> decreased considerably with dietary levels of cyanocobalamin. Nevertheless, the effect on carcass indicated that a supplement of 200 ppb could be a valuable tool to enrich pork meat in vitamin B<sub>12</sub>.

**Table 1. B<sub>12</sub>(µg) in the different metabolic pools**

Dietary B12 (ppb)	Urine	Carcass	Liver	Intestinal tract	Whole body	Bioavailability (%)
0	--	132.4±4.7 <sup>a</sup>	96.2±5.8 <sup>x</sup>	10.2±0.4 <sup>a</sup>	238.8±8.7 <sup>a</sup>	--
20	1.0±.3 <sup>a</sup>	180.0±7.5 <sup>b</sup>	117.4±7.1 <sup>y</sup>	14.7±.6 <sup>b</sup>	313.0±12.2 <sup>b</sup>	37.1±5.9 <sup>a</sup>
200	2.2±.3 <sup>b</sup>	207.8±8.2 <sup>c</sup>	113.8±7.5 <sup>y</sup>	19.4±.9 <sup>c</sup>	343.1±12.1 <sup>b</sup>	5.2±.6 <sup>b</sup>

Values (mean±SE) with <sup>a, b or c</sup> and <sup>x,y</sup> are different at P≤0.01 and P≤0.07, respectively

**Key Words:** Vitamin B<sub>12</sub>, Bioavailability, Pigs

**97 Evaluation of a extruded wheat and milk by-product mixture in diets for early-weaned pigs.** J. C. Sánchez, M. P. Serrano, D. G. Valencia, R. Lázaro, and G. G. Mateos\*, *Universidad Politécnica de Madrid, Spain*.

Condensed whey (MP) is a by-product of the cheese and milk protein industry that results from the ultrafiltration and pasteurization of liquid whey. On DM bases, MP is rich in lactose (46%) and has a moderate amount of CP (12%), MP is high in electrolytes (6.1% K; 3.8% Cl; 2.1% Na). The MP, conveniently mixed with wheat (W), can be extruded (HP), a process that reduces the moisture content of the mixture to less than 10%. We studied the benefits of including a mixture (W-MP) composed of 80% wheat and 20% MP (W-MP) on coefficient of total tract apparent digestibility (CTTAD) and performance of pigs weaned at 21 d. There were five experimental diets: 1) 49% raw wheat and 20% dried whey; 2) 31% W-MP, 25% raw wheat, and 14% dried whey; 3) 62% W-MP and 8% dried whey; and 4) and 5) same than diets 1 and 2 but replacing the raw wheat for HP wheat. All the diets have similar nutrient content except for the electrolytes that increased with increasing levels of MP. Each treatment was replicated seven times (six piglets) and the trial lasted 28 d. From 21 to 39 d of age piglets fed diets containing HP wheat grew more (308 vs. 282 g/d; P ≤ 0.05) and tended to be more efficient (1.14 vs. 1.19 g/g; P ≤ 0.10) than piglets fed diets containing W-MP but the effects disappeared with age. Replacing wheat (either raw or HP) and dried whey with equivalent amounts of W-MP increased CTTAD of nutrients (P ≤ 0.01). Also, HP of wheat increased the digestibility of OM, CP, and GE (P ≤ 0.01) over raw wheat. Pigs fed diets with high levels of MP and HP wheat (diets 3 and 5) had a higher incidence of diarrhea than pigs fed diets based on raw wheat and dried whey (P ≤ 0.01). We conclude that the inclusion of an extruded mixture of wheat and milk by-product increased nutrient digestibility but has little effect on productive traits. The high content of minerals of the milk by-product tested may be responsible for the higher incidence of diarrhea observed and might preclude its use at high levels in diets for young pigs.

