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MONDAY, MARCH 11

GARY ALLEE SYMPOSIUM: SCIENCE IN PRACTICE

O001 **Factors to consider when doing fat quality research—Perspectives of a meat scientist.** S. N. Carr*, P. J. Rincker, *Elanco Animal Health, Greenfield.*

Fat quality is a topic of vast importance to all sectors of the swine industry. When researching, we must consider the primary objective of the study as this should dictate the breadth and depth of measuring fat quality. Some questions to consider may be: Do we expect an effect and if so, what kind? Are we trying to alter the fat or just monitor for changes? Once we have established the extent of the measurement, we must determine what to measure. Some of the important characteristics of fat include composition, color, firmness, fatty acid profile, and iodine value. It should be noted that although these characteristics can be measured separately, they are not necessarily independent. Additional items of interest may include effects on further processing such as brine uptake, slicing yield, smearing, and storage stability. Few research labs operate commercial style equipment, so the results of small scale research may not translate directly to the commercial processing industry. Next, we need to determine anatomically where to measure. It would be cost prohibitive and out of scope for most research studies to measure all fat depots and characteristics. Therefore, we should focus where we expect an effect and that are economically important to the industry. Some options would include areas specific to a carcass such as belly fat, back fat, ham or shoulder seam fat, and loin marbling. Alternatively, the interest may be in fat intended for further processing, which would be a combination of all of these. It is important when collecting samples to understand that fat exists in multiple layers. General characterization of fat from a specific carcass location should include all of the layers while other research may want to focus on specific layers. The storage of the fat samples should also be taken into consideration. Shorter chain fatty acids will oxidize rapidly, so if these are of interest, the samples may require special treatment and/or storage at extreme temperatures. Finally, consider that there is value in all kinds of research ranging from basic to commercial. However, it may not always be feasible to address this entire range with a single study.

Key Words: fat quality, meat scientist, research

O002 **What factors need to be considered when doing fat quality research—Perspective of a nutritionist**. M. D. Tokach*, R. D. Goodband, J. M. DeRouchey, S. S. Dritz, J. L. Nelssen, *Kansas State University, Manhattan.*

Increased use of byproducts from the ethanol and food processing industries has led to greater concern over pork fat quality. As a nutritionist, targeting fat quality as an outcome raises several issues. Fat quality importance and definition varies by pork processor. Processors that sell bellies for cured bacon or target Japanese markets require firm fat with low iodine value (IV). Processors that sell bellies for microwaveable bacon or market fresh pork to domestic markets may have less stringent requirements. Once fat quality becomes a target, the method for measuring it becomes an issue. Because IV is used by some processors, it has become the most common measure; however, it is not highly correlated with bacon slicing yields and is influenced by many factors besides diet. If measuring IV, another consideration is which fat depot to evaluate. Although jowl fat typically has a higher IV than belly or back fat, the relationship between depots is not consistent. The method of measuring IV also must be standardized. The cost of analysis (NIR < calculation from fatty acid analysis < direct iodine titration) is inversely related to their accuracy. Calculation of IV from fatty acid analysis is preferred by many, but differences exist in the number of fatty acids used in the equation. From a diet standpoint, although there is a relationship between dietary IV product and IV of fat depots, numerous other factors influence our ability to predict IV outcome of carcass fat. These include diet factors, such as previous diet history, withdrawal programs, ractopamine, and dietary fiber and non-diet factors, such as disease, genetics, environmental temperature, or gender. Anything that alters ADG and de novo fat synthesis can alter IV. Use of immunocastration greatly alters the dynamics of the change in fatty acid composition due to the rapid increase in feed intake and de novo fat synthesis with time post second injection. Recent meta-analysis of existing data has provided us with tools to better predict IV; however, we still need considerable research to fully predict IV. Finally, other methods of measuring fat quality need research attention.

Key Words: fat quality, nutrition, pig

O003 **Pork fat quality: Implications for international product specifications and determining its economic value.** E. B. Sheiss*, A. W. Duttlinger, *Indiana Packers Corporation, Delphi.*

The quality of carcass fat influences pork processing characteristics, manufacturing efficiencies and product quality, due mainly to impacts on product firmness. A minimum requirement for firmness of fresh bellies, loins and shoulders is a key component in specifications for important international markets. The US pork industry exports approximately 25% of its annual production. Thus, failing to meet product specifications for export markets may have significant negative effects to the pork value chain. Published research measuring nutritional, genetic and management influences on fat quality has largely attempted to measure the impact on bacon processing and the oxidative stability of pork during storage. Fat quality and product firmness and its corresponding influence on meeting specifications for fresh premium export products has not been quantified. This may be due to the lack of objective criteria for product quality standards, inconsistent industry specifications, confounding factors influencing premium export pass rate, or the availability of sufficient observations. Nonetheless, in addition to processing characteristics, fresh product quality attributes should be evaluated in order to determine total carcass value. Differences in carcass value attributed to fat quality will likely vary between companies. The economic value of fat quality will be impacted

by the level of further processing, specifications of finished products, proportion of products and sales volumes committed to various markets, relationship between existing and desired carcass population, differences in operational cost structures, and foreign exchange rates. Fat quality plays a large role in determining the pass rate of chilled fresh export products. Accurate measurement and value assessment of carcass fat quality differences are critical to establishing and communicating fat quality targets to the industry.

Key Words: swine, fat quality, carcass value

O004 **Economic implications of achieving fat quality specifications.** A. M. Gaines[1], D. DiPietre[2,*], [1]*The Maschhoffs, Carlyle, IL,* [2]*Knowledge Ventures LLC, Columbia, MO.*

High levels of unsaturated fat found in DDGS contribute to soft fat in the pork carcass. With the increased use of DDGS in swine diets, pork processors are monitoring fat quality levels more closely. Soft pork fat is undesirable to the pork processor as the product is less appealing to the consumer, negatively affects processing characteristics, and reduces shelf life. The most common measurement of pork fat quality utilized by pork processors is iodine value. Typically, iodine value is measured indirectly using equations based upon fatty acid analysis or near infrared analysis. Iodine value is positively correlated with the presence of unsaturated or soft fat in the carcass. Given the negative impact of soft pork on the value of the carcass and its cost of fabrication, some pork processors have imposed standards for iodine value. As an example, pork carcasses going to a pork processor who is imposing such a standard may not exceed a threshold level for the iodine value such as 74. Producers who fail to meet this standard are asked to change their production practices in order to comply with this standard. Although there are several non-nutritional factors that influence iodine value the imposition of a minimum threshold value for iodine is likely to have a meaningful impact on the producer's nutrition program. From a nutritional standpoint, this could mean feeding lower levels of DDGS in total or in late stage diets, which in today's market environment would increase total finishing feed costs. With 40% of the U.S. corn crop being diverted to mandated ethanol production, it is already challenging for pork producers to find replacement feed ingredients, especially in crop years where overall production of feed grains is limited, such as in a widespread drought condition. As pork processors continue to determine the impact of soft pork fat on their business and as the supply of feed ingredients becomes more volatile and subject to other production process demands, it is imperative to understand the economic consequence of adopting future iodine value standards and how the profit optimal outcome for producers and processors is likely to change as a result.

Key Words: economic value, fat quality, swine

UNDERGRADUATE STUDENT ORAL COMPETITION

O005 **Effects of glucuronic acid and N-acetyl-D-glucosamine supplementation on the in vitro maturation and fertilization of porcine oocytes.** K. Boyd*, T. Donley, C. Fahy, K. Lemon, B. D. Whitaker, *Animal Science, University of Findlay.*

Pig oocytes were supplemented with components of the perivitelline space, which could decrease the incidence of polyspermic penetration and improve embryonic development. Oocytes were supplemented with 0.01 mM glucuronic acid (GA) and N-acetyl-D-glucosamine (GlcNAc) or 0.005 mM GA and GlcNAc during the last 24 h of maturation. At the end of maturation, oocytes (n = 300) were evaluated for zona pellucida and perivitelline space thickness, intracellular glutathione concentrations, and fertilization kinetics at 12 h after fertilization. Embryos were evaluated for cleavage and blastocyst formation at 48 h and 144 h after fertilization, respectively. There were no significant differences between the treatment groups for zona pellucida thickness, intracellular glutathione concentrations, sperm penetration rates, or male pronuclear formation. Oocytes supplemented with 0.01 mM GA and GlcNAc or 0.005 mM GA and GlcNAc had significantly thicker ($P < 0.05$) perivitelline space (6.28 ± 0.92μm) and (5.99 ± 0.86μm) compared to the control (8.91 ± 0.71μm) and a significantly lower incidence ($P < 0.05$) of polyspermic penetration (20.00 ± 4.23%) and (24.00 ± 3.14%) compared to the control (32.00 ± 4.80%). Oocytes supplemented with 0.01 or 0.005 mM GA and GlcNAc had a significantly higher ($P < 0.05$) percentage of embryos cleaved by 48 h after fertilization (80.00 ± 5.23%) and (78.00 ± 5.14%) compared to the control (66.00 ± 5.27) and a significantly higher ($P < 0.05$) percentage of embryos reaching the blastocyst stage of development by 144 h after fertilization (28.00 ± 5.23%) and (26.00 ± 5.14%) compared to control (14.00 ± 2.27%). Results indicate that there are positive effects of supplementing 0.01 mM GA and GlcNAc or 0.005 mM GA and GlcNAc to the oocytes during maturation in order to decrease the incidence of polyspermic penetration and improve embryonic development in pigs.

Key Words: N-acetyl-glucosamine, polyspermy, pigs

O006 **Estrogen receptor 1 and 2 mRNA expression and protein localization in the porcine endometrium during the estrous cycle and early pregnancy.** O. L. Swanson [1,*], J. R. Miles [2], J. L. Vallet [2], [1]*Departmart of Animal Science, South Dakota State University, Brookings,* [2]*Reproduction Research Unit, USDA-ARS U.S. Meat Animal Research Center, Clay Center.*

Between d 10 and 12 of gestation, the pig embryo undergoes elongation and produces estrogen, which serves as the key molecule for maternal recognition of pregnancy. Around d 15 of gestation, the embryo begins its superficial implantation with the endometrium and a second spike in estrogen occurs from the embryo. The objective of this study was to characterize the estrogen receptors (ESR), ESR1 and 2, mRNA expression and protein localization in pig endometrium during the estrous cycle and early pregnancy. White crossbred gilts (n=30) were randomly assigned to cyclic or pregnant treatment groups. Endometrial tissues were collected, frozen and fixed at d 10, 12, 14, 16 and 18 of estrous cycle and pregnancy (n=3 per day per treatment group). Expression for *ESR1* and *2* mRNA was measured using Real-time PCR and data were analyzed using GLM procedure for ANOVA. For localization of ESR1 and 2 proteins, immunohistochemistry was performed within microscopic sections of pig endometrium. Expression of *ESR1* mRNA was increased ($P<0.01$) at d 10 of the estrous cycle and pregnancy compared with d 12, 14, 16 and 18. Interestingly, *ESR1* mRNA expression was greater ($P<0.05$) from estrous cycle compared to pregnant, irrespective of day. In contrast, *ESR2* mRNA expression was greater ($P<0.05$) at d 14, 16 and 18 compared to d 10 and 12 of pregnancy; however, *ESR2* mRNA expression remained minimally expressed throughout the estrous cycle. Protein for ESR1 localized to nucleus of luminal and glandular epithelium and staining intensity decreased during

pregnancy and the cycle. In contrast, ESR2 protein was only faintly localized to the nuclei of luminal and glandular epithelium at d 16 and 18 of pregnancy. These results suggest that ESR2 may play a role in mediating the response of the endometrium to embryonic estrogen, particularly during implantation. †USDA is an equal opportunity provider and employer.

Key Words: estrogen receptor, pig, pregnancy

O007 **Serum bovine pregnancy associated glycoproteins and progesterone in beef heifers that experienced late embryonic/fetal mortality.** L. K. Kill[1,*], K. G. Pohler[2], G. A. Perry[1], M. F. Smith[2], *[1]Department of Animal Science, South Dakota State University, Brookings, [2]Division of Animal Science, University of Missouri, Columbia.*

The incidence of late embryonic/fetal mortality in beef heifers is approximately 4 to 5% and most of the loss occurs around the time of embryo-uterine attachment (d 27 to 41; d 0 = insemination). Inadequate placental function and (or) a compromised maternal environment may be causes of late embryonic/fetal mortality. Bovine pregnancy associated glycoproteins (bPAGs) are secreted by fetal binucleate trophoblast cells into the maternal circulation and have been used as a marker of placental function. Progesterone is secreted by the corpus luteum and is required for preparation of the maternal environment and maintenance of pregnancy in mammals. Our hypothesis was that maternal serum concentrations of bPAGs and progesterone will be lower around d 30 in heifers that subsequently undergo late embryonic/fetal mortality compared to heifers that maintain pregnancy. Therefore, our objective was to examine the relationship between late embryonic/fetal mortality and maternal concentrations of bPAGs and progesterone in beef heifers. Ovulation was synchronized in 679 beef heifers on five ranches in South Dakota and insemination occurred at a predetermined time (d 0). Pregnancy was determined (d 30 to 35 and after d 65) and a single blood sample was collected on d 30 to 35 and circulating concentrations of bPAGs and progesterone were assayed utilizing an ELISA or RIA, respectively. The incidence of late embryonic/fetal mortality was 5% (n = 21; final pregnancy rate = 60%) and serum concentrations of bPAGs were higher ($P < 0.05$) in heifers that maintained pregnancy (n = 406) (2.43±0.06; mean ± SEM) compared to heifers that experienced embryonic/fetal loss (1.98 ± 0.05). There was no difference ($P = 0.14$) in serum concentrations of progesterone between heifers that did or did not maintain pregnancy. In summary, a decrease in bPAGs but not progesterone, in heifers that experienced late embryonic/fetal mortality, suggests that failure to maintain pregnancy may be initiated by the conceptus rather than due to inadequate luteal secretion of progesterone.

