SWINE SPECIES: REPRODUCTION AND MANAGEMENT

0742 Betaine supplementation in maternal diet modulates the epigenetic regulation of hepatic gluconeogenic genes in neonatal piglets.

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Maternal gestational nutrition provides a critical window in which neonates are predisposed to metabolic syndrome in adult life. Betaine as a methyl-donor nutrient is critical for fetal development and it donates methyl donors for DNA and protein methylation through methionine metabolism, which is critical for the epigenetic regulation of gene expression. However, direct evidence regarding the effects of betaine supplementation in maternal diet during gestation on hepatic gluconeogenic genes in neonatal offspring are lacking. In this study, gestational sows were fed control or betaine-supplemented diets (0.3% w/w) throughout the pregnancy, and we are aiming to elucidate if maternal dietary betaine affects offspring hepatic gluconeogenic genes through epigenetic mechanisms. Neonatal piglets born to betaine-supplemented sows had significantly higher serum and hepatic betaine contents ($P < 0.05$), together with significantly enhanced expression of methionine metabolic enzymes ($P < 0.05$) in the liver. Interestingly, significantly higher serum concentrations of lactic acid ($P < 0.05$) and glucogenic amino acids, including serine ($P < 0.05$), glutamate ($P < 0.05$), methionine ($P < 0.05$) and histidine ($P < 0.05$) were detected in betaine-exposed piglets, which coincided with higher hepatic glycogen content ($P < 0.05$) and greater protein expression of gluconeogenic enzymes, pyruvate carboxylase (PC) ($P < 0.05$), cytoplasmic phosphoenolpyruvate carboxykinase (PEPCK1) ($P < 0.05$), mitochondrional phosphoenolpyruvate carboxykinase (PEPCK2) ($P < 0.05$) and fructose-1, 6-bisphosphatase (FBP1) ($P < 0.05$). Moreover, maternal betaine significantly changed the methylation status of both CpGs and histones on the promoter of gluconeogenic genes. The decreased *PEPCK1* mRNA was associated with DNA hypermethylation ($P < 0.05$) and increased repression histone mark H3K27me3 ($P < 0.05$), while the up-regulated *PEPCK2* and *FBP1* mRNA was associated with DNA hypomethylation ($P < 0.05$) and increased activation histone mark H3K4me3 ($P < 0.05$). Furthermore, hepatic expression of miRNAs predicted to target *PC* and *PEPCK1* was also affected by maternal betaine supplementation. Two out of seven miRNAs targeting *PC* and 6 out of 7 miRNAs targeting *PEPCK1* were detected to be dramatically suppressed ($P < 0.05$) in the liver of betaine-exposed piglets. Our results provide the first evidence that maternal betaine supplementation affects hepatic gluconeogenic genes expression in newborn piglets through enhanced hepatic methionine metabolism and epigenetic regulations which involve DNA and histone methylations, as well as miRNAs-mediated post-transcriptional mechanism.

Key Words: betaine, epigenetic regulation, gluconeogenic genes expression

0743 Rearing system affects the efficiency of oleic acid deposition in Duroc x Iberian pigs.

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The aim of the study was to evaluate the impact of the rearing system (intensive 2.5 m^2/pig vs. semi-extensive 30 m^2/pig) used during the growing-finishing period on PUFA deposition by using an oleic enriched diet during the finishing period. The Iberian pig regulations require a minimum of 51% of oleic acid in fat (10 cm from the caudal basis) at slaughter to be considered for cured ham. Therefore, the effect of the rearing system on the time spend to reach the oleic acid proportion was also evaluated. A total of 16 barrows (Duroc x Iberian) were selected at 90 kg of BW ($n = 8$ per system) and offered the same growing and finishing diets. A diet based on barley–wheat–oats and soybean–sunflower meal to contain 14.7 MJ/kg ME; 5.7 g/kg Lys; 60.9 g/kg ether extract and 34.3 g/kg oleic acid was fed for the finishing period. Back fat samples were collected from each pig on Days 0, 14, 28, 62, and 85 (slaughter) of the finishing period. Back fat samples were collected by an automatic cut/extraction system with a needle (8 mm Ø), and fatty acid profile was analyzed by the direct transesterification method and the percentage of oleic acid content calculated. The deposition response of the oleic acid was fitted by linear regression using the REG procedure of SAS. The comparison of slopes and times were analyzed with ANOVA by using the GLM procedure of SAS. The oleic acid deposition response for the semi-extensive reared pigs was y = 46.6 + 0.054(t) ($R^2 = 0.84$), while for the intensive reared pigs was y = 47.5 + 0.071(t) ($R^2 = 0.83$). Higher efficiency for oleic acid deposition was observed for the animals reared in the intensive system ($P = 0.013$). Therefore, a reduction of the days spent to reach the required level of oleic acid (51%) was observed for the animals reared in the intensive system than those reared in a semi-extensive system (49.0 vs. 80.4 d SEM = 5.24; $P = 0.003$). However, although higher efficiency on oleic acid and PUFA deposition was observed for the animals reared in the intensive system, the higher subcutaneous and inter-muscular but not intramuscular (marbling) fat content of the semi-extensive reared pigs has to be taken into account. It is concluded that the rearing system has a high impact on the efficiency of oleic acid deposition.