**Key Words:** Piglet performance, Wheat, Milk by-product

**98 Use of rice in substitution of corn and zinc oxide in diets for young pigs.** B. Vicente, D. G. Valencia, J. C. Sánchez, R. Lázaro, and G. G. Mateos\*, *Universidad Politécnica de Madrid, Spain.*

We studied the influence of the cereal (rice vs corn) and the inclusion of zinc oxide (ZnO) in the diet on performance of pigs weaned at 21 d. Control pigs received a complex diet based on milk products, fish meal, and 47% extruded corn. Neither animal plasma nor growth promoters were included in this diet. The experimental groups received the same complex diet as the control group but corn was substituted by rice either raw, cooked or extruded. In addition, there was an extra diet based on extruded rice that included 0.3% ZnO. Each treatment was replicated six times (six piglets penned together) and the trial lasted 28 d. The percentages of starch gelatinisation (SG) and resistant starch of the cereal were 83.6 % and 4.04% for extruded corn, 20% and 2.70% for raw rice, 51.2% and 2.68% for cooked rice, and 76.2% and 2.85% for extruded rice. From 21 to 28 d of age ZnO inclusion reduced the incidence of scours (7.05 vs. 0.80 %;  $P < 0.01$ ) and improved growth (196 vs. 133 g/d;  $P < 0.05$ ) and G:F ratio (1.09 vs. 0.90 g/g;  $P < 0.10$ ). At the end of the trial (49 d of age) ZnO inclusion tended to increase ADFI (501 vs. 453 g/d;  $P < 0.10$ ) but did not affect ADG or G:F ratio. Also at this age, piglets fed the rice containing diets grew faster (402 vs. 341 g/d;  $P < 0.01$ ), tended to eat more feed (500 vs. 479 g/d;  $P < 0.10$ ), and had better G:F ratio (0.80 vs. 0.71 g/g;  $P < 0.01$ ) than piglets fed corn. Rice extrusion did not improve piglet performance ( $P < 0.01$ ) as compared to raw or cooked rice. It is concluded that the inclusion of ZnO reduces the incidence of scours and improves growth from 21 to 28 d and that rice, either raw or cooked to obtain a moderate degree of SG improves piglet performance from 21 to 49 d. A further increase in the degree of SG, as that obtained with extrusion of rice, did not improve pig performance. The inclusion of ZnO during the first days after weaning and of rice either raw or moderately cooked during the prestarter phase is recommended in piglet diets.

**Key Words:** Rice, Piglet performance, Starch gelatinization

**99 Dietary spray dried (immune) plasma protects against experimental F4+ Escherichia coli post-weaning diarrhea in pigs.**

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In order to establish the effect of spray dried porcine plasma powder (SDPP) and spray dried porcine immune plasma powder (SDPIP) on pig health and performance, a diet containing either SDPP or SDPIP was compared to a standard weaning ration in a model of enterotoxigenic F4+ Escherichia coli post-weaning diarrhea. Plasma was obtained at slaughter from non-immunized pigs, and from pigs immunized with a vaccine containing F4 and LT. Newly weaned piglets (n=96) were housed in groups of eight and were given pelleted control feed, or feed containing either 8% SDPP, or 8% SDPIP. Rectal fecal samples were taken daily and were assessed for diarrhea (as percentage of dry matter), and F4+ E. coli excretion (CFU/g). Average daily gain of the piglets was determined. At necropsy, jejunal samples were taken for determination of the F4R status by brush border adhesion assay. In total 30% of the piglets were determined to be F4 receptor positive (F4R+). Statistical analysis (REML variance components analysis) showed a significant correlation between F4R status and morbidity. SDPIP significantly improved all parameters in F4R+ animals and reduced diarrhea in F4R- piglets. SDPP however, reduced diarrhea

in F4R+ animals without reduction of F4+ E. coli excretion. We believe that this could (partly) be explained by the occurrence of neutralizing anti-LT antibodies in SDPP, which reflects natural exposure to pathogens. Antibody titers of the piglets against F4 and LT were found to be related to parity of the sow, diet, and F4R status of the piglets. In conclusion, comparing SDPP and SDPIP it is evident that the latter not only protects against diarrhea, but also reduces F4+ E. coli excretion. As a consequence, transmission within a herd will be reduced, and a larger effect on pig health and performance can be expected.