Key Words: beef heifers, bovine pregnancy associated glycoproteins, embryonic/fetal mortality

O008 **Utilization of an estrogen antagonist to develop a non-surgical model for delayed implantation in rats.** B. E. Abramovitz[*], J. A. Green, K. G. Pohler, R. D. Geisert, *University of Missouri, Columbia.*

Delayed implantation is a term that describes how development of mammalian embryos can be put into seasonal or lactational diapause until a suitable time to give birth. In the rat, embryonic diapause can be induced during lactation through suckling inhibition of follicular estrogen secretion which is necessary for initiation of implantation on d 4 post-coitus (pc). Ovariectomy followed by daily administration of progesterone is one method of artificially inducing diapause in mate rats. Objective of the present study was to determine ability of an estrogen antagonist (ICI) to induce delayed implantation in mated rats and demonstrate if a single treatment with estrogen can trigger implantation following induced delay. Thirty-two Sprague Dolly rats (8 wks of age) were exposed to intact males and checked daily for mating. Females were assigned to one of three experimental groups: 1) Control group (CON) received no treatment (n=6); 2) ICI group (n=8) received a 100 µg s.c. injection of the estrogen antagonist ICI 182,780 (TOCRIS BioSciences) plus 2 mg progesterone daily from d 2 to 8 pc; and 3) ICI+E group (n=7) received 100 µg of ICI 182,780 plus 2 mg progesterone from d 2 to 8 pc and treated with 1µg of estradiol-17b on d 9 pc. All females treated with ICI continued to receive 2 mg progesterone until sacrificed on d 15 or 16 pc. Total number of implantation sites (IS), total uterine weight (UW), fetal + placental weight (FW), and crown-rump length (CR) were measured. No IS were detectable in uteri of ICI females. Number of IS were similar ($P < 0.08$) between CON and ICI+E females (15.5 vs 12.3). There was a day x trt effect ($P < 0.001$) for UW, FW and CR. UW (CON d15 16.8 g; d16 25.3 g vs ICI+E d15 1.8 g; d16 3.1 g), FW (CON d15 0.8 g; d16 1.5 g vs ICI+E d15 0.06 g; d16 0.1 g), and CR (CON d15 11.2 mm; d16 16.4 mm vs ICI+E d15 2.5 mm; d16 2.9 mm) decreased in ICI+E females. Implantation was delayed with ICI administration but treatment of females with estrogen was necessary to reinitiate implantation 5 days later.

Key Words: delayed implantation, ICI, rat

O009 **Blood glucose concentrations during the peripartum in insulin resistant dairy cattle at prepartum period.** F. Da Rosa[1,2,3,*], E. Schwegler[3,4], E. Schmitt[5], A. Schneider[3,6], P. Montagner[3,4], M. Weschenfelder[3,4], A. R. Krause[2,3], F. Del Pino[3,7], C. Brauner[2,3], M. N. Corrêa[3,4], *[1]Animal Sciences, University of Illinois, Urbana, [2]Animal Sciences, [3]Núcleo de Pesquisa, Ensino e Extensão em Pecuária (NUPEEC), [4]Department of Veterinary Clinics, Federal University of Pelotas, [5]Brazilian Agricultural Research Corporation, EMBRAPA - CPAFRO, Porto Velho, [6]Nutrition College, [7]Department of Biochemistry, Federal University of Pelotas, Brazil*

The aim of this study was to assess the serum glucose level during the peripartum period in pluriparous dairy cows diagnosed in three different levels of insulin resistance in the prepartum. Nineteen cows from a commercial herd kept in a semi-extensive system in southern Brazil were enrolled in this study. Glucose tolerance test (GTT)was conducted on 20 d prepartum and the cows were categorized into three groups according to the rate of glucose metabolism. Sensitive Group (GS): the higher rate of glucosemetabolism; Intermediate Group (GI) and Resistant Group (GR): lower rate of glucose metabolism. The level of insulin resistance was indirectly measured by the AUC (area under the curve) of glucose, where the GS was more sensitive (lower area), and the GR more resistant (greater area). The blood was collected on 23, 14, 7 and 3 d prepartum, on the day of partum and on 3, 6, 9, 16 and 23 d postpartum. Statistical analysis was performed using the SAS program. The GTT was compared between groups by analysis of variance using one-way ANOVA and glucose measurements were analyzed by repeated measures using the MIXED procedure with a value of $P<0.05$ considered significant. It was observed a similarity glucose concentrations between GS, GI and GR (66.47 mg/dl; 66.23 mg/dl; 70 mg/dl, respectively), in the prepartum, whereas, on the postpartum period the GR group (88.71 mg/dl) had higher concentrations of glucose than the GI (71.48 mg/

dl) (P=0.02) and also higher than the GS (75.27 mg/dl) (P=0.07). Considering the energetic metabolism, our results showed that dairy cows more resistant to insulin in the prepartum had higher glucose concentrations in the postpartum. This is due to the less capacity for uptake the glucose by the tissues. In addition, previous approaches reported that during the peripartum the insulin resistance increases in mammals tissues. In summary, pluriparous dairy cows more insulin resistant during the prepartum, demonstrates higher glucose concentrations during the postpartum. Therefore, our results further emphasize the importance of the glucose metabolism during the prepartum with its response to insulin resistance during the transition period.

Key Words: dairy cows, energetic metabolism, insulin resistance

O010 **Effect of organic zinc supplementation on metallothionein and zinc transporter -1 mRNA expression in duodenum of grow-finish pigs.** J. Feldpausch[1,*], P. S. D. Weber[2], G. M. Hill[1], J. Link[2], D. C. Mahan[3], *[1]Animal Science, [2]Michigan State University, East Lansing, [3]Animal Sciences, Ohio State University, Columbus.*

Zinc (Zn) is an important trace mineral in the diet of grow-finish pigs. Metallothionein (MT1A) and Zn Transporter-1 (ZnT1) play an important role in Zn homeostasis. Currently, the expression and molecular regulation of MT1A and ZnT1 in the duodenum of grow-finish pigs is not known. Therefore, the objective of this study was to establish that MT1A and ZnT1 are expressed in the duodenum and to determine the effect of different dietary concentrations of organic Zn on the expression of these genes in duodenal mucosal cells of grow-finish pigs. Treatment groups consisted of 4 diets: 1) 0 ppm trace minerals; 2) 25 ppm organic Zn; 3) 50 ppm organic Zn; and 4) 100% NRC trace minerals (organic) added to a corn-soybean meal basal diet with no added TM but supplemented with Se, Ca, and P to meet NRC requirements. Pigs used in the current study were a subset of a larger study in which 25 kg BW pigs were allotted in RCBD to treatments (5 or 6 pigs/pen) based on sex, weight and litter; 3 dietary phases were fed with ractopomine (9 g/909 kg) added during the last 3 wk. Pigs were killed at approximately 117 kg at which time duodenum mucosa scrapings were collected and snap-frozen in liquid nitrogen. RNA was extracted from 3 duodenum samples in each of the 4 diet groups (12 animals total). cDNA was synthesized from the RNA isolates (average RIN=7.5) and used to evaluate gene expression of MT1A and ZnT1 by specific Taqman Expression Assays. MT1A and ZnT1 expression was normalized using the geometric mean of GAPDH and SDHA by qbase software. GAPDH and SDHA were identified as the two most stably expressed reference genes from a pool of 9 potential reference genes using gNorm. Both MT1A and ZnT1 were expressed in the mucosal cells but no significant dietary effect for either was observed in this data set (P=0.95). These results indicate that regulation of MT1A and ZnT1 in the duodenum of grow-finish pigs may not be at the pre-translational level. Further investigation, therefore, is warranted to determine if MT1A and ZnT1 are regulated at the post-translational level and/or if other Zn transporters are regulated at the pre- or post-translational level.

Key Words: duodenum, grow-finish pigs, zinc

O011 **Differential gene expression of skeletal muscle tissue due to association with intramuscular fat in beef cattle.** C. Bayliff*, P. Lancaster, G. Horn, *Animal Science, Oklahoma State University, Stillwater.*

Methods to increase intramuscular fat (IMF) without increasing other fat depots are needed to improve efficiency of beef production. The objective of this experiment was to identify genes in muscle that may affect IMF development. Steers (9 animals; 300-400 kg) were harvested and *longissimus dorsi* muscle tissue samples were dissected to separate fat and muscle under magnification; muscle was separated into muscle fibers that are (LDW) and are not (LDWO) in close proximity to IMF deposits. A bovine microarray (24,000 oligonucleotide probes, 70 nucleotides long, printed in singlet) was used to compare the transcriptome in a subset of 4 steers between LDW and LDWO within a steer to identify novel genes. In addition, genes of interest were evaluated between LDW and LDWO using RT-PCR. Microarray found 56 differentially expressed genes, 7 of which were found to be of interest to our study and seem to have functional similarities among them. The two main similarities are categorized as: 1) those involved in angiogenesis and blood flow, and 2) those involved in the cytoskeleton. Genes involved in angiogenesis and blood flow were up-regulated (2-fold or greater) in LDW compared to LDWO. In the second category, 2 genes were down-regulated and 1 was up-regulated in LDW versus LDWO. RT-PCR showed no significant differences in mRNA expression of lactate dehydrogenase B *(LDHB)* or cytochrome c oxidase subunit 3 *(COX3)* between LDW and LDWO, but mRNA expression of *LDHB* and *COX3* in LDWO was negatively correlated (r = -0.76 and -0.60, respectively) with marbling score. Likewise, there was no significant difference in mRNA expression of insulin-like growth factor-I *(IGF-I)* or myostatin *(MSTN)* between LDW and LDWO. It was found that *MSTN* mRNA expression was positively correlated (r = 0.74) between LDW and LDWO, but *IGF-I* mRNA expression was not. Differentially expressed genes with potential influence on IMF development were identified, and further studies should explore their effects. Though RT-PCR showed no significant differences in the initial genes of interest, they yielded interesting correlations that should be examined.

Key Words: gene expression, intramuscular fat tissue

O012 **Effects of late-gestation coproduct supplementation and time of weaning on cow performance and reproduction.** A. C. Kloth*, L. M. Shoup, D. W. Shike, *Animal Sciences, University of Illinois, Urbana.*

The objective of this study was to evaluate the effects of late-gestation coproduct supplementation and time of weaning on cow performance and reproduction. Fall-calving, Angus (n = 123) and crossbred cows (n = 164) grazing mixed tall fescue/red clover pastures were blocked by breed (1 Angus block and 2 crossbred blocks) and randomly assigned to 1 of 3 gestational treatments; 1) no supplement (CON), 2) low supplement (2.1kg DM/head·d^{-1}, LS) and 3) high supplement (8.3kg DM/head·d^{-1}, HS). Supplement was 30% soybean hulls and 70% dried distillers grains with solubles. Supplementation period was 102 d from 6/2/11 to 9/13/11. The average calving date was 9/12/2011 ± 10 days. Effects of weaning time were also evaluated; half of male calves (n = 69) were early weaned (EW) at 80 ± 10 d of age. The other half of males and all female calves (n = 196) were normal weaned (NW) at 185 ± 10 d of age. Cows were synchronized with CO-Synch+CIDR® and timed

AI on 80 ± 10 d postpartum. Cows were exposed to a clean-up bull for 45 days. Only effects of supplementation were evaluated for variables up until time of EW. For variables after EW, there were no interactions between supplementation and time of weaning; thus, only main effects will be presented. The HS cows had greater ($P \leq$ 0.04) BW at the mid-point of supplementation and post-calving than LS and CON cows. At time of pregnancy determination, HS and LS cows had greater ($P \leq 0.01$) BW than CON cows. At all timepoints, the HS cows had greater BCS than the CON cows, with LS cows being intermediate ($P \leq 0.01$). Supplementation had no effect ($P \geq 0.12$) on calf birth BW, BW at time of EW, milk production, AI conception or overall pregnancy rates. Early weaning increased ($P \leq 0.04$) cow BW and BCS at time of pregnancy determination. The AI conception rates were greater ($P = 0.03$) for EW cows (69%) than NW cows (53%); however, there was no difference ($P = 0.71$) in overall pregnancy. Although gestational supplementation improved cow BW and BCS, it did not affect calf performance, milk production, or cow reproduction. Early weaning increased cow performance and AI conception rates.

Key Words: early wean, reproduction, supplementation

O013 **Effects of varying palmitic to stearic acid ratio in supplemental fat on dry matter intake, milk yield and milk composition of heat stressed primiparous cows.** K. A. Froehlich*, J. Spahn, N. B. Litherland, *Animal Science, University of Minnesota, St Paul.*

Previous research has demonstrated that a high proportion of stearic acid is incorporated into milk fat and may aid in maintaining milk fat yield during heat stress. Objectives of this pilot study were to determine if increasing the palmitic acid to stearic acid ratio in supplemental fat alters DMI and milk component yield. We hypothesized that primiparous cows supplemented with a low palmitic:stearic ratio would have greater milk and milk fat yield than a high palmitic:stearic ratio fat supplement and that supplemental fat would result in higher milk fat yield than control. Twenty-seven (n=9) primiparous Holstein and cross-bred cows averaging 27.3 kg milk/d and 201 days in milk were fed one of three diets: 1) control TMR, 2) control TMR + low palmitic:stearic fat and 3) control TMR + high palmitic:stearic fat for 21 days. Supplemental fat was added to the control diet by replacing 680 g/d of ground corn with 680 g/d of fat. Control diet contained 17.7% crude protein, 27.1% NDF, 26.7% starch and 3.0% fat. Cows were housed in tie stalls and average ambient temperature during the study was 29.4 °C. Supplemental fats were similar in fatty acid composition with the exception of low palm contained 36.8% C16:0 and 54.8% C18:0 and high palm contained 55.7% (C16:0) and 46.7% C18:0. Data were analyzed using Proc MIXED in SAS with model effects of treatment, day and breed. DMI was similar ($P = 0.47$) and averaged 18.3, 17.7 and 17.2 ± 0.7 kg/d for control, low palm and high palm respectively. Milk yield was also similar ($P = 0.53$) among treatments and averaged 22.8, 24.6, 23.0 ± 1.2 kg/d and 3.5% FCM yield was also similar ($P = 0.18$) and averaged 22.4, 25.2 and 22.5 ± 1.2 kg/d for control, low palm and high palm respectively. Milk fat content was similar among treatments ($P = 0.60$) and averaged 3.4, 3.7 and 3.6 ± 0.2 % and milk protein was also similar ($P = 0.82$) among treatments and averaged 3.2, 3.2 and 3.3 ± 0.1% for control, low palm and high palm respectively. In conclusion, compared with control, supplemental fat did not result in significant changes in DMI, milk yield or milk component yield.