Key Words: Iberian, oleic acid, rearing system

0744 Effects of sugar beet pulp on reproductive performance of gestation sows. Z. Cheng*, D. Hou, Y. Chen, H. Zhang, B. Wang, Y. Wang, S. Bai, H. Lei, S. Jiang, and W. Jin, *Animal Nutrition & Feed Center, COFCO Nutrition and Health Institute, Beijing, China.*

Sugar beet pulp is widely used as feed ingredient in dairy feeds. However, its use in sow feeds may benefit sows because of its high level of fiber. The purpose of the study was to investigate the use of sugar beet pulp to see if there is any benefits for gestation sows fed sugar beet pulp. One hundred gestation sows were divided into three treatments with 33, 34, and 33 sows per treatment, they were fed diets containing 0, 7.5, or 15% of sugar beet pulp at breeding, respectively, for 3 mo. The diets contained the same calculated levels of crude protein and digestible energy. On d 91, they were fed the same lactating sow diets for another 25 d until farrowing. Total number of pigs born were 12.48 ± 2.44, 12.28 ± 2.21, and 13.24 ± 2.26 for sows fed diets containing 0, 7.5, or 15% of sugar beet pulp, respectively. Total pigs born live weight were 17.66 ± 2.87 kg, 17.86 ± 3.82 kg, and 18.45 ± 2.98 kg, for sows fed diets containing 0, 7.5, or 15% of sugar beet pulp, respectively. There were no significant differences in total pigs born and total pigs born live weight among all treatments ($P = 0.063$). Total number of pigs born alive were 11.76 ± 2.23, 12.00 ± 2.08, and 13.05 ± 2.40, for sows fed diets containing 0, 7.5, or 15% of sugar beet pulp, respectively; total number of pigs born alive were significantly increased ($P < 0.032$) by supplementing 15% sugar beet pulp into gestation sow diets as compared to control sow diets.

Key Words: sugar beet pulp, gestation sows, reproductive performance

0745 Utilizing meta-analyses to generate prediction equations for pork carcass back, belly, and jowl fat iodine value. C. B. Paulk*[1], J. R. Bergstrom[2], M. D. Tokach[1], S. S. Dritz[1], D. D. Burnett[1], J. M. DeRouchey[1], R. D. Goodband[1], J. L. Nelssen[1], and J. M. Gonzalez[1], *[1]Kansas State University, Manhattan, [2]DSM Nutritional Products, Inc., Parsippany, NJ.*

Iodine value (IV) is a measure of unsaturated fatty acids and is currently the industry standard for assessing pork fat quality. The objective of this meta-analysis was to use data from existing literature to generate equations to predict back, belly, and jowl fat IV of finishing pigs. The final database resulted in 24 papers with 169 observations for backfat IV, 21 papers with 124 observations for belly fat IV, and 29 papers with 197 observations for jowl fat IV. Some observations (back $n = 36$, belly $n = 37$, and jowl $n = 45$) changed dietary fatty acid composition during the experiment (i.e., switching from higher to lower or lower to higher iodine value product diet), where initial diets (I) were defined as those fed before the change in diet composition and final diets (F) were defined as those fed after the change in diet composition. The predictor variables tested were divided into five groups: 1) diet fat composition (dietary percent C16:1, C18:1, C18:2, C18:3, EFA, and unsaturated fatty acids, and iodine value product) for both I and F diets; 2) duration of feeding of the I and F diets; 3) ME or NE content of the I and F diet; 4) performance criteria (initial BW, final BW, ADG, ADFI, and G:F); and 5) carcass criteria (HCW and backfat thickness). PROC MIXED (SAS institute, Inc., Cary, NC) was used to develop regression equations, and experiment within paper was included as a random effect. Statistical significance for including terms in the models was determined at $P < 0.10$. Evaluation of models with significant terms was then conducted based on the Bayesian Information Criterion (BIC), where the lowest BIC were preferred. Optimum equations to predict back (BIC = 739), belly (BIC = 558), and jowl (BIC = 758) fat IV were: backfat IV = 84.83 + (6.87 × I EFA) − (3.90 × F EFA) − (0.12 × I d) − (1.30 × F d) − (0.11 × I EFA × F d) + (0.048 × F EFA × I d) + (0.12 × F EFA × F d) − (0.0060 × F NE) + (0.0005 × F NE × F d) − (0.26 × backfat depth); belly fat IV = 106.16 + (6.21 × I EFA) − (1.50 × F d) − (0.11 × I EFA × F d) − (0.012 × I NE) + (0.00069 × I NE × F d) − (0.18 × HCW) − (0.25 × BF); and jowl fat IV = 85.50 + (1.08 × I EFA) + (0.87 × F EFA) − (0.014 × I d) − (0.050 × F d) + (0.038 × I EFA × I d) + (0.054 × F EFA × F d) − (0.0066 × I NE) + (0.071 × I BW) − (2.19 × ADFI) − (0.29 × backfat depth). These regression equations may be used to predict the back, belly, and jowl fat IV of finishing pigs fed different diets.