**Key Words:** Pig, E.coli, Plasma

**100 Effects of soybean meal concentration on growth performance of nursery pigs fed simple and complex diets.** P. M. Clark\*, J. D. Hancock, K. C. Behnke, and A. C. Fahrenholz, *Kansas State University, Manhattan.*

Two 35-d growth assays were conducted to determine the effects of soybean meal (SBM) concentration on performance of nursery pigs fed simple and complex diets. For Exp. 1, 168 weaning pigs (avg initial BW of 6.9 kg) were used. The control diet for d 0 to 7 was formulated to 1.80% lysine. Treatments were none, 10, 20, and 30% SBM added to replace corn on a wt:wt basis. A common diet was fed to all pigs from d 7 to 21 (1.6% lysine) and d 21 to 35 (1.35% lysine). For d 0 to 7, ADG and ADFI were not affected ( $P > 0.21$ ) by concentration of SBM in the diet. However, there were linear increases in G:F for d 0 to 7 ( $P < 0.001$ ), d 0 to 21 ( $P < 0.05$ ), and overall (d 0 to 35,  $P < 0.01$ ) as SBM concentration was increased from none to 30%. For Exp. 2, another 168 weaning pigs (avg initial BW of 6.3 kg) were used. Treatments were diet complexity (without and with 10% fishmeal and 10% plasma protein) and SBM concentration (none and 30%) arranged as a 2 x 2 factorial. For d 0 to 7, there were no interactions among diet complexity and SBM concentration for ADG, ADFI, and G:F ( $P > 0.39$ ). However, ADG was 30% greater for pigs fed complex vs simple diets ( $P < 0.001$ ) and 22% greater for pigs fed diets with 30% SBM vs none ( $P < 0.003$ ). Overall (d 0 to 35) there were no significant treatment interactions or main effects on ADG, ADFI, and G:F ( $P > 0.13$ ). In conclusion, it appears that use of high concentrations of SBM in simple and complex diets for weaning pigs had no negative effects on growth performance.

**Table 1.**

	Exp. 1, d 0 to 7				SE
	SBM, % 0	SBM, % 10	SBM, % 20	SBM, % 30	
ADG, g	353	335	368	362	17
ADFI, g	281	270	274	258	13
G:F, g/kg	1,256	1,240	1,343	1,403	31
	Exp. 2, d 0 to 7				SE
	Simple None	Simple 30%	Complex None	Complex 30%	
ADG, g	209	278	296	337	14
ADFI, g	225	254	256	270	16
G:F, g/kg	928	1,094	1,156	1,248	94

**Key Words:** Nursery pig, Soybean meal, Diet complexity

**101 Supplemental effects of lactobacillus based probiotics on aerial odor production and growth performance of pigs.** S. K. Kommera\*, R. D. Mateo, D. A. Monson, and S. W. Kim, *Texas Tech University, Lubbock*.

Probiotics (*Lactocare*, GBTech) containing *Lactobacillus plantarumcase* and *Lactobacillus salivariuscase* were added to pig diets to test their effect on odor emission from pig excreta and growth performance of pigs. Ninety six, 28 d old, pigs were allotted to three treatments: the CON (without any probiotics), the LL (with the liquid type probiotic at 0.1%) and the SB (with the powder type probiotic at 0.1%). There were 4 replicates per treatment and 8 pigs per pen. Pigs were fed the assigned diets ad libitum for 5-wk. Weight gain and feed intake of pigs were measured weekly until wk 3. From wk 3, all pigs in each pen were moved to a pen (1.2 x 2.4 m) in a ventilated environmental chamber (3.0 x 3.0 x 2.4 m) for 70 h to measure aerial ammonia, amine, and hydrogen sulfide production from the pigs under controlled conditions at 10 min intervals using two gas monitors (Pac III and Miniwarn, Draeger Safety, Inc., Pittsburgh, PA). The fan was working continuously and constantly during the experimental period. Feed intake and weight gain of pigs during the 70 h period were also measured. Pigs in the SL and LL had greater ( $P < 0.05$ ) ADG and ADFI than pigs in the CON during the 3 wk feeding period, whereas gain:feed ratios were the same among the treatments. Averaged ammonia levels during the last 2-h collection period from the SL (8.4 ppm) and LL (7.8 ppm) were lower ( $P < 0.05$ ) than that from the CON (9.3 ppm). Averaged amine level during the last 2-h collection period from the LL (7.3 ppm) was lower ( $P < 0.05$ ) than that from the CON (9.5 ppm) and was not different from the SL (8.0 ppm). Using the slope ratio analysis, the rates of increase of aerial ammonia and amine from the LL (0.108 and 0.062, respectively) and the SL (0.107 and 0.066, respectively) were different ( $P < 0.001$ ) from the CON (0.129 and 0.080, respectively). Hydrogen sulfide was not detectable during the 70 h period. This study shows that ammonia and amine from pig excreta can be reduced and the growth performance can be improved by dietary supplementation of a probiotic with *Lactobacillus plantarumcase* and *Lactobacillus salivariuscase*.