Key Words: heat stress, primiparous cow, supplemental fat

O014 **Effects of dietary sulfur source on hydrogen sulfide gas concentrations in feedlot lambs.** C. J. Long[1,*], T. L. Felix[2], K. M. Daniels[1], S. C. Loerch[1], *[1]Animal Sciences, The Ohio State University, Wooster, [2]Animal Science, University of Illinois, Urbana.*

Sulfate reducing bacteria (SRB) reduce dietary SO_4 to hydrogen sulfide gas (H_2S) in the rumen through a pH dependent process. Elevated H_2S increases the incidence of S-induced polioencephalomalacia. Data on the abrupt exposure of ruminants to different sources of dietary S and the effects on ruminal H_2S are lacking. We hypothesize that acidic sources of SO_4, such as DDGS and H_2SO_4, will result in greater ruminal H_2S and greater reductions in DMI than $NaSO_4$. Therefore, the objectives of this research were to determine effects of 3 sources of dietary S on DMI, ADG, and ruminal H_2S concentrations over a 27 d period. Lambs (n = 88; BW = 51.1 ± 0.4 kg) were blocked by BW (heavy and light) and gender (male and female), and allotted to 23 pens with 3 lambs/pen. Lambs were fed a corn-based control diet with no supplemental S (0.12% S on a DMB) for 56 d prior to an abrupt switch to the experimental diets. Experimental diets were: 1) 60% DDGS, 2) corn-based diet with $NaSO_4$, and 3) corn-based diet with H_2SO_4 All diets were formulated to contain 0.4% S. Diets were allotted within block to the 23 pens. Ruminal gas samples were collected by rumenocentesis at 4 h after feeding on d 1, 14, and 27 to measure H_2S. Data were analyzed using Proc MIXED (SAS) for a complete block design with effects of day as a repeated measure. Diet acidity was measured and pH was 4.57, 6.18, and 4.01 for the DDGS, corn-based $NaSO_4$, and corn-based H_2SO_4 diets, respectively. Lambs fed supplemental $NaSO_4$ had greater ($P < 0.05$) ADG, DMI, and G:F than those fed supplemental H_2SO_4 or 60% DDGS. A day by diet interaction occurred ($P < 0.01$) for ruminal H_2S concentration. Lambs fed supplemental $NaSO_4$ had H_2S concentrations below 200 mg/L on d 1, 14, and 27. Lambs fed supplemental H_2SO_4 had 0, 800, and 600 mg H_2S/L on d 1, 14, and 27, respectively. Lambs fed 60% DDGS had 0, 2,200, and 1,950 mg H_2S/L on d 1, 14, and 27, respectively. These data suggest that at the same dietary S concentration, acidic supplemental S sources increased ruminal H_2S concentration, and decreased DMI and ADG.

Key Words: hydrogen sulfide, ruminant, sulfur

O015 **Effects of grazing novel endophyte-infected fescue following grazing endophyte-infected fescue on steer performance.** M. R. Milnamow*, T. B. Wilson, D. B. Faulkner, F. A. Ireland, D. W. Shike, *Animal Sciences, University of Illinois, Urbana-Champaign.*

The objective of this study was to investigate the use of novel endophyte-infected fescue as a means to alleviate fescue toxicosis symptoms; exhibited as poor ADG, BCS, hair coat score (HCS; 1-5), and increased respiration rate. Fall-born, Simmental x Angus crossbred steers (n = 36, average BW = 182.2 ± 28.2 kg) were stratified by BW and randomly allotted into 6 groups. Groups were randomly assigned 1 of 3 treatments; 1) endophyte-infected fescue (May 2–September 18, 2012, E+), 2) novel endophyte fescue (May 2–September 18, 2012, NE), and 3) E+ (May 2–July 10, 2012; period 1) followed by NE (July 11–September 18 2012; period 2; E+/NE). Groups were grazed on 4.05 ha pastures that were subdivided into six 0.68 ha paddocks, and were rotated every 5 days. Put-and-take cattle were used to maintain similar forage availability. Period 1 data were analyzed using a contrast of NE vs. E+ and E+/NE as both treatments were grazed on E+ pastures during this time. In period 1, NE cattle had greater ($P < 0.01$) ADG and tended ($P = 0.09$) to have greater BCS gain than E+ cattle. Period 1 HCS was improved ($P < 0.01$) for NE cattle compared to E+ cattle. There were no differences

($P = 0.54$) in period 1 respiration rates. Period 2 ADG of NE and E+/NE cattle was not different ($P = 0.18$), with both being greater ($P \leq 0.01$) than E+ cattle. In period 2, cattle grazing E+/NE had greater improvement in HCS than cattle grazing E+, and cattle grazing NE were intermediate ($P \leq 0.01$). Period 2 respiration rates for NE cattle were lower ($P = 0.03$) than E+ cattle and tended to be lower ($P = 0.10$) for E+/NE than E+ cattle. Overall ADG and BCS of NE and E+/NE cattle were greater ($P < 0.01$) than E+ cattle. Overall HCS change tended to be greater ($P = 0.06$) for E+/NE than NE cattle, but both groups showed greater ($P < 0.01$) improvement than E+ cattle. Cattle grazed on NE following E+ experienced compensatory gain and had similar performance to those that grazed NE continuously. Partial pasture renovation with novel endophyte-infected fescue could be an effective strategy to mitigate the effects of fescue toxicosis.

Key Words: cattle, endophyte, fescue

O016 **Effects of feed delivery methods (automated feeding, salt limiting, or hand-feeding) for stocker calves grazing bermudagrass on growth performance, behavior, and labor inputs.** E. M. Mashie [1,*], A. K. Sexten [1], E. B. Kegley [2], J. L. Reynolds [2], J. A. Hornsby [2], S. Gadberry [3], *[1]Animal Science, Kansas State University, Manhattan, [2]Division of Agriculture, University of Arkansas, Fayetteville, [3]Cooperative Extension Service, University of Arkansas, Little Rock.*

The successes of new technology, such as automated feeders (Solar Feeders, Inc., Fort Smith, AR) have not been explored as a potential resource for supplementing grazing stocker calves. Crossbred heifers (n = 78, initial BW = 246 ± 3.5 kg) were used to evaluate the effects of delivery methods on behavior, BW gain, pasture and corn gluten (CG) supplement utilization, and labor inputs. Calves were stratified by BW and assigned randomly to 1 of 6-2.4 ha bermudagrass pastures. Pastures were blocked by location and assigned randomly to 1 of 3 delivery treatments: 1) hand feeding CG once daily (HF); 2) automated feeder dispersing CG 3x/d (AF); or 3) CG mixed with 7.5% salt offered ad-libitum (SL). Data were analyzed using PROC MIXED of SAS with pen as the experimental unit. For the 85-d trial, the AF, HF, and SL calves had similar final BW ($P = 0.22$). However, AF and SL calves had lower ADG at d 28 than HF (0.88, 0.90, and 1.04 kg; $P = 0.05$), and total ADG tended to be lower in SL calves compared to HF (0.69 vs. 0.81 kg; $P = 0.08$). Visual observations of behavior (11 h/d every 14 d) did not detect any differences in time spent lying, standing, or grazing ($P > 0.14$). AF calves tended to be more mobile than HF and SL (7.9, 3.56, and 5.0 observations/period; $P = 0.15$), but tended to not lay in the shade as often as SL (2.0 and 8.0 observations/period; $P = 0.16$). Data from accelerometers (HoBoware Pendant G, Onset Computer Corp, Bourne, MA) attached to 3 heifers/pasture for 7-d periods at 14 d intervals indicated that AF calves spent a greater proportion of time standing ($P < 0.05$). The AF required less ($P < 0.01$) feeding labor (38.2 min/wk) than HF (43.4 min/wk) or SL (50.3 min/wk). Results indicated that using AF in place of HF or SL had minimal effects on growth performance or behavior while saving the producer labor.

Key Words: stocker cattle, supplement delivery method, supplementation

O017 **A comparison of mixing milk replacer by weight vs. volume.** S. M. Koch [1,*], L. Baumann [2], S. McGuirk [3], N. Cook [3], D. Ruff [4], *[1]School of Veterinary Medicine, UW-Madison School of Veterinary Medicine, [2]Animal and Food Science, University of Wisconsin, River Falls, [3]Department of Medical Sciences, UW-Madison School of Veterinary Medicine, [4]Mayville Animal Clinic.*

Ensuring that calf milk replacer (MR) maintains a consistent concentration of total solids can improve health in young calves. The objective of this study was to determine if mixing milk replacer powder by weight (W) was more consistent than mixing by volume (V). The second objective was to determine if mixing temperature (T) affected variability in solids content of the MR. Data were collected from two farms in WI where Farm 1 mixed multiple batches of MR and Farm 2 mixed one large batch of MR for all calves. On Farm 1, a total of 85 samples were collected by V and 75 samples by W. On Farm 2, a total of 60 samples were collected by W. Temperatures were recorded at the time of mixing and Brix measurements were taken at room temperature from mixed samples. Data were analyzed using a one way analysis of variance. Differences were not significant between mixing by V or W for total solids concentration (15.58 ± 0.17% and 15.37 ± 0.18% for V and W, respectively). However, the variance of total solid concentration for V was 1.14% and for W was 3.88%. Ranges in total solid concentration at Farm 1 were 11.4-19.2% and Farm 2 were 12.6-16.2% indicating inconsistency in mixed MR. The mixing temperature was collected for 190 samples on both farms. A correlation coefficient of -0.2799 was significant indicating temperature had a negative effect on the total solids concentration of the milk replacer. The outcome of this study indicates a wide range of variation of MR solids on farms; this needs to be further evaluated and addressed. Using appropriate mixing methods for MR may increase consistency and help in improving calf health.

Key Words: dairy calves, milk replacer, total solids concentration

O018 **Assessment of non-penetrating captive bolt stunning followed by electrical induction of cardiac arrest in veal calves. Part I: Maintenance of insensibility and electrocardiographic activity.** K. D. Vogel, B. Bartz*, M. Collins, R. Livingood, H. Sobczynski, *Animal and Food Science, University of Wisconsin, River Falls.*

Effective stunning and maintenance of unconsciousness are important factors in assuring food animal welfare during the slaughter process. The purpose of this study was to evaluate the impact of non-penetrating captive bolt stunning followed by electrical induction of cardiac arrest on maintenance of insensibility and electrocardiographic activity in veal calves. This was the first part of a two part study. Ninety calves from the same farm were randomly assigned to one of two treatment groups in a balanced unpaired-comparison design. The first treatment group (CONTROL) was stunned with a non-penetrating captive bolt gun (n = 45). The second group (n = 45) was stunned with a non-penetrating captive bolt gun followed by secondary electrical induction of cardiac arrest (HEAD/HEART). Means separation for the incidence of events in this study were determined through the use of chi square tests. All calves in both treatments were rendered instantly insensible by the initial non-penetrating captive bolt stun. Signs of return to sensibility were monitored before shackling, immediately after shackling, and

at the end of blood collection. The following signs of return to sensibility were monitored: corneal reflex (eye blink from touch), response to squeezing the nose with a needle-nose plier, rhythmic breathing, vocalization, and righting reflex. No signs of return to sensibility were observed during the three data collection points from any of the calves in this study. The HEAD/HEART method resulted in a reduction ($P < 0.05$) of rhythmic QRS complexes (15.1% detected) versus the control method (94.1% detected). Overall, the data indicated no difference between CONTROL and HEAD/HEART with regard to animal welfare because the initial non-penetrating captive bolt stun was effective in maintaining insensibility in all calves. However, the HEAD/HEART method did not completely abolish the presence of rhythmic QRS complexes. The data in this study suggest that secondary induction of cardiac arrest is not necessary with effective non-penetrating captive bolt stunning in veal calves.

Key Words: stunning, veal, welfare

O019 **Assessment of non-penetrating captive bolt stunning followed by electrical induction of cardiac arrest in veal calves. Part II: Veal quality and blood yield.** K. Vogel, B. Bartz, M. Collins*, R. Livingood, H. Sobczynski, *Animal and Food Science, University of Wisconsin, River Falls.*

The purpose of this study was to evaluate the impact of non-penetrating captive bolt stunning followed by electrical induction of cardiac arrest on veal quality and blood yield. This is the second part of a two part study. The first part revealed that secondary electrical induction of cardiac arrest was unnecessary because all calves were rendered instantly insensible by the initial stun and did not return to consciousness. Ninety calves from the same farm were randomly assigned to one of two treatment groups in a balanced unpaired-comparison design. The first treatment group (CONTROL) was stunned with a non-penetrating captive bolt gun (n=45). The second group (n=45) was stunned with a non-penetrating captive bolt gun followed by secondary electrical induction of cardiac arrest (HEAD/HEART). For meat quality evaluation, all samples were collected from the 12th rib region of the *Longissimus thoracis.* Carcasses were evaluated for petechial hemorrhaging (blood splash) and rib fractures at the cardiac region. Meat samples were evaluated for color, drip loss, ultimate pH, cook loss, and Warner-Bratzler shear force. The L* values (measure of meat color lightness) were darker ($P < 0.05$) in the HEAD/HEART group (45.08 ± 0.72) than the CONTROL group (47.10 ± 0.72). There were no differences ($P > 0.05$) observed in a* (redness) and b* (yellowness) values between treatments. No differences ($P > 0.05$) were observed in drip loss, ultimate pH, cook loss, and Warner-Bratzler shear force. The blood yield from CONTROL (7,217.9 ± 143.5 g) was greater ($P < 0.05$) than HEAD/HEART (6,656.4 ± 143.5 g). Overall, the data indicated no difference between CONTROL and HEAD/HEART with regard to animal welfare because the initial stun was effective in all calves. However, meat quality and blood yield were negatively impacted by the HEAD/HEART method. The data in this study suggest that secondary induction of cardiac arrest is not necessary with effective non-penetrating captive bolt stunning in veal calves.

Key Words: meat quality, stunning, veal

O020 **Effects of pyrethroid insecticides on reproductive parameters of beef bulls.** T. P. DelValle [1,*], C. F. Shipley [2], F. A. Ireland[1], H. M. French [2], V. L. Jarrell [1], D. B. Faulkner [1], J. Fuselier[2], D. W. Shike [1], *[1]Department of Animal Sciences, [2]College of Veterinary Medicine, University of Illinois, Urbana-Champaign.*

Pyrethroid insecticides are commonly used in the beef cattle industry. Research with lab animals and case studies with livestock have suggested that these chemicals may reduce male fertility. The objective of this study was to determine if pyrethroids, cyfluthrin and beta-cyfluthrin, have antiandrogenic effects in bulls. Angus x Simmental bulls (n=24) ranging from 1 to 6 years of age (BW = 773.00 +/- 185.51 kg) were given a breeding soundness exam and semen was collected via electroejaculation on d 0. Bulls were stratified by age and allotted to treatments: control (CON; n = 5), pour-on (POUR; n = 5), fly tag (TAG; n = 7), and pour-on and fly tag (POUR+TAG; n = 7). POUR bulls received 24 mL of the product CyLence (1% cyfluthrin) by topical syringe, TAG bulls were ear tagged with two CyLence Ultra fly tags (8% beta-cyfluthrin), and POUR+TAG bulls received both products. Bulls were maintained by treatment group on non-adjacent pastures and semen was collected weekly for the next 9 weeks. Semen was analyzed for motility, progressive motility, and morphology with the aid of computer-assisted semen analysis. Blood samples were also taken weekly from the tail vein for testosterone (T) assays. Only samples from CON and POUR+TAG bulls were analyzed for T. There were no ($P \geq 0.13$) treatment by week interactions for any response variables; thus, only treatment means are presented. There were no differences in motility ($P = 0.41$) or progressive motility ($P = 0.60$) among treatments. Furthermore, there were no differences ($P = 0.41$) in morphology percentages among treatments. The T concentration did not differ ($P = 0.16$) between CON and POUR+TAG bulls. In conclusion, pyrethroid treatments showed no significant effects on semen quality or T levels. These findings therefore indicate that the pyrethroids cyfluthrin and beta-cyfluthrin do not have adverse effects on bull fertility when administered at label dosages by topical pour-on and fly tag methods respectively.