Key Words: Iodine value, meta-analysis, pork quality

0746 The effects of copper source (copper sulfate or methionine hydroxy analogue chelate; Mintrex) on growth performance, carcass characteristics, and barn cleaning time in finishing pigs. K. F. Coble*[1], J. M. DeRouchey[1], M. D. Tokach[1], S. S. Dritz[1], B. Lawrence[2], J. Escobar[2], J. C. Woodworth[1], R. D. Goodband[1], and N. Boettger[2], *[1]Kansas State University, Manhattan, [2]Novus International, St. Charles, MO.*

Copper source and feeding duration on growth performance, carcass characteristics, and pen wash time were determined using 1196 pigs (initially 25.7 kg BW) in a 111-d study. Pigs were allotted to one of six dietary treatments, based on initial pen weight in a randomized incomplete block design with 26 pigs/pen and seven to eight pens/treatment. A negative control diet was supplemented with 17 ppm Cu from the basal trace mineral. Remaining diets were formulated by supplementing the negative control with 50 ppm Cu from $CuSO_4$ or Mintrex, or 125 ppm Cu from $CuSO_4$. The 50 ppm Cu as CuSO4 diet was fed for 111 d. The 50 ppm Mintrex and 125 ppm CuSO4 diets were fed for either 42 or 111 d. Diets were formulated 0.05% below the estimated standardized ileal digestible Lys

Table 0746. Copper source, level and duration for finishing pigs

Cu source		$CuSO_4$	Mintrex Cu	$CuSO_4$	Mintrex Cu	$CuSO_4$		
Added Cu, ppm		50	50	125	50	125		Treatment,
Duration, d	0–111	0–111	0–42	0–42	0–111	0 -111	SE	$P <$
d 111 BW, kg	122.7	124.6	124.3	122.5	125.3	125.0	1.33	0.16
ADG, kg	0.890	0.907	0.901	0.883	0.909	0.901	0.008	0.12
ADFI, kg	2.25[c]	2.33[a]	2.26[bc]	2.25[c]	2.30[abc]	2.31[ab]	0.027	0.02
G:F	0.397[ab]	0.389[c]	0.399[a]	0.393[abcc]	0.396[abc]	0.390[bc]	0.003	0.04
HCW, kg	89.0	89.3	88.9	89.4	89.7	90.2	0.92	0.71
Wash time, s	345	332	323	365	324	352	15.2	0.26

[1] Means within row with different superscripts differ, $P < 0.05$.

requirement. Average daily gain was not affected ($P > 0.12$). Pigs fed either 50 or 125 ppm of Cu from $CuSO_4$ from d 0–111 had greater ADFI ($P < 0.02$) than pigs fed the control or diet with 50 ppm of added Cu from Mintrex from d 0–42. Feed efficiency was poorer ($P < 0.04$) for pigs fed either 50 or 125 ppm of added Cu from $CuSO_4$ fed throughout compared with those fed 50 ppm of Cu from Mintrex from d 0 to 42. There were no differences in final BW, HCW, or pen wash time. In summary, pigs fed 50 ppm of Cu from Mintrex for the first 42 d of the finishing period had improved G:F compared with pigs fed 50 or 125 ppm of Cu from $CuSO_4$ for the complete finishing period; however, G:F for those pigs was not improved when compared to those not fed added Cu.