**Key Words:** Lactobacillus, Odor, Growth performance

**102 The effect of salmon protein hydrolysate and spray-dried porcine plasma on growth performance of nursery pigs.** J. Tucker\*, B. Perkins, S. Johnston, T. Bidner, and L. Southern, *LSU Agricultural Center, Baton Rouge*.

The objective of this research was to evaluate the effects of salmon protein hydrolysate (SPH) and spray-dried porcine plasma (SDPP) on growth performance of nursery pigs (17 to 21 d weaning age; 5.86 kg initial BW; Phase 1, 7 or 8 d; Phase 2, 14 d; and Phase 3, 7 or 8 d). The SPH is a protein source enzymatically-produced from Atlantic salmon and Rainbow trout tissues; it consists of free AA, peptides, and protein. A total of 644 nursery pigs (10 to 14 replicates per treatment with 5 to 6 pigs per pen) were used in a series of 2 experiments with 2 trials each. In Exp. 1, pigs were fed a conventional complex Phase 1 nursery diet containing: 1) no SPH or SDPP; 2) 1.5% SPH; 3) 1.5% SDPP; 4) 3.0% SPH; 5) 3.0% SDPP; or 6) 1.5% SPH and 1.5% SDPP. Pigs were then fed the same Phase 2 and 3 diets with no experimental ingredient. In Exp. 2, pigs were fed a conventional complex Phase 1 nursery diet (no mammalian protein source) containing: 1) no SPH or SDPP; 2) 1.5% SPH; 3) 1.5% SDPP; or 4) 1.5% SPH and 1.5% SDPP. Pigs were then fed the same Phase 2 and 3 diets with no experimental ingredient. Dietary Lys levels were the same in all diets within each phase. In Exp. 1, ADG, ADFI, and G:F were not affected by source or

level of protein source during any growth phase ( $P > 0.10$ ). Overall G:F was greater ( $P = 0.08$ ) for pigs fed the 1.5% level of protein source than for those fed the 3.0% level of protein source, but there was no difference between protein source. In Exp. 2 during Phase 1, G:F was greater ( $P < 0.05$ ) for pigs fed SDPP than for those fed SPH. During Phase 2, ADFI was greater ( $P < 0.05$ ) for pigs fed SPH than for those fed the control diet. During Phase 3, ADG was greater ( $P = 0.08$ ) for pigs fed SDPP than for those fed SPH. Overall, ADG, ADFI, and G:F were not affected by protein source ( $P > 0.10$ ). The results of these experiments indicate that SPH or SDPP are excellent protein sources for nursery pigs. We acknowledge partial financial support and SPH from Green Earth Industries, Washington, DC.

**Key Words:** Nursery pigs, Marine protein, Plasma protein

**103 Prediction of the proximate content of homogenized whole Pacific Herring (*Clupea pallasii*) using near-infrared reflectance spectroscopy (NIRs).** C. Morishige<sup>1</sup>, J. R. Carpenter\*<sup>1</sup>, and B. Rasco<sup>2</sup>, <sup>1</sup>University of Hawaii at Manoa, Honolulu, <sup>2</sup>Washington State University, Pullman.