Key Words: bull, fertility, pyrethroid

O021 **Choosing appropriate temperature-humidity indices to predict the incidence of heat stress in lactating dairy cattle using local weather data in Iowa.** E. Hodges [1,*], P. J. Berger [2], G. Takle [3], *[1]Dairy Science, Iowa State University, [2]Animal Science, Iowa State University , [3]Geological and Atmospheric Sciences, Iowa State University, Ames.*

Heat stress is known to cause a drop in milk production and reduce reproductive success in dairy cattle. Few areas in the United States have been evaluated to compare temperature-humidity index (THI) values to milk production and reproductive success. THI results from other areas were matched against those of central Iowa, with the incorporation of wind speed and solar radiation impact. Wind speed and solar radiation have been ignored in comparison of indices with regard to dairy cattle. A majority of the THI models have been evaluated in areas of warm average monthly winter dry-bulb temperature (above 5ºC) and hot summers (above 20ºC) in Georgia and Arizona. Iowa, like other Midwest states, has cold winter temperatures (below -5ºC) and high relative humidity in summer and in winter months (above 75%). These factors, combined with strong winds, make Iowa a unique climate for milk production and dairy cattle management. Iowa's winters yielded THI monthly averages greater than 15 THI units below those of

Athens, Georgia. Additionally, the THIs for Iowa were below those observed in Georgia. Iowa, however, had higher peak summer average percent relative humidity. The incorporation of wind speed and solar radiation relationships from beef feedlot trials in Nebraska matched an existing THI formula established from Georgia work in central Iowa. This finding reduces the need to record solar radiation and wind speed data in order to predict heat stress in pasture based dairy herds. No one THI should be used to compare predicted heat stress for multiple geographic locations, due to differences in climate factors.

Key Words: heat stress, Iowa, temperature-humidity index

GRADUATE STUDENT COMPETITION: MS ORAL

O022 **Effects of feeding high- and low-fiber fractions of air-classified canola meal on diet nutrient digestibility and growth performance of weaned pigs.** X. Zhou [1,*], M. A. Oryschak [2], R. T. Zijlstra [1], E. Beltranena [2], *[1]Department of Agricultural, Food & Nutritional Science, University of Alberta, [2]Alberta Agriculture and Rural Development, Edmonton, Canada.*

The energy value of solvent-extracted canola meal (CM) is limited by its high fiber content. The fiber-rich seed hull is denser than the oil-free cotyledons. Using a stream of air, air classification separates CM into low-fiber, light particles and high-fiber, heavy particles of interest for feeding pigs and cattle, respectively. Crude fiber, ADF, and NDF in light-particles were reduced by 96, 34, and 28% compared with CM. Also, *Brassica* (*B*) *juncea* meal is a novel canola species with lower fiber but higher glucosinolate content that needs quality evaluation. *B. napus and B. juncea* CM, or their 2 fractions were fed to 288 weaned pigs (7.1 kg) as a 2 × 3 factorial arrangement with 12 replicate pens per treatment. Wheat-based diets including 20% test feedstuff provided 2.5 and 2.4 Mcal NE/kg and 5.3 and 4.8 g standardized ileal digestible lysine/Mcal NE and were fed for 9 and 28 d, respectively. Feed added, orts, and pig BW were measured weekly to calculate pen ADFI, ADG, and G:F. Feces were collected to calculate diet apparent total tract digestibility (ATTD) of DM, GE, and CP. Pigs fed *B. juncea* had 3 and 2% higher ($P < 0.001$) ATTD of DM and GE than pigs fed *B. napus*. Feeding the light-particle fraction increased ($P < 0.001$) ATTD of DM, GE, and CP by 4, 3, and 3% compared with CM, respectively. For the entire trial, pigs fed *B. juncea* consumed 33 g/d less feed ($P < 0.001$), had 0.02 g:g higher G:F ($P < 0.05$), but ADG did not differ compared to pigs fed *B. napus*. Feeding pigs light-particle fractions did not affect ADFI ($P > 0.05$), increased G:F ($P < 0.05$) 0.02 g:g, and tended to increase ADG ($P = 0.07$) by 18 g/d compared to CM. In conclusion, air classification of CM increased diet nutrient digestibility, but only modestly increased G:F of weaned pigs due to dietary fiber reduction.

Key Words: air classification, canola meal, digestibility, performance, weaned pig

O023 **Bioavailability of lysine in *Rhizopus microsporus* for nursery pigs as determined by slope-ratio bioassay.** D. M. van Sambeek [1,*], A. Rahkshendah [1], B. J. Kerr [2], J. H. van Leeuwen [3], N. K. Gabler [1], *[1]Animal Science, Iowa State University, [2]USDA-ARS, [3]Civil and Construction Engineering, Iowa State University.*

Fluctuations in feed prices have led pig producers to search for alternative feed ingredients. Our previous studies have suggested that the filamentous fungus *Rhizopus microsporus* variant *oligosporus* (RO), grown in the leftovers of ethanol production, can potentially be used as a high quality source of dietary protein, fat, vitamins, and minerals for growing pigs. The objective of this study was to evaluate the bioavailability of lysine (Lys) in RO for nursery pigs. A total of 32 gilts (6.5±0.25 kg BW) were individually penned and assigned to 5 dietary treatments. A basal diet (n = 5) formulated to contain 8 g of lysine/kg, but adequate in all other amino acids, was supplemented with 2 and 4 g of lysine/kg from either RO (n =14) or L-lysine-HCl (n =13). Diets were formulated to contain 15.4 MJ/kg of DE. Average daily gain (ADG) and feed intake (ADFI), gain to feed ratio (G:F) and lean growth (LG) were determined over a 7 week period. The latter was determined using dual-energy X-ray absorptiometry. Bioavailability of Lys was estimated using the slope ratios (RO : L-lysine-HCl) obtained from common-intercept multiple regression analyses. Daily feed intake was similar among treatment groups ($P > 0.1$). Average daily gain, LG and G:F response to dietary Lys was linear regardless of Lys source ($P < 0.01$). The bioavailability of Lys in RO for ADG, G:F and LG was 0.54, 0.61 and 0.69, respectively. These results suggest that RO can be used as a source of protein in the diet of nursery pigs. Supported by the Iowa Pork Producers Association grant #12-112.

Key Words: lysine bioavailability, pig, *Rhizopus microsporus*

O024 **Evaluation of chocolate candy feed as an alternative carbohydrate source to lactose for weanling pigs.** J. Guo [1,*], C. Phillips [2], M. T. Coffey [2], S. W. Kim [1], *[1]Animal Science, North Carolina State University, Raleigh, [2]Murphy Brown LLC, Rose Hill.*

This study was to determine the effect of chocolate candy feed, (CCF, IIC, St. Louis, MO), as an alternative carbohydrate source to lactose for nursery pigs. Weaned pigs (21 d age, 7.1 ± 0.3 kg, n = 1,408) were fed 4 diets (16 pens/treatment and 22 pigs/pen) in phase 1 (10 d) and 2 (17 d). During phase 3 (22 d), pigs were fed a common diet. Treatments were L100 (20 and 8% lactose in phase 1 and 2, respectively; 0% replacement of lactose with CCF), L85 (15% replacement), L70 (30% replacement) and L55 (45% replacement). Whey permeate was used as a source of lactose. Replacement of lactose by CCF was based on an equivalent total sugars basis. Treatment diets contained equal amounts of essential amino acids and energy. During phase 1, ADFI linearly increased ($P < 0.05$) as CCF increased in the diet with no differences in ADG or G:F. During phase 2, ADG linearly decreased ($P < 0.05$) as CCF increased in the diet whereas ADFI and gain: feed were not affected. No differences were observed in growth performance during the combined phase 1 and 2 period when treatment diets were fed. In phase 3, ADFI was linearly reduced ($P < 0.05$) in pigs fed increasing levels of CCF during the previous treatment phases, but no differences were detected for ADG or G:F. During the overall trial period, ADG, ADFI, and G:F were not different among treatments indicating no adverse effects of CCF replacing lactose on growth performance of nursery pigs. Plasma urea nitrogen was not different among treatments at the end of phase 1 but tended to linearly increase ($P = 0.088$) with increasing CCF at the end of phase 2. During phase 1, there was no difference in fecal scores among treatments. Mortality rate of pigs was not different among treatments whereas morbidity of pigs tended to linearly decrease ($P = 0.083$) as CCF increased. In conclusion, CCF can be used to replace up to 45% of the lactose in weanling pig diets without negative effects on growth performance or health status.

Key Words: chocolate candy feed, lactose, nursery pig

O025 **Effect of cranberry on salmonella colonization and performance of nursery pigs.** M. Stanley*, M. Rostagno, B. Richert, S. Eicher, *Purdue University, W. Lafayette.*

A major goal of the swine industry is to develop and implement alternatives to antibiotics in the control of pathogens. Cranberry-based additives have shown promise in human medicine by preventing or controlling urinary tract infections in humans, presumably by reducing adhesion of pathogenic bacteria such as *E. coli* and *Salmonella*. In this study, we examined whether cranberry-based additives can effectively reduce *Salmonella* colonization in nursery pigs. At weaning, 126 nursery pigs were divided into four groups and administered one of four treatments: 1) a powdered cranberry additive administered in feed; 2) a fiber cranberry additive administered in feed; 3) a powder cranberry additive administered in water; or 4) control (no cranberry additive). At 4 weeks post-weaning, all pigs were challenged (orally) with 10^5 CFU of *Salmonella enterica* serovar Typhimurium. Fecal samples were collected at weaning, 2, 3, and 4 wks post-weaning, and 24 h and 1 wk post-challenge. Performance data (ADFI, G:F and ADG) were collected from each pig to quantitate *Salmonella* colonization. Pigs were euthanized 2 wks post-challenge and ileal contents, ileal mucosa scrapings, mesenteric lymph nodes, cecal contents and rectal contents were collected and examined for *Salmonella* colonization. There were no differences in growth performance (ADFI, G:F, ADG) across all treatments ($P < 0.05$). Likewise, while there were differences in *Salmonella* concentrations at different times points and in different samples, there were no differences in *Salmonella* concentrations across the treatments ($P < 0.05$). Taken together, these data indicate that under these experimental conditions, cranberry additives do not affect performance, but also do not reduce *Salmonella* concentrations in challenged nursery pigs.

Key Words: antibiotic alternative, cranberry, swine industry

O026 **See page 45 for abstract.**

O027 **Divergent selection for residual feed intake impacts carcass composition of pigs on high or low energy diets.** E. K. Arkfeld[1,*], E. R. Benedict[1], R. C. Johnson[2], J. M. Young[1], J. F. Patience[1], J. C. M. Dekkers[1], N. K. Gabler[1], S. M. Lonergan[1], E. Huff-Lonergan[1], *[1]Animal Science, Iowa State University, Ames, [2]Farmland Foods, Denison.*

The objective was to determine the effects of divergent selection for residual feed intake (RFI) on carcass composition of pigs fed a high energy low fiber (HELF) or a low energy high fiber (LEHF) diet. RFI is the difference between a pig's observed and expected feed intake based on its level of growth and backfat; low RFI (LRFI) pigs are more efficient than high RFI (HRFI). Pigs (n=168 LRFI [n=85 barrows, n=83 gilts], n=170 HRFI [n=88 barrows, n=82 gilts]) from the 8thgeneration of the ISU selection project were randomly assigned to 20 pens in 2 rooms. Ten pens were placed on the HELF diet (ME 3.31 Mcal/kg; 9.5% NDF) and 10 on the LEHF diet (ME 2.91Mkal/kg; 24.6% NDF). Pigs were harvested (92-140kg BW) in 3 groups and evaluated for HCW, fat depth (FD), loin depth (LD) and calculated percent lean (PL) using a Fat-O-Meater® probe. Data were analyzed using the PROC MIXED procedure of SAS with fixed effects of line, diet, and sex, random effects of harvest group (n=3), room (n=2), and pen (n=20), and live weight at harvest as a covariate. LEHF diets decreased HCW ($P<0.01$; 92.3 v. 97.0kg), FD ($P<0.01$; 17.4 v. 21.7mm), and LD ($P<0.01$; 57.9 v. 60.5mm) and increased PL ($P<0.01$; 55.2 v. 52.9%). The LRFI carcasses had reduced FD (18.5 v. 20.6mm) and greater LD (60.8 v. 57.6mm) and PL (54.9 v. 53.2%) compared to the HRFI carcasses ($P<0.01$ for all traits). Gilts had decreased FD (7.4 ±0.8 v. 20.7 ±0.7mm) and greater LD (60.4 v. 58.0mm) and PL (54.7 v. 53.2%) than barrows ($P<0.01$ for all traits). A tendency for interactions ($P=0.06$) of line with sex and diet were observed for FD, with LRFI gilts having the least FD, and HRFI pigs on the HELF diet having the greatest FD v. LRFI pigs fed LEHF diet the lowest. Regardless of diet, LRFI pigs were leaner and heavier muscled than HRFI pigs. Although diet impacted composition, carcasses from HRFI and LRFI lines were generally not differentially impacted by diet. Supported by USDA-AFRI Grant no. 2011-68004-30336.