Key Words: finishing pig, copper, wash time

0747 Immunocastration affects testicular mass, serum concentrations of testosterone, and average daily gain of boars. D. Lugar*[1], S. Clark[2], S. Callahan[1], L. Wittish[1], and M. Estienne[3], *[1]Virginia Tech, Blacksburg, [2]Virginia–Maryland Regional College of Veterinary Medicine, Blacksburg, VA, [3]Virginia Tech, Suffolk.*

The objective of this study was to determine the effects of an immunological castration product (Improvest, Zoetis) on reproductive steroid hormones, reproductive organs, and growth. A total of 72 Landrace x Yorkshire boars (69 d of age, 22.76 ± 4.64 kg BW) were used in two successive replications. This study was a randomized design with three treatment groups: single injection (SI) of Improvest at 10 wk of age, double injection (DI) of Improvest at 10 and 15 wk of age, and intact controls (no Improvest; CNT) (n = 24 per group). At wk 10, 15, 20, and 25, blood was collected and serum harvested to evaluate testosterone concentrations via RIA, and BW were determined. At wk 25, 18 pigs (n = 6 per group) were sacrificed and testicles were removed, weighed, and measured for length, width, and circumference. Statistical analysis was performed using JMP Pro 10. Testosterone concentrations at wk 20 and 25 were less ($P < 0.0001$ and $P = 0.0003$, respectively) for DI (0.065 ng/mL and 1.178 ng/mL, respectively) compared to SI (1.589 ng/mL and 6.372 ng/mL, respectively) and CNT (1.356 ng/mL and 5.920 ng/mL, respectively). Testosterone concentration for wk 10 and 15 were similar ($P = 0.5332$ and $P = 0.7875$, respectively) among the three treatments. Body weights were greater ($P = 0.017$) for DI compared to CNT at wk 25 (122.0 kg and 117.6 kg, respectively), while SI (120.1 kg) was not different ($P = 0.398$) from DI and tended ($P = 0.119$) to be greater than CNT. The ADG from birth to the initiation of the treatments (10 wk of age) was not different ($P = 0.7631$) among treatments; ADG from 10 to 25 wk of age was greater ($P = 0.0093$) for DI compared to CNT and there was a tendency ($P = 0.067$) toward a greater ADG for SI compared to CNT. Both left and right testicle length, width, and circumference were less ($P < 0.0001$) for DI compared to SI and CNT. Testicle wt (g/kg BW) was less ($P < 0.0001$) for both the left and right testicles for DI compared to SI and CNT. The results of the current study indicate that immunological castration has a major impact on ADG and that a single injection tended to cause a greater ADG when compared to intact males

Key Words: boars, immunocastration, swine

0748 New perspectives to the enterotoxigenic *E. coli* F4 infection model in weanling piglets in relation to the susceptibility genotypes and bacterial shedding. P. J. Roubos*, R. H. G. M. Litjens, J. W. Resink, and Y. M. Han, *Nutreco Research & Development, Boxmeer, Netherlands.*

Post-weaning diarrhea caused by enterotoxigenic *E. coli* (ETEC) is a major problem in weaner piglets. Responses of individual animals to ETEC infection are very different and show high varieties in animal experiments with ETEC infection. The aim of this study was to optimize the ETEC F4ac infection model in piglets by combining the genotype susceptibility with performance and bacterial shedding.

Before weaning 120 male piglets (individual housed) were tested for susceptibility or resistance towards ETEC O149:F4ac by a DNA marker based test. After weaning (27 ± 2-d-of-age) the piglets were orally infected with 5 mL of an inoculum suspension (containing $1.5*10^8$ CFU/ml ETEC F4ac in a 2.5% sucrose solution) at d 7, 8, and 9 after weaning. Fecal bacterial shedding was determined at d 7 (before challenge), 10, and 13 by spreading on CBA plates. Hemo-

lytic colonies were confirmed by an agglutination test with an ETEC F4ac specific antiserum. In the first week after challenge all (n = 4) homozygote sensitive (SS) animals died. During the same period, feed efficiency (FE) was significant lower ($P < 0.001$) in heterozygote sensitive (RS)-animals (FE = 0.67; n = 61) compared with the homozygote resistant (RR) animals (FE = 0.8; n = 55). After this week the animals started to recover and the feed efficiency differences became less. Diarrhea incidence was significantly different ($P < 0.001$) between genotypes SS (91%) compared to RS (67%) and RR animals (47%) in the first week after challenge. Furthermore while ETEC was hardly detected in the fecal material of the RR animals, they were found in most of the RS animals and in all SS animals (see Table 0748). In conclusion, susceptible animals (RS and SS) compared to resistant animals (RR) animals showed poorer feed efficiency, higher diarrheal incidence and higher numbers of ETEC fecal shedding in the first week after challenge. The DNA marker based test can be used to select animals that are susceptible for ETEC for inclusion in the ETEC infection model.

Key Words: ETEC F4, infection model, genotype

Table 0748. Detection of ETEC in fecal material at Day 10 and 13 as grouped by genotype

Genotype	Positive both days	Negative	Positive at Day 10	Positive at Day 13	ND	Total
RR	0	51	2	2	0	55
RS	35	10	9	6	1	61
SS	4	0	0	0	0	4
						120

ND = not determined