Numerous marine parks in the United States house and exhibit marine mammals. One of the main components of the diets of these animals is herring. In most marine mammal facilities, diet assessment is a key part of daily husbandry. In a facility that houses an endangered or threatened species of marine mammal, diet analysis is more critical. Traditional methods of diet analysis are time consuming and costly. The objective of this project was to use visible and short-wavelength near-infrared reflectance spectroscopy (SW-NIRs), because of its speed, efficiency and cost effectiveness, to develop chemometric calibration models for the prediction of fat, protein, moisture and mineral content of whole homogenized Pacific herring (*Clupea pallasii*). Eighty-six random samples from four different lots and two fisheries – North Bay Meat Company in British Columbia, Canada, and Petersburg Fisheries in Alaska – were homogenized and sub-samples were both analyzed with standard methods of proximate analysis and scanned by SW-NIRs using wavelengths from 600 to 1100nm. There were differences ( $P < 0.001$ ) between all analytes for both lots and location of catch. The prediction equations ( $R^2$ ) for the calibrations for lots ranged from .27-.88, .66-.93, .48-.87, and .24-.91 for moisture, fat, protein and ash, respectively. Calibration models for each location were fairly comparable: Alaska (Lot D)  $R^2 = 0.66-0.91$  and Canada (Lots A through C)  $R^2 = 0.47-0.81$ . Using the leave one out cross validation technique the NIRs equations were extremely repeatable and accurate in predicting nutrient composition of Pacific herring.

**Key Words:** Proximate analysis, NIRs, Pacific herring

**104 Catabolism of essential amino acids in enterocytes of growing pigs.** L. X. Chen\*<sup>1,2</sup>, Y. L. Yin<sup>1</sup>, W. S. Jobgen<sup>2</sup>, D. A. Knabe<sup>2</sup>, and G. Wu<sup>1,2</sup>, <sup>1</sup>The Chinese Academy of Sciences, Changsha, Hunan, P.R. China, <sup>2</sup>Texas A&M University, College Station.

Recent in vivo work with growing pigs suggests that the small intestinal mucosa plays an important role in degrading dietary essential amino acids (EAA). This study was conducted to test the hypothesis that EAA are extensively catabolized by pig enterocytes. Jejunal enterocytes were isolated from ten 50-d-old pigs weaned at 21 d of age (5 barrows and 5 gilts). Cells were incubated at 37 °C for 45 min in 2-ml oxygenated (95% O<sub>2</sub>/5% CO<sub>2</sub>) Krebs-bicarbonate buffer (pH 7.4) containing 1% BSA, 5 mM glucose, and plasma concentrations of amino acids (Wu et al. J Nutr 127: 2342, 1997). The medium also contained one of the

following L-amino acids at 0.5, 2, or 5 mM plus their L-[1-<sup>14</sup>C]- or L-[U-<sup>14</sup>C]-labeled tracers: His, Ile, Leu, Met, Phe, Lys, Thr, Trp, and Val, as well as 0 or 5 mM L-cycloserine (an inhibitor of transaminase). The use of [1-<sup>14</sup>C]- and [U-<sup>14</sup>C]-labeled amino acids allowed for quantification of the oxidation of their carboxyl carbons and remaining carbon skeletons (Wu et al. *Int J Biochem* 19: 937, 1987). Results indicate extensive transamination of all the three branched-chain amino acids (BCAA) in enterocytes, with their  $\alpha$ -ketoacids undergoing limited oxidation by branched-chain  $\alpha$ -ketoacid dehydrogenase or the Krebs cycle. BCAA degradation was markedly inhibited by L-cycloserine

( $P < 0.01$ ). Rates of enterocyte BCAA catabolism did not differ ( $P > 0.05$ ) between barrows and gilts. Oxidation of all other EAA was negligible in the cells from barrows or gilts. The lack of degradation of His, Met, Phe, Lys, Thr, and Trp was confirmed by HPLC analysis of amino acids in medium plus incubated cells. Collectively, our results demonstrate that BCAA are degraded substantially in pig enterocytes and that these cells are not the site for the extensive catabolism of His, Lys, Met, Phe, Thr, and Trp in the pig small intestine. Supported by funds from the Chinese Academy of Sciences, China NSF, and TAES.