Key Words: composition, fiber, RFI

O028 **Response of swine divergently selected for feed efficiency to an exogenous adrenocorticotropin hormone (ACTH) challenge.** J. D. Jenkins[1,*], A. K. Johnson[1], L. L. Anderson[1], J. C. M. Dekkers[1], N. K. Gabler[1], F. R. Dunshea[2], *[1]Iowa State University, Ames, [2]The University of Melbourne, Parksville, Australia.*

Stress factors such as disease, social structure and fear generally reduce livestock performance and feed efficiency. The objective of this study was to evaluate the role of the ACTH-cortisol axis and its associated stress response in feed efficiency, using pigs divergently selected for residual feed intake (RFI). Pigs selected for high RFI (HRFI) are less feed efficient than those selected for low RFI (LRFI), for a given growth rate and composition. Six HRFI and six LRFI gilts (68±5.2 kg) from the 8th generation of the ISU Yorkshire RFI selection lines were challenged with 0.2 IU/kg BW of exogenous porcine ACTH. Serial blood samples were collected at -30, -15, -1, 30, 45, 60, and 90 min relative to ACTH administration and plasma cortisol concentrations were determined. Concentration and area under the curve (AUC) data were analyzed using the MIXED procedure of SAS. Compared to HRFI gilts, the average baseline endogenous cortisol was 25% lower in the LRFI vs. HRFI gilts (240 vs. 324 nmol/L, $P=0.08$) and was used as a covariate adjustment in all analyses. As expected, both lines responded to the ACTH challenge by increasing plasma cortisol over time ($P<0.01$). However, cortisol concentrations peaked earlier for LRFI than HRFI gilts but, LRFI gilts tended to have a lower maximum concentration ($P=0.07$). Compared to the HRFI challenged gilts, the average post-challenge cortisol level was lower in LRFI gilts (452 vs. 612 nmol/L, $P=0.03$). LRFI gilts also tended to have a lower AUC up to 90 min than the HRFI pigs ($P=0.07$). In conclusion, divergent selection for RFI has resulted in altered pre- and post ACTH induced cortisol responses in gilts. The HRFI gilts tended to be more responsive to this stress challenge but recovered equally as well as gilts selected for LRFI. Therefore, the ability of livestock to recognize and cope with stress may be related to RFI and feed efficiency. This project was supported by USDA-AFRI Grant no. 2011-68004-30336.

Key Words: cortisol, feed efficiency, swine

O029 **The effect of heat stress on inflammatory signaling in porcine skeletal muscle.** S. I. Rosado Montilla[1,*], S. C. Pearce[1], D. Gardan-Salmon[1], N. K. Gabler[1], J. W. Ross[1], R. P. Rhoads[2], L. H. Baumgard[1], S. M. Lonergan[1], J. T. Selsby[1], *[1]Animal Science, Iowa State University, Ames, [2]Animal Science, Virginia Technical Institute, Blacksburg.*

Heat stress (HS) is a major concern for the swine industry as pigs under HS conditions exhibit reduced feed intake and impaired growth rate. Skeletal muscle has been shown to release its own

cytokines and contribute to a pro-inflammatory environment during times of stress; however, little is known about how porcine skeletal muscle responds to HS. The objective of this study was to determine the extent to which HS increased inflammatory signaling in pig red semitendinosus muscle (STR). Crossbred gilts were exposed to thermoneutral (TN) conditions (20°C; 35%>40% humidity) or HS (35°C; 20%>35% of humidity) conditions for a period of 1, 3 or 7 days. A group of TN animals was pair fed to mimic intake patterns of the 7 day HS animals to account for reduced feed intake effects in HS pigs. Inflammatory signaling was assessed by measuring the expression of TNF-α, NFκB, IkB-α, and IL-6 through Western blots. The expression of NFκB, IL-6 and IkB-α was similar between all treatment groups. However, TNF-α was increased after 1 and 3 days of HS before returning to baseline levels (1.00±0.34 vs 2.65±0.21 and 1.00±0.34 vs 2.37±0.39, respectively). Despite alterations in TNF-α expression, these data demonstrate that HS does not substantially increase inflammatory signaling in porcine STR. Supported by USDA/NIFA Grant No. 2011-67003-30007.

Key Words: cytokines, hyperthermia, pig

O030 **Impact of maternal exercise on ovarian development in the pig.** S. Kaminski*, A. Grazul-Bilska, E. Berg, K. Vonnahme, *Animal Science, NDSU, Fargo.*

The objective was to determine how maternal exercise from mid to late gestation impacts offspring ovarian growth at 3 different developmental stages in the pig. At parity 1, Yorkshire gilts were not exercised (CON; n=4) or were exercised 3 times/wk for 30 min from d 40-105 of gestation (EX; n=4). Within 12-15 h after birth, ovaries were collected from the heaviest (H) and lightest (L) piglets. Remaining gilts were raised until 6 mon and ovaries were collected. At parity 2, sows were assigned to the same treatment group and on d 94 of gestation ovaries from the H and L fetuses were collected. Fetal, neonatal, and adolescent ovaries were fixed in formalin, and Ki67 (a marker of proliferating cells) was immunodetected in tissue sections followed by image analysis to determine labeling index (LI; a proportion of proliferating cells). In neonates, ovarian weight was similar across treatment in H gilts, but was greater (P<0.02) in EX than CON of L gilts. There were no differences in fetal or adolescent ovarian weights. In fetal and neonatal ovaries, primordial and primary follicles were present. LI was greater (P<0.01) in fetal than neonatal ovaries, and was greater (P<0.01) in the cortex (COR) than medulla (MED) region. In fetal ovaries, but not neonatal or adolescent, EX had enhanced LI (P<0.01) when compared to CON, and LI was greater (P<0.01) in H than L. In adolescent ovaries, secondary (S), antral healthy (AH), and antral atretic (AA) follicles were present. LI was the greatest (P<0.01) in AH and least in AA granulosa (G) layer. In AH, LI was greater (P<0.01) in G than theca (T) cells. These data demonstrate that exercise during mid to late gestation enhances cell proliferation in fetal ovaries and ovarian weight in L neonates; cell proliferation is greater in fetal than neonatal ovaries; G cell proliferation increases during growth from S to AH; LI in AA is very low; and LI in G cells is greater than in T cells. While exercise of sows increases LI in fetal ovaries, ovarian LI is similar by birth in EX and CON sows. Future studies determining how maternal activity during gestation impacts ovarian function and fertility is warranted.

Key Words: exercise, ovary, swine

O031 **Effects of continuous or rotational grazing schemes on available forage, performance, parasite burden, and reproductive measurements by yearling Katahdin ewes grazing tall fescue.** E. A. Backes[1, 2,*], J. D. Caldwell[2], B. C. Shanks[2], K. R. Ness[2], A. N. Stewart[2], L. S. Wilbers[2], C. A. Clifford-Rathert[2], A. Wurst[2], H. A. Swartz[2], D. L. Kreider[1], M. L. Looper[1], [1]*Department of Animal Science, University of Arkansas, Fayetteville* , [2]*Department of Agriculture and Environmental Sciences, Lincoln University, Jefferson City.*

Use of alternative grazing schemes has increased in popularity in recent years, especially rotational grazing. However, rotational grazing has not been well evaluated with Katahdin hair sheep grazing tall fescue [*Lolium arundinaceum* (Schreb.) Darbysh; E+]. Our objective was to evaluate performance, parasite burden, and reproductive measurements by yearling Katahdin ewes grazing E+ using either continuous or rotational grazing schemes in late spring through summer. Over two consecutive years, yearling Katahdin ewes (n = 50; 53 ± 1.41 kg initial BW; 3.3 ± 0.09 initial BCS) were stratified by BW and allocated randomly to one of five, 0.4-ha pastures consisting of two treatments: 1) Continuous (C; five replications); or 2) 4-cell rotation (4R; five replications). Available forage measurements were taken monthly for the duration of the study. Twelve disk meter readings were taken per pasture and calibrated on each sampling date. Available forage did not differ (P = 0.47) across treatments; however, available forage ($P \leq 0.0001$) was greater for the month of August compared with May, June, and July, but did not differ ($P \geq 0.33$) for June compared with May and July. Body weight at beginning and end of breeding, breeding and final ADG, final BW, and total gain did not differ ($P \geq 0.20$) across treatments. Beginning breeding BCS tended (P = 0.10) to be greater for C compared with 4R. End breeding and final BCS and beginning, end of breeding, and final FAMACHA© scores did not differ ($P \geq$ 0.12) across treatments. Lambing rates (80% and 52% for 4R and C, respectively) and frequency of multiple births were greater ($P \leq$ 0.04) from 4R compared with C. Number of lambs/ewe exposed did not differ (P = 0.14) across treatments. Therefore, utilizing rotational grazing schemes with yearling Katahdin ewes on E+ pastures in late spring though summer may not increase available forage or improve performance, parasite burden, or number of lambs/ewe exposed. However, rotational grazing may increase frequency of multiple births and lambing rates.

Key Words: continuous grazing, Katahdin, rotational grazing

O032 **Effect of winter supplementation level on yearling system profitability.** K. Gillespie*, T. Klopfenstein, B. Nuttelman, C. Schneider, G. Erickson, *Animal Science, University of Nebraska, Lincoln.*

Winter supplementation level economics in a forage-based calf backgrounding system were analyzed using five studies. In each study, British breed calves were backgrounded on corn residue with a high (HI) or low (LO) winter supplementation level, grazed through the summer, and finished. Within study, cattle were randomly assigned to treatment and had identical implant procedures and finishing diets. Feedlot performance values were adjusted to an equal fat thickness and April, 2012 economic assumptions applied. In study 5 (not previously reported), heifer calves (n=116, initial BW = 206 ± 23 kg), grazed corn residue 138 d and were supplemented with 0.91 kg (LO) or 2.27 kg (HI) wet distillers grains with solubles (DM basis). Heifers grazed bromegrass 30 d, range 128 d, and fed a common finisher. Winter gains were greater for HI heifers (0.64

vs. 0.32 kg/d, $P < 0.01$) and summer gains greater for LO heifers (0.65 vs. 0.54 kg/d, $P < 0.01$). Final BW was 50 kg greater for HI heifers with HI finishing at 607 kg and LO at 557 kg ($P = 0.01$). Finishing phase ADG was numerically greater for HI heifers at 1.8 kg compared to 1.72 kg for LO heifers ($P = 0.21$). In the economic scenario, 227 kg British breed calves were backgrounded on corn residue with modified distillers grains (MDGS) supplemented at 0.91 or 2.27 kg/head/day, summered on grass, and finished. Assumptions were $1.70/cwt for a 227 kg calf, $0.31/day on cornstalks, $0.80/day on summer grass, $0.27/kg DM fed of MDGS, $0.29/kg DM fed of feedlot diet, and $120/cwt sale price. Cattle backgrounded at HI level had a 0.09 kg greater ADG during finishing and required five less finishing days. Total feedlot DMI was 9.07 kg less for HI cattle, for $2.50 less feedlot diet cost. The maintained performance advantage of HI cattle resulted in 39 added kilograms of saleable product. Scenario profitability was -$9.48 when backgrounding at LO, and $46.53 at HI. Calves backgrounded at HI level maintained their performance advantage through finish and were more profitable.

Key Words: backgrounding, beef cattle, supplementation

O033 **Performance characteristics of beef cows limit-fed by-products from corn ethanol production.** M. Faulkner[1,*], P. Walker[1], R. Atkinson[2], L. Forster[3], *[1]Department of Agriculture, Illinois State University, Bloomington, [2]Department of Animal Science, Food & Nutrition, Southern Illinois University, Carbondale, [3]Archer Daniel's Midland Co., Decatur.*

Feed costs account for greater than 60% of total annual cow costs and are identified as the largest factor influencing profit and loss in the cow-calf enterprise. With increasing corn prices, feeding ethanol by-products has become economically attractive to cow-calf producers. The objective of this study was to evaluate the efficacy of reduced fat, modified wet distillers grains (RFDGS), high fat, modified wet distillers grains (HFDGS) and high fat, condensed distillers solubles (HFCDS), containing 8.01, 10.53 and 10.99% ether extract (crude fat), respectively, on beef cow and calf performance. Angus x Simmental crossbred cows (n=128) were limit-fed one of four dietary treatments beginning in the third trimester through calf weaning (n=206 d). Cows were blocked by parity (first parity, and two or more parities) and stratified within parity by BW subject to variation in BCS to 16 pens. Each block was equally represented within treatment. Thus, all data were analyzed using MIXED procedures of SAS, $\alpha = 0.05$ and the experimental unit = pen. The model statement included TREATMENT and the RANDOM statement included pen within treatment. Control cows were fed corn silage, shelled corn, and soybean meal based diets to provide 12.0% CP (T1). In treatment diets, corn silage and either RFDGS (T2) or HFDGS (T3) replaced shelled corn and soybean meal to provide 12.0% CP. High fat, condensed distiller's solubles (T4) replaced shelled corn and a portion of soybean meal to provide 12.0% CP. Mean DMI/d was 10.13 ± 1.12, 9.88 ± 1.02, 8.07 ± 0.88, 10.08 ± 1.20 kg for T1, T2, T3 and T4, respectively. Differences were observed for % crude fat ($P = 0.001$) and DMI/d ($P = 0.01$) between dietary treatments. A difference ($P = 0.02$) was observed for milk production, where T4 > T2 = T3, T1 = T4 and T1 = T2 = T3. Milk Urea Nitrogen differed between treatments ($P = 0.02$), where T1 > T2 = T3, T1 = T4 and T4 = T2 = T3. No differences ($P > 0.05$) between treatments were observed for calf birth weight, calf BW, and cow BW and BCS at the end of the feeding period. In corn silage based beef cow diets HFDGS, RFDGS and HFCDS can replace shelled corn and soybean meal diets, with similar performance.

Key Words: beef cow and calf performance, reduced fat and high fat modified wet distillers grains, high fat condensed distillers solubles

O034 **Dietary inclusion of dried distillers grains with solubles modifies milk composition and production in lactating dairy cows.** E. D. Testroet[1,*], G. Li[1], D. C. Beitz[2], S. Clark[1], *[1]Food Science & Human Nutrition, [2]Animal Science, Iowa State University, Ames.*

Feeding dried distillers grains with solubles (DDGS) to lactating dairy cows has been shown to increase the proportion of unsaturated fatty acids, which are more susceptible to free radical-mediated oxidative damage, in the milk produced by those cows. The objective of this study was to investigate the effect of feeding DDGS to lactating dairy cows on milk production parameters as well as milk oxidative stability and flavor attributes. Mid-lactation Holstein dairy cows (n = 24) were blocked by parity and DIM into two groups (n =12). The experiment was set up as a three-period crossover design with three diets (0%, 10%, and 25% DDGS DM basis) fed ad libitum for 28 days, following an initial 7 day acclimation period. Diets were formulated to be isocaloric and isonitrogenous. To eliminate a carryover effect, milk was not collected until day 14 of each treatment period, and milk yield data from the first 7 days of each treatment period were not included in statistical analysis. Milk yield was not significantly impacted for cows fed 0% or 10% DDGS (34.03 and 34.82 kg/day respectively) but decreased at 25% DDGS (30.60 kg/day $P < 0.05$). Milk fat depression resulted from the 10% and 25% DDGS diets ($P < 0.05$); there was a concomitant increase in milk protein content ($P < 0.05$). No significant differences in rumen volatile fatty acids ($P > 0.05$) and acetate to propionate ratio were detected amongst treatments ($P = 0.515$). Short and medium chain fatty acids (C 6:0-C 15:0), as well as linoleic acid (C 18:2), were significantly affected ($P < 0.05$) by treatment, with elevated concentrations of linoleic acid observed at 10% and 25% DDGS diets. Total antioxidant capacity of milk (a measure of oxidative stability) was not impacted by treatment. Finally, no differences in detected off-flavors in milk from any treatment were identified by a trained sensory panel. Dietary inclusion of DDGS modified milk composition but did not result in cows producing milk that was less oxidatively stable or more prone to development of off-flavors.

Key Words: dried distillers grains with solubles, milk composition, milk stability

O035 **Effects of feeding CaO treated WDGS or treated corn stover to cattle on performance, carcass characteristics, and ruminal metabolism.** M. J. Duckworth[1,*], A. R. Schroeder[1], D. B. Faulkner[2], D. W. Shike[1], T. L. Felix[1], *[1]Animal Sciences, University of Illinois, Urbana, [2]Animal Sciences, The University of Arizona, Tuscon.*

Chemically treating corn alternatives, corn stover and wet distillers grains with solubles (WDGS), may increase feeding value for feedlot cattle. The objective of this study was to determine effects of feeding CaO treated WDGS or treated corn stover to cattle during the finishing phase on growth, efficiency, and carcass characteristics; and on ruminal metabolism and in situ dry matter disappearance in fistulated cattle. *Exp 1*: Steers (n = 162) were fed for ad libitum intakes 1 of 3 treatments: 1) 20% corn stover, untreated (UCS), 2) 20% corn stover, treated with 5% CaO (TCS), and 3) 40% WDGS,

treated with 2.5% CaO (TDG). *Exp 2*: Heifers (n = 138) were fed for ad libitum intakes 1 of 3 treatments: 1) UCS, 2) TCS, and 3) 40% corn silage (SIL). *Exp 3*: fistulated steers (n = 5) were fed for ad libitum intakes in a 5x5 Latin Square design. Diets were: 1) UCS, 2) TCS, 3) TDG, 4) SIL, and 5) control, 50% cracked corn (CON). *Exp 1*: Calcium oxide treatment of both WDGS and corn stover reduced ($P \leq 0.03$) DMI, ADG, and final BW when compared to feeding UCS. Marbling and backfat (BF) were decreased ($P \leq 0.04$) in calves fed TCS compared to those fed TDG and UCS. *Exp 2*: Feeding TCS to heifers reduced ($P < 0.01$) DMI, ADG, final BW, and BF when compared to feeding UCS and SIL. *Exp 3:* Ruminal pH was not affected ($P = 0.23$) by treatment. Steers fed TCS had the greatest ($P \leq 0.05$) concentrations of acetate and total VFA. Apparent dry matter digestibility was affected ($P = 0.02$) by treatment (62.6%, 70.0%, 66.4%, 70.2%, and 75.0%, for diets 1 through 5, respectively). When steers were fed UCS, dry matter digestibility was reduced, but it did not differ when steers were fed TCS, CON, and SIL diets; TDG was intermediate. In situ dry matter disappearance increased ($P = 0.01$) in steers fed UCS and SIL diets when compared to steers fed TCS and CON diets; steers fed the TDG diet was intermediate. Treatment of corn stover decreased DMI and reduced ADG although it increased digestibility when compared to untreated corn stover; however, treatment of WDGS decreased DMI and reduced ADG, but it did not affect digestibility.

Key Words: beef cattle, calcium oxide, corn stover

O036 **Effects of modified distillers grains plus solubles and condensed distillers solubles with and without oil extraction on finishing performance.** M. L. Jolly*, B. L. Nuttelman, D. B. Burken, C. J. Schneider, G. E. Erickson, T. J. Klopfenstein, *Animal Science, University of Nebraska, Lincoln.*

Ethanol plants are removing a portion of the corn oil from condensed distillers solubles (CDS) resulting in lower fat distillers byproducts. Our objective was to evaluate the effects of modified distillers grains plus solubles (MDGS) and CDS with and without oil extraction on finishing performance. In this trial, 225 crossbred steers (300 ± 9.1 kg) were utilized in a randomized block design. Steers were blocked by BW, stratified within block, and assigned randomly to treatment using a 2x2+1 factorial treatment design. Factors were fat content (de-oiled or normal), byproduct type (MDGS, 40% DM inclusion or CDS, 27% DM inclusion) and a corn based control (CON). All diets contained a 1:1 blend of high-moisture and dry-rolled corn, 7.5% sorghum silage, and 5% supplement. The fat content was 6.0% for de-oiled CDS, 21.1% for normal CDS, 9.2% for de-oiled MDGS, and 11.8% for normal MDGS. Therefore, dietary fat was 4.7% for de-oiled CDS, 8.8% for normal CDS, 6.1% for de-oiled MDGS, and 7.2% for normal MDGS compared to 4.4% for CON. There were no fat x by-product type interactions ($P > 0.34$); however, we used pre-planned contrasts to test fat within each byproduct type diet. There were no differences in DMI, ADG, or G:F between de-oiled and normal CDS ($P > 0.25$) or between de-oiled and normal MDGS ($P > 0.44$). However, when compared to CON, feeding CDS decreased DMI ($P < 0.01$) and improved G:F ($P < 0.01$), regardless of fat. Feeding MDGS resulted in similar DMI ($P > 0.48$), greater ADG ($P < 0.01$), and improved G:F ($P < 0.01$) compared to CON, regardless of fat. No differences ($P > 0.20$) were observed in carcass characteristics due to fat content of CDS and MDGS. Including a by-product, regardless of fat content, improves feed efficiency when compared to CON. These data suggest little effect on performance with this new centrifugation process used to remove a portion of the oil from distillers byproducts.

Key Words: centrifugation, de-oiled byproducts, feedlot

GRADUATE STUDENT COMPETITION: PHD ORAL

O037 **Detrimental effects of oxidized lipids in nursery diets.** D. Rosero [1,*], J. Odle [1], A. Moeser [2], R. D. Boyd [3], E. van Heugten [1], *[1]Department of Animal Sciences, [2]Department of Population Health and Pathobiology, NCSU, Raleigh, NC, [3]Hanor Company, Inc., Franklin, KY.*

The objective of this study was to determine the effects of highly oxidized soy oil on growth, nutrient digestibility, intestinal morphology, and oxidative stress in nursery pigs. A total of 216 pigs (6.48 ± 0.09 kg) were allotted within BW blocks and fed 1 of 5 dietary treatments. Pigs were placed in 55 pens (3 to 4 pigs per pen) resulting in 11 replications. Treatments included a control diet (no fat added), and diets supplemented with 6% soy oil previously exposed to heat (80°C) and constant oxygen flow (1 L/min) for 0, 6, 9 and 12 d; which increased peroxide (1, 46, 58 and 52 meq/kg for soy oil exposed for 0, 6, 9 and 12 d, respectively) and anisidine values (4.1, 18.6, 24.5 and 39.4). Pigs were fed a phase 1 diet for 14 d and a phase 2 diet for 21 d. Addition of soy oil improved overall ADG (P=0.027; 0.393 and 0.431 kg/d for control and unexposed soy oil diets, respectively) and G:F ratio (P<0.01; 0.609 and 0.681), but did not affect feed intake (P=0.33; 0.633 and 0.621 kg/d). Increasing peroxidation reduced ADG (P=0.024; 0.431, 0.409, 0.401 and 0.392 kg/d for soy oil 0, 6, 9 and 12 d; respectively) and feed intake linearly (P<0.001; 0.621, 0.633, 0.588 and 0.576 kg/d), but did not affect G:F ratio (P=0.923; 0.681, 0.668, 0.671 and 0.683). Increasing peroxidation linearly reduced the apparent total tract digestibility of GE (P=0.016; 82.5, 82.4, 81.2 and 78.9%) and fat (P<0.001; 72.4, 69.5, 72.3 and 61.6%). Absorption of mannitol (measured in blood serum from pigs 2h post-gavage with a solution containing 0.3 g/ml of mannitol) decreased linearly with increasing peroxidation (P=0.05; 9.42, 8.29, 6.85 and 6.81 mg/ml). Oxidative stress marker malonaldehyde measured in the duodenal mucosa increased with increasing peroxidation (quadratic, P=0.035; 0.453, 0.539, 0.588 and 0.373 μM/mg protein). Increasing peroxidation resulted in longer (linear, P<0.001) and thinner (linear, P=0.001) villi and deeper crypts (linear, P=0.008) in jejunum. In conclusion, addition of soy oil to nursery diets improved animal performance, but peroxidation diminished this advantage. Peroxidation reduced nutrient digestibility, increased oxidative stress and modified morphology and function of the small intestine of nursery pigs.

Key Words: nursery pigs, peroxidation, soy oil

O038 **Efficacy of plasma protein to mitigate the negative effects on performance of pigs fed mycotoxin contaminated corn.** A. C. Weaver[1,*], J. Campbell [2], J. D. Crenshaw[2], J. Pol [2], S. W. Kim[1], *[1]Animal Science, North Carolina State University, Raleigh, [2]APC, Inc., Ankeny.*

The ability of plasma protein to reduce the negative effects of 180 ppb aflatoxin (AF) and 9 ppm fumonisin (FUM) on performance was determined in newly weaned pigs (n = 128, 6.8 ± 0.1 kg). For 12 d after weaning, pigs were fed a phase 1 nursery diet without supplemental plasma protein (PP0) or with 6% plasma protein (PP6) and phase 1 diets had no mycotoxin. After 12 d, pigs were fed a phase 2 diet for 3 wk. Pigs fed PP0 in phase 1 were either continued with no plasma protein (PP0/PP0) or were fed a diet with mycotoxin (M) contaminated corn (PP0/PP0M). Pigs with 6% plasma protein

in phase 1 were fed either a diet with no plasma protein (PP6/PP0), a diet with mycotoxins and no plasma protein (PP6/PP0M), a diet with mycotoxins and 3% plasma protein (PP6/PP3M), or a diet with mycotoxins and 6% plasma protein (PP6/PP6M). During phase 1, pigs fed PP6 had increased ($P < 0.01$) ADG and ADFI and tended to have increased ($P = 0.076$) gain:feed compared with pigs fed PP0. During phase 2, pigs fed a diet with mycotoxins (PP0/PP0M) had reduced ADG ($P < 0.01$) and ADFI ($P < 0.05$) in contrast to pigs in PP0/PP0. Growth performance of pigs fed PP6 in phase 1 was not affected by mycotoxins in phase 2 even if they did not receive plasma protein during phase 2. The ADG of pigs in PP6/PP0M, PP6/PP3M, and PP6/PP6M was greater ($P < 0.05$) than pigs in PP0/PP0M but did not differ from pigs in PP0/PP0. Overall, it appears that plasma protein improves growth performance and feed intake of newly weaned pigs directly after weaning. Feeding 6% plasma protein in the phase 1 diet reduced the negative effects of mycotoxins on growth performance fed during phase 2 regardless of supplementation level of plasma protein in phase 2 diets. This study indicates that pre-exposure conditions are important when pigs consume feed contaminated with mycotoxins, and dietary supplementation of plasma protein prior to mycotoxin exposure enhanced the ability of pigs to cope with mycotoxin challenges.

Key Words: aflatoxin, fumonisin, pigs

O039 **Relative bioavailability of L-methionine to Dl-methionine for nursery pigs.** Y. B. Shen*, S. W. Kim, *Animal Science, North Carolina State University, Raleigh.*

To evaluate the relative bioavailability (RBA) of L-methionine (LM, 99%; CJ Bio) to DL-methionine (DLM, 99%), 168 crossbred pigs (7.15 ± 0.97 kg BW) at 26 d of age (5 d post-weaning) were randomly allotted to 7 dietary treatments. Dietary treatments included 1) basal diet (BD), 2) BD + 0.048% DLM, 3) BD + 0.096% DLM, 4) BD + 0.144% DLM, 5) BD + 0.048% LM, 6) BD + 0.096% LM, and 07) BD + 0.144% LM. The BD contained endogenous methionine at 55% of the NRC requirement (0.18%). The treatments supplemented with increasing levels of either DLM or LM brought the methionine content to 70%, 85%, or 100% of NRC requirement. Each treatment contains 8 pens with 3 pigs per pen. Pigs were fed assigned diets for 20 d. The body weight of individual pigs and feed disappearance were recorded at every 5 d for computation of growth performance. Blood was collected on d 10 and 20. A nonlinear exponential regression analysis was used to evaluate RBA of LM to DLM. Preplanned contrasts were used to evaluate the effects of Met sources (DLM vs. LM for average of three supplemental levels). During the first 5 d, pigs fed diets supplemented with LM had 24.2% greater ADG (201 vs. 162, g; $P = 0.011$) and 16.4% greater gain:feed ratio (0.567 vs. 0.487, g; $P = 0.024$) than the pigs fed diets supplemented with DLM. During the entire 20 d, pigs fed diets supplemented with LM tended to have 5.8% greater ADG (355 vs. 335, g; $P = 0.087$) than the pigs fed diets supplemented with DLM. The RBA of LM to DLM for overall ADG and gain:feed ratio was 143.8 and 122.7% (R^2=0.96 and R^2=0.94), respectively. On d 10, pigs fed diets supplemented with LM had 20.1% lower (1.92 vs. 2.42, µg/mL; $P = 0.042$) concentration of plasma urea nitrogen than the pigs fed diets supplemented with DLM. Collectively, the RBA of LM to DLM was 143.8 and 122.7% for ADG and gain:feed ratio, respectively.

Key Words: bioavailability, methionine, pigs

O040 **Effect of different feed enzyme combinations on metabolizable energy (ME) and nitrogen digestibility (ND) of corn and DDGS for growing pigs.** A. A. Passos*, S. W. Kim, *Animal Science, North Carolina State University, Raleigh.*

Eight studies were conducted to measure ME and ND of corn and DDGS with or without feed enzymes, including phytase (Phy, 1000 FYT/kg); xylanase (Xyl, 200 FXU/kg), and protease (Pro, 15,000 PRO/kg) from DSM Animal Nutrition. Four studies were completed for corn (1: control, Phy, Xyl, Phy+Xyl; 2: control, Phy, Pro, Phy+Pro; 3: control, Pro, Xyl, Pro+Xyl; 4: Phy+Xyl, Phy+Pro, Pro+Xyl, Phy+Pro+Xyl) using 16 pigs (39.2±2.4 kg BW) in individual metabolism cages for four 4 x 4 Latin Squares. Each period had 4-d adaptation, 4-d collection using chromium oxide as an indicator. Daily feed allowance was based on 0.09 x $BW^{0.75}$ divided into 2 equal meals. DDGS (35% DDGS + 65% Corn) was evaluated in 4 studies using 16 pigs (24.0±3.7 kg) with the same designs used for previous studies testing corn. Gross energy was measured using bomb calorimeter (IKA, Wilmington, NC) and protein by combustion method (Leco, St Joseph, MI) to calculateME (kcal/kg) and ND (%). The four corn studies showed no difference ($P>0.10$) among treatments for ME (3,315) and ND (83.8). The four DDGS studies indicated that the use of Xyl (ME=2,776; ND=78.5) and Phy+Xyl (ME=2,881; ND=80.5) increased ($P<0.05$) ME and ND compared with those for control (ME=2,632; ND=77.0). Use of Pro had greater ($P<0.05$) ME (2,897) and ND (81.0) than control (ME=2,741; ND=77.5). In conclusion, supplementation of protease, xylanase, and xylanase+phytase improved utilization of energy and nitrogen in DDGS whereas any feed enzymes or enzyme combination did not affect those in corn. Use of select feed enzymes or combinations of feed enzymes can benefit pigs when consuming a diet with DDGS.