**Key Words:** Amino acids, Catabolism, Small intestine

## Physiology and Endocrinology: Metabolic Regulation of Food Intake

**105 Hepatic energy status as a stimulus for hunger and satiety.** M. Friedman\*, *Monell Chemical Senses Center, Philadelphia, PA.*

Eating requires at least two basic decisions: what to eat, which is a decision about food choice, and how much to eat, which is a decision about food intake. Feeding behavior is controlled by a variety of signals, including those generated by the supply and utilization of metabolic fuels, which influence food intake in the short and long-term. Traditionally, it has been thought that separate metabolic signals associated with glucose and fat metabolism control food intake. More recently, evidence is accumulating that metabolic processes and events common to the metabolism of both glucose and fat, at the level of ATP production, are involved. Many studies point to a role of the liver in controlling feeding behavior, and a variety of evidence indicates an inverse relationship between hepatocyte ATP concentration and food intake. Experiments using metabolic inhibitors have shown that a reduction in hepatic energy status can trigger feeding behavior and have also elucidated how changes in fatty acid oxidation influence food intake by affecting energy metabolism in the liver. Other studies have demonstrated a relationship between food intake and liver energy in experimental diabetes and under fasting/refeeding conditions. Currently, we are studying the role of hepatic metabolism in obesity and have found that hyperphagia in several animal models of obesity is associated with reduced liver energy status. Very little is known about how changes in hepatocyte energy metabolism are transduced into a signal the nervous system can interpret. To date, evidence suggests that transduction could be mediated via changes in intracellular calcium concentrations and by alterations in hepatocyte sodium pump activity. Theoretically, changes in hepatic energy status could be transmitted to the brain via a neural or humoral route; at present, however, there is evidence only for a neural connection, specifically via vagal afferent neurons. Recent electrophysiological experiments suggest that a relatively small population of afferents in the hepatic branch of the vagus carry metabolic signals from the liver to the brain.

**Key Words:** Liver, Appetite, ATP

**106 The role of ghrelin in the regulation of energy balance in the sheep.** I. Clarke\*, *Monash University, Melbourne, Australia.*

Ghrelin mainly secreted by the stomach is an endogenous ligand for the growth hormone secretagogue receptor/s (GHS-R) and stimulates growth hormone (GH) secretion in a variety of species including sheep. In monogastric species examined, ghrelin also stimulates food intake. The ruminant presents an interesting model to study in this regard,

since the gastrointestinal tract is never completely emptied. The ghrelin producing cells are found in the abomasum of this species. Ghrelin levels transiently increase pre-prandially and fall post-prandially, indicating a conditioned response to feeding. The preprandial rise occurs in animals of all body weights and this stimulates a post-prandial rise in plasma GH levels. Such a relationship is maintained with increasing adiposity, but is lost in diet-induced reduction in body weight. Since GH is an important metabolic regulator, the pre-prandial rise in ghrelin secretion is probably important in relation to partitioning of energy. In sheep, either central or peripheral administration of ghrelin fails to stimulate food intake, in spite of changes in plasma GH levels. Since the central administration of ghrelin stimulates GH secretion, this demonstrates action via growth hormone releasing hormone and somatostatin neurons that is relayed to the pituitary somatotropes. Whereas ghrelin does not affect food intake in this species, it remains possible that central action affects energy expenditure, as in other species. Ghrelin receptor levels are higher in the arcuate nucleus of lean ewes, but the functional significance of this is unknown; if ghrelin reduces energy expenditure in this species, this may be one salient mechanism. The ghrelin system may present a means of regulating GH without affecting food intake in ruminants. Supported by NH&MRC, Australia.

**Key Words:** Ghrelin, GH, Appetite

**107 Metabolic regulation of food intake in ruminants.** M. S. Allen\* and B. J. Bradford, *Michigan State University, East Lansing.*

Food and energy intake of ruminant animals can change dramatically in response to changes in diet composition or metabolic state, and such changes are poorly predicted by traditional models of food intake regulation. Recent work suggests that temporal patterns of fuel absorption, mobilization, and metabolism affect food intake in ruminants by altering meal size and frequency. Research with non-ruminants suggests that meals can be terminated by a signal carried from the liver to the brain via afferents in the vagus nerve that are affected by hepatic oxidation of fuels and generation of ATP. Of fuels metabolized by the ruminant liver, propionate is likely a primary satiety signal because its flux to the liver increases greatly during meals. Propionate is utilized for gluconeogenesis or oxidized in the liver and stimulates oxidation of acetyl CoA. While propionate is extensively metabolized by the ruminant liver, there is little net metabolism of acetate or glucose, which may explain why these fuels do not consistently induce hypophagia in ruminants. Lactate is metabolized in the liver but has less effect on satiety probably because hepatic uptake