Key Words: corn, DDGS, enzyme

O041 **Effects of feeding ractopamine (Paylean) to physical and immunological castrates (Improvest) in a commercial setting on carcass characteristics**. B. K. Lowe [1,*], G. D. Gerlemann [2], S. N. Carr [3], P. J. Rincker [3], A. L. Schroeder [4], D. B. Petry [5], G. L. Allee [2], F. K. McKeith [1], A. C. Dilger [1], *[1]Animal Sciences, University of Illinois, Urbana, [2]Animal Sciences, University of Missouri, Columbia, [3]Elanco Animal Health, Greenfield, IN, [4]Pfizer Animal Health, Kalamazoo, MI, [5]Newsham Choice Genetics, West Des Moines, IA.*

Sixty-four pens with 22 pigs per pen were used to evaluate effects of feeding ractopamine (RAC; 5 mg/kg) to physical castrates (PC) and immunological castrates (IC). Male pigs were randomly assigned to sex treatments at birth prior to allotment in a grow-finish barn. Pigs in the PC treatment were surgically castrated at 5 d of age; pigs in the IC treatment were injected with Improvest at 11 and 18 wk of age. Diet treatments (control or RAC) were initiated on d 87 and final treatment arrangement was a 2 x 2 factorial of sex and diet. Pigs were marketed 12 d (4.5 wk post-2nd Improvest injection), 19 d (5.5 wk post-2nd Improvest injection), and 33 d after start of diet treatment (7.5 wk post-2nd Improvest injection). Data were analyzed as a split-plot in time using PROC MIXED in SAS with fixed effects of sex, diet, market group, and their interactions; experimental unit was pen. Immunological castrates were 2.5 kg heavier ($P<0.01$) at slaughter, had similar ($P=0.10$) carcass weights, and a 1.8 percentage unit less ($P<0.01$) dressing yield than PC pigs. Additionally, PC pigs had 1.3 mm more ($P<0.01$) carcass fat and 1.7 mm deeper ($P<0.01$)

loins than IC pigs. Also, RAC-fed pigs were 2.9 kg heavier ($P<0.01$) at slaughter and had 2.3 kg heavier ($P<0.01$) carcasses than control-fed pigs while having similar ($P=0.21$) dressing yields. For carcass characteristics, RAC-fed pigs had 2.2 mm deeper ($P<0.01$) loins and tended ($P<0.10$) to have 0.4 mm less fat than control-fed pigs. Market group 3 pigs were the heaviest ($P<0.01$) at slaughter, had the heaviest ($P<0.01$) carcasses, greatest ($P<0.01$) dressing yields, and the most ($P<0.01$) carcass fat of the market groups. For leanness, RAC-fed IC pigs were estimated to be the leanest ($P<0.05$) of pigs in the first market group; control-fed PC pigs were estimated to have the least amount of lean ($P<0.05$) of pigs in the second market group; and RAC-fed pigs were estimated to be the leanest ($P<0.05$) of pigs in the third. These results show that the effects of immunological castration and feeding RAC are additive in terms of improving carcass characteristics.

Key Words: carcass characteristics, Improvest, Paylean

O042 **Fate and biological activity of antibiotics used in fuel ethanol production.** D. M. P. Compart [1,*], A. M. Carlson [2], G. I. Crawford [1], R. C. Fink [3], F. Diez-Gonzalez [3], A. DiCostanzo [1], G. C. Shurson [1], *[1]Animal Science, University of Minnesota, Twin Cities, Saint Paul, [2]SGS North America, Inc, Brookings, [3]Food Science, University of Minnesota, Twin Cities, Saint Paul.*

Antibiotics are utilized in ethanol production to control deleterious bacteria from competing with yeast for nutrients during ethanol fermentation. However, there is no published scientific information on whether antibiotic residues are present in distillers grains (DG) co-products from ethanol production, or whether they retain their biological activity. Therefore, the objectives of this study were to quantify concentrations of various antibiotic residues in DG and to determine whether residues were biologically active. Twenty distillers wet grains and 20 distillers dried grains samples were collected quarterly from nine states and 43 ethanol plants in the United States. Samples were analyzed for DM, CP, NDF, crude fat, S, P, pH, and titratable acidity to describe the nutritional characteristics of the samples evaluated. Samples were also analyzed for the presence of erythromycin, penicillin G, tetracycline, tylosin, and virginiamycin M1 using liquid chromatography and mass spectrometry. Additionally, virginiamycin residues were determined using an FDA-approved bioassay method. Samples were extracted and further analyzed for biological activity by exposing the sample extracts to 104 to 107 CFU/ mL concentrations of sentinel bacterial strains *Escherichia coli* ATCC 8739 and *Listeria monocytogenes* ATCC 19115. Extracts that inhibited bacterial growth were considered to have biological activity. Physiochemical characteristics varied among samples, but were consistent with previous findings. Thirteen percent of all samples contained low ($\leq$ 1.12 ppm) antibiotic concentrations. Only one sample extract inhibited growth of *E. coli* at 104 CFU/g, but this sample contained no detectable concentrations of antibiotic residues. No extracts inhibited *L. monocytogenes* growth. These data indicate that the likelihood of detectable concentrations of antibiotic residues in DG is low, and if detected, they are found in very low concentrations. The inhibition in only one DG sample by sentinel bacteria suggests that antibiotic residues in DG were inactivated during the production process or are present in sublethal concentrations.

Key Words: antibiotics, distillers grains, ethanol production

O043 **Evaluation of energy digestibility of canola co-products using in vitro analyses and digestion discrepancies using spectroscopy**. L. Wang [1,*], M.-L. Swift [1, 2], R. Zijlstra [1], *[1]University of Alberta, Edmonton, [2]Alberta Agriculture and Rural Development, Lacombe, Canada.*

An in vitro method poorly described the apparent total tract digestibility of energy in canola co-products for pigs. To explore, ingredients, diets, digesta, feces and in vitro digestion residues (ivR) of either high (HFCC) or low fat (LFCC) canola co-products were scanned on a Fourier transform infrared (FTIR) instrument with an attenuated total reflectance attachment, because spectra peaks are indicative of chemical composition and peak intensity (PI) is proportional to analyte concentration. The PI was then adjusted (API) according to DM digestibility to reflect the extent of digestion. The API of methylene at 2923 cm^{-1} and ester carbonyl at 1745 cm^{-1}, both characteristic of triglyceride, were higher in ivR than in feces for both HFCC (2.49×10^{-02} vs. 1.18×10^{-02}; 1.04×10^{-02} vs. 2.07×10^{-03}; respectively, $P < 0.01$) and LFCC (1.24×10^{-02} vs. 3.48×10^{-03}; 4.91×10^{-03} vs. 1.49×10^{-03}; respectively, $P < 0.01$), indicating poor enzymatic digestion of fat in vitro.The API of amide I area (1670~1631 cm^{-1}) of ivR was higher than that of fecal spectra for HFCC (0.40 vs. 0.31; $P = 0.01$), but did not differ for LFCC (0.31 vs. 0.32; $P = 0.32$), indicating in vitro protein digestion was poorer for HFCC. In addition, the API of 2nd derivative spectra of β-sheet peak at 1623 cm^{-1} was higher in the ivR than in feces for both HFCC (8.08×10^{-05} vs. 1.42×10^{-05}; $P < 0.01$) and LFCC (1.12×10^{-04} vs. 3.20×10^{-05}; respectively; $P < 0.01$), indicating that in vitro protein digestion was less complete. The API of fiber (1120-1105 cm^{-1}) was higher in ivR than in feces for HFCC (0.24 vs. 0.13; $P < 0.01$), whereas it was lower in ivR than in feces for LFCC (0.16 vs. 0.19; $P < 0.01$), indicating that fat content interacted with fiber digestion. In conclusion, improved fat digestion should be the first priority for the in vitro assay for canola co-products, because fat may hinder access of enzymes to digest protein and fiber.

Key Words: canola co-products, in vitro, spectroscopy

O044 **Impact of replacing corn with corn silage in diets containing distillers grains on feedlot performance.** D. B. Burken*, B. L. Nuttelman, T. J. Klopfenstein, G. E. Erickson, *Animal Science, University of Nebraska, Lincoln.*

When corn price is elevated, corn silage may be an economical alternative in combination with the common use of distillers grains in finishing diets. A finishing experiment evaluated substitution of corn with corn silage in diets with modified distillers grains with solubles (MDGS). Steers (n=324; BW=324 ± 17 kg) were separated into two BW blocks and assigned randomly to one of 36 pens (9 hd/ pen). Dietary treatments fed were 15, 30, 45, or 55% corn silage in diets with 40% MDGS. Two other treatments were tested with 30% corn silage and 65% MDGS and 45% corn silage and 0% MDGS. Elevated levels of corn silage and MDGS replaced a 1:1 blend of dry-rolled corn: high moisture corn. All steers were on feed for 173 days. Performance measures were calculated from HCW adjusted to a common dressing percentage (63%). Marbling score, 12th rib fat thickness, and LM area were recorded after a 48 hr chill. As corn silage inclusion increased in diets containing 40% MDGS, DMI and ADG (1.83 and 1.60 kg/d for steers consuming 15% and 55% corn silage, respectively) linearly decreased ($P < 0.05$), which equated to a linear decrease in G:F ($P < 0.01$) with the steers on the 15% corn silage treatment being 1.5%, 5.0%, and 7.7% more efficient

than steers on treatments containing 30%, 45%, and 55% corn silage, respectively. Cattle fed 45% corn silage with 40% MDGS instead of 0% MDGS had increased ADG and G:F ($P < 0.05$) with no difference in DMI ($P = 0.30$). For steers fed 30% dietary corn silage, the addition of 65% MDGS (compared to 40% MDGS) resulted in decreases in DMI, ADG, and G:F ($P < 0.01$). Dressing percentage, HCW, 12th rib fat, and calculated YG decreased linearly ($P < 0.01$) with increasing corn silage inclusion in diets containing 40% MDGS. In general, corn silage with distillers grains in place of corn in finishing diets results in a modest reduction in performance and slightly leaner carcasses, however these responses appear to be dependent on dietary inclusion level of distillers grains.

Key Words: cattle, corn silage, distillers grains

DAVID H. BAKER AMINO ACID SYMPOSIUM

O045 **Modeling the response of growing pigs to amino acid intake—beyond NRC (2012).** C. De Lange*, *Animal and Poultry Science, University of Guelph, Canada.*

The (NRC) 2012 publication "Nutrient Requirements of Swine" included a thorough review of amino acid requirement studies and biological body functions that contribute to amino acid requirements of growing pigs. The latter provided the basis for a modeling approach to estimate amino acid requirements of pigs at varying levels of performance and under varying environmental conditions. In NRC (2012) limitations to our understanding of amino acid utilization for body maintenance functions and body protein deposition were also identified, and areas for further research were suggested; these include: (1) routine quantification of amino acid bioavailability in feed ingredient, (2) relationships between dietary amino acid balance and voluntary feed intake, (3) interactive effects of pig genotype and environmental conditions on amino acid utilization for body protein deposition, (4) the impact of nutritional history on response to amino acid intake, (5) marginal responses of groups of growing pigs to varying levels of amino acid intake, (6) utilization of non-protein nitrogen for endogenous synthesis of non-essential amino acid, and (7) enteric, microbial production of essential amino acids that may be used by the pig. For these topics the relevance to practical amino acid nutrition of growing pigs is discussed and recent research findings are presented. In future research it will become increasingly important to improve understanding of the physiology that underlies the feed intake and growth response of groups of pigs that are exposed to varying types of environmental stressors and to varying dietary amino acid levels. This will provide the basis for informed decision making to optimize nutrient utilization and maximize profits in commercial pork production.

Key Words: amino acids, nutrition, pigs

O046 **Determination of tryptophan requirements for grow-finish pigs raised under commercial conditions.** M. Young [1,*], V. Zamora [1], N. Campbell [1], R. T. Zijlstra [2], J. Usry [3], M. Stevenson [4], *[1]Gowans Feed Consulting, Wainwright, AB, [2]University of Alberta, Edmonton, Canada, [3]Ajinomoto Heartland LLC, Chicago, IL, [4]Halchemix, Port Perry, ON, Canada.*

Accurate definitions of nutrient requirements and use of alternative ingredients such as pulses and distillers dried grains with solubles can offset rising cost of traditional ingredients. In diet formulations with higher inclusions of these ingredients using the NE system, Trp becomes limiting and in turn limits use of other ingredients and crystalline AA. Thus, the objective was determine the Trp requirement expressed as SID Trp:Lys ratio for 34 to 125 kg pigs raised under commercial conditions. A total of 1,050 pigs (34 ± 0.52 kg) were fed within 4 feeding phases with 4 SID Trp:Lys ratios (16, 18, 20, and 22%) in Lys-limiting diets and a positive control formulated with adequate Lys. Assessed over the entire feeding period, ADG increased (linear, $P < 0.001$) by 2.9% as SID Trp:Lys ratio increased in the diet. The G:F increased (linear and quadratic, $P < 0.01$) by 2.7% in pigs fed with diets with adequate Lys. As Trp:Lys ratio increased, carcasses tended to be heavier (linear, $P < 0.08$) and backfat tended to increase (linear, $P < 0.08$). Loin depth increased (linear, $P < 0.001$) by 1% when Trp:Lys ratio increased in Lys-limiting diets and was 1.5% greater in pigs fed diets with adequate Lys. Average diet cost (linear and quadratic. $P < 0.001$) and feed cost per kg gain (linear, $P < 0.01$) increased as the Trp:Lys ratio increased in the diet but income over feed cost was highest at Trp:Lys ratio of 18% (linear, $P < 0.01$). Taking the biological and economic criteria into consideration, grow-finish pigs (34 to 125 kg) reach optimum growth performance without detrimental effects on carcass with diets formulated at 18% SID Trp:Lys ratio. Performance and carcass benefits at higher Trp:Lys ratios suggest re-evaluation with feed cost or pig pricing changes.

Key Words: grow-finish pigs, tryptophan

O047 **Improvement of growth and stress response of nursery pigs: Functional application of tryptophan.** Y. B. Shen*, S. W. Kim, *Animal Science, North Carolina State University, Raleigh.*

Tryptophan (Trp) as a precursor of cerebral 5-hydroxytryptamine (5-HT, serotonin) may mitigate stress of animals. Trp competes with large neutral amine acids (LNAA) for LNAA transporter to cross the blood-brain barrier. Thus, a series of studies was conducted with nursery pigs to 1) evaluate the effect of L-Trp on growth and stress response, 2) determine an optimal daily total Trp intake that would benefit stress response, 3) validate effects of short term supplementation of L-Trp on growth and stress response, and 4) to evaluate if reducing dietary LNAA could facilitate the effect of L-Trp. In Exp. 1, 72 male pigs at 6 wk of age were randomly allotted to 6 dietary treatments representing supplementation of 0, 2, 4, 6, 8, or 10 g L-Trp/kg to a corn and soybean meal based diet. During the entire experiment, ADG and G:F increased (linear, $P = 0.01$ and $P < 0.01$, respectively) with increasing supplemental L-Trp. On d 15, hypothalamic 5-HT increased (linear, $P < 0.01$) while concentrations of salivary cortisol decreased (linear, $P < 0.01$) with increasing supplemental L-Trp. Estimates of the daily total Trp intake based on the greatest ADG on d 15 were 10.8 g/d ($P < 0.01$; $R^2 = 0.16$). In Exp. 2, 674 pigs in 40 pens were allotted to 2 treatments representing supplementation of 0 and 8 g L-Trp/kg. Pigs were provided the test diets for 5 d before social mixing stress. During the entire experiment, pigs fed diet with 8 g L-Trp/kg had greater ADG ($P < 0.05$) and G:F ($P < 0.01$) compared with pigs fed diet with 0 g L-Trp/kg. In Exp. 3, 48 barrows at 6 wk of age were randomly allotted to 4 dietary treatments based on a 2x2 factorial arrangement. First factor was L-Trp supplementation (0 or 6 g L-Trp/kg) and the second factor was LNAA concentrations (45 or 38 g LNAA/kg). During the entire experiment, L-Trp supplementation improved ($P < 0.01$) feed efficiency of pigs and lowering LNAA further enhanced ($P < 0.05$) the effects of L-Trp. Collectively, supplementation of L-Trp

improved growth performance of nursery pigs under social stress in association with increasing hypothalamic 5-HT production and reducing stress hormone concentrations.

Key Words: nursery pigs, stress, tryptophan

O048 **Dietary amino acid balance in gestating and lactating sows: From theory to practice**. N. L. Trottier*, *Animal Science, Michigan State University, East Lansing.*

The modern sow is a highly prolific animal. Between 2005 and 2011, weaned pigs per mated female increased from 21.8 to 23.9. Such prolificacy continues to increase dietary requirements for amino acids to support gestation and lactation demands. In parallel, it is estimated that as many as 47% of the sows are culled every year, largely because of failure to rebreed following weaning. The discussion will cover the concepts used to define the dietary amino acid requirements of gestating and lactating sows, the existing gaps between the optimum amino acid balance theory and its application, and the potential mechanisms by which amino acid balance may impact feed intake, sow performance and longevity.

Key Words: amino acids, requirement, sow

O049 **Evaluation of tryptophan to lysine ratio in sow lactation diets**. L. Greiner [1,*], Z. Jiang [2], C. Neill [3], J. Connor [1], G. Allee [4], *[1]Innovative Swine Solutions, LLC, Carthage, [2]Ajinomoto Heartland, Chicago, [3]PIC, Hendersonville, [4]Porktech, LLC, Columbia.*

Two hundred and thirty-five primiparous and multiparous sows were evaluated in a study to determine the effect of SID tryptophan:lysine ratio in lactating sow diets. PIC Camborough 1050 sows ranging from first parity to eighth parity were blocked by parity and randomly allotted to one of four experimental diets containing different levels of added L-tryptophan (0.006, 0.026, 0.045, and 0.064%, respectively) while soybean meal, 30% corn dried distiller's grain with solubles (DDGS), and L-lysine levels were held constant. The SID lysine level for the diets was .95% so that the SID tryptophan:lysine ratios were formulated to be 14, 16, 18 and 20, respectively. All diets were formulated to have 3.2 Mcal ME/kg and contained vitamins and minerals that exceeded NRC recommendations (NRC, 1998). Sows were fed twice a day with a Howema computerized feed system and were allowed a maximum intake (5.91 kg/day). Analyzed values from the diets indicated that the total tryptophan:lysine ratio of 15, 16.3, 17.6, and 19, respectively. Average daily feed intake was significantly reduced when sows were fed a diet below the 16.3 ratio (5.17, 5.39, 5.26, 5.30 kg/d, $P<0.07$). In addition, sow wean to estrus (6.21, 5.35, 4.74, 5.29, $P<0.04$) and percent bred by 10 days (88.46, 93.33, 97.87, and 96.36, $P<0.05$) was improved linearly as the ratio increased from 15 to 19. There were no differences in litter gain (2.36, 2.47, 2.48, 2.46 kg/day, $P>0.49$). In conclusion, a minimum SID tryptophan:lysine ratio of 16 should be provided to lactating sows when 30% DDGS are fed.

Key Words: lactation, sow, tryptophan ratio

O050 **Utilization of the pig in biomedical research: A realization of the pig genome sequencing project.** L. B. Schook*, *Department of Animal Sciences, University of Illinois, Urbana-Champaign.*

The Swine Genome Sequencing Consortium (SGSC) was formed to provide international coordination for sequencing the pig genome. The SGSC's mission is to advance biomedical research for animal production and health by the development of DNA-based tools and products resulting from the sequencing of the swine genome. Recently, the assembly and analysis of the genome sequence of a female domestic Duroc pig provides an important resource for further improvements of this important livestock species and our identification of many putative disease-causing variants in the porcine genome extends the potential of the pig as a biomedical model. The pig is an important biomedical model for organ transplantation surgery and imaging, as well as for genetic diseases. The ability to generate transgenics and knockouts in combination with somatic nuclear cloning procedures has resulted in a number of models for specific human diseases. Naturally occurring mutations offer further opportunities to use pigs as biomedical models. In order to explore the potential for natural models further, pig predicted protein sequences were compared with their human orthologues. In total, 75 positions were observed where the porcine protein has the same amino acid implicated in a human disease. The majority of these changes in humans have been shown to increase risk in multifactorial traits such as obesity (*ADRB3, SDC3*) and diabetes (*PPP1RA, SLC30A8*) or shown to result in relatively mild phenotypes (e.g. dyslexia: *KIAA0319*) or diseases that manifest themselves later in life such as Parkinson's disease (*MACF1*) and Alzheimer's disease (*TUBD1*). Nevertheless, these porcine variants are of special interest, as they will allow a detailed comparison between these variants in a model organism whose physiology is very similar to that of human. When considering the use of porcine organs in pig-to-human xenotransplantation, porcine endogenous retroviruses (PERVs) pose a risk of zoonotic infection. The pig genome contains fewer endogenous retroviruses than many vertebrates, including humans and mice, and most PERVs were characterized as defective.

Key Words: genome

ANIMAL BEHAVIOR, HOUSING AND WELL-BEING

O051 **Effect of core body temperature or time of day on lying behavior of lactating dairy cows.** J. Allen [1,2,*], L. Hall [2], R. Collier[2], J. Smith [2], *[1]Agriculture Sciences, Northwest Missouri State University, Maryville, [2]Animal Sciences, University of Arizona, Tucson.*

The objective of this study was to evaluate the effect of core body temperature (CBT) and period of day (0000 to 0600, 0600 to 1200, 1200 to 1800, and 1800 to 0 h) on lying behavior of lactating dairy cows. Data collected from 3 separate trials (California, Arizona, and Minnesota) utilizing 157 lactating dairy cows equipped with intravaginal and posture data loggers were combined and standardized to 5-min measurement intervals. Milking periods (2 hr/period) were excluded from the data set to limit human interference. Standing cows had warmer ($P <$ 0.01) CBT (38.91 °C) than lying cows (38.80 °C). No difference ($P > 0.10$) in CBT was observed at time points when cows were shifting to a standing (38.84 °C) or lying posture (38.84 °C). Average CBT differed ($P < 0.05$) across periods of day. However, regardless of period of day, standing and lying bouts continued until CBT had decreased or increased 0.15 °C, respectively, from the initial CBT of the bout. Using over 150,000 data points, a regression model of [$y = -0.03x^2 + 2.79x - 56.81$] was developed, where y is the likelihood (%) for a dairy cow to be standing, and x is CBT in °C ($r^2 = 0.56$). A 50% likelihood for a dairy cow to be standing was calculated at a CBT of 38.93 °C. Standing duration bouts were longest ($P < 0.01$; 64.6 min/bout) during the afternoon time period (1200 to 1800 h) compared to the 3 other 6-hr periods (~54.3 min/bout). Results indicate both CBT and time of day affect the lying behavior of dairy cows.

Key Words: behavior, core body temperature, dairy cow

O052 **Effects of nursery floor-space allowance on growth, physiology, and immunology in replacement gilts.** S. R. Callahan[1,*], M. J. Estienne [1], A. E. DeDecker [2], A. J. Cross [3], *[1]Animal and Poultry Sciences, Virginia Tech, Blacksburg, [2]Murphy-Brown, LLC, Rose Hill, NC, [3]North Carolina State University, Raleigh.*

Environmental conditions to which young gilts are exposed could impact future reproduction. Thus, the objective was to determine effects of floor space in the nursery on growth, physiology, and immunology of replacement gilts. Gilts (n = 2,537; BW = 5.6 ± 0.6 kg) from 13 groups of weaned pigs were allocated by BW and placed in pens of 14, 11 or 8 pigs resulting in floor spaces of 0.15 (high [HI]), 0.19 (normal [NO]), or 0.27 (low [LO]) m^2/pig, respectively. Gilts were weighed on d 0 (weaning) and d 46. Blood chemistry and complete blood counts were assessed at d 6 and 43 for a subsample of gilts (n = 18/treatment) within a single group. Data were analyzed using the mixed model procedure of SAS (SAS Institute Inc., Cary, NC). Floor-space allowance influenced gilt performance. The ADG was greater ($P = 0.01$) for LO (0.465 ± 0.005 kg) than NO (0.446 ± 0.005 kg). The NO gilts tended ($P = 0.06$) to have greater ADG than HI (0.432 ± 0.005 kg). There were many main and interactive effects of treatment, BW and day on blood response variables. For example, blood calcium was affected by treatment and was greater ($P = 0.04$) for LO (10.43 ± 0.07 mg/dL) and NO (10.45 ± 0.07 mg/ dL) than HI (10.19 ± 0.07 mg/dL). Globulin tended to be affected by treatment x day ($P = 0.07$) and increased from d 6 to 43 in HI (2.07 to 2.55 ± 0.08 g/dL) but not LO or NO. Creatine kinase was affected by treatment x day and increased ($P = 0.03$) with time in LO (732.17 to 1774.78 ± 194.35 U/L) but not NO or HI. Chloride was affected by treatment x day and increased with time for LO (99.94 to 102.11 ± 0.45 mEq/L; $P = 0.03$) and NO (99.39 to 101.67 ± 0.45 mEq/L; $P = 0.02$), but not HI. Reticulocyte numbers tended to be affected by treatment x day ($P = 0.07$) and on d 43 were greater in LO (289.45 ± 11.09 $x10^9$/L) compared to NO (229.80 ± 11.09 $x10^9$/L) and HI (240.07 ± 11.09 $x10^9$/L). Greater space allowance in the nursery increased ADG and affected blood parameters in replacement gilts. This trial is ongoing and data will be collected to determine if the differences detected within result in reproductive implications and lifetime productivity. (Funding by National Pork Board.)

Key Words: floor space, gilt, nursery

O053 **Social stress and space allowance in gestational group housing influences sow and piglet welfare.** L. A. Mack [1,*], S. D. Eicher [2], A. K. Johnson [3], D. C. Lay Jr. [2], B. T. Richert [1], E. A. Pajor [4], *[1]Animal Sciences, Purdue University, [2]LBRU, USDA-ARS, West Lafayette, [3]Animal Science, Iowa State University, Ames, [4]Production Animal Health, University of Calgary, Canada*

Sow gestational group housing presents unique welfare risks and benefits. The first study examined effects of social stress associated with sow regrouping on the reproductive morphology and performance of piglets. At 37.2 ± 0.3 d of gestation (GD), 6 cohorts of 18 sows (N = 108) entered 1 of 3 treatments: socially stable (Stable), hydrocortisone acetate (HCA), or mixed (Mixed). In the 21 d treatment, HCA sows were given 140 mg/d oral HCA to simulate a stress response. Each Mixed sow was penned with 2 companion sows (Companion) and regrouped on d 7 and 14 with 2 different Companions in a new pen. Stable and HCA sows were penned in treatment groups of 3 sows. Data were analyzed with a Tukey-Kramer adjusted (TK) mixed model in SAS. Sow treatment did not affect productivity. Male pigs from HCA sows had greater preweaning mortality than males from Mixed sows ($P = 0.04$). Pig BW did not differ before weaning, but at d 160 males from HCA sows weighed more than males from Stable sows ($P = 0.01$). Males from Companions had longer anogenital distances, a fetal testosterone marker, than males from Mixed sows ($P = 0.03$). Gestational maternal stress altered male, but not female, pig growth and reproductive morphology. The second study examined effects of group space allowance in a free-access stall (FAS) system on sow performance and behavior. At 35.4 ± 2.3 GD, 9 cohorts of 21 sows (N = 189) entered 3 pens containing 7 FAS and a group space of 1.93, 2.68, or 3.24 m^2/sow. Data were analyzed with a TK mixed model. Space did not affect sow BW, BCS, lesions, aggression, or litter traits. Sows with 1.93 m^2 spent more time in FAS ($P < 0.05$) and less in the group space ($P < 0.05$) than other sows. Use of FAS mitigated the risks associated with small pen housing; however, sows with the least space exhibited restricted social behavior. Well-designed group

housing can benefit sows by allowing social behavior while limiting aggression and safeguard offspring development.

Key Words: housing, swine, welfare

O054 **Performance and well-being of pregnant sows housed in pens retrofitted from stalls.** L. Johnston*, Y. Li, A. Hilbrands, *West Central Research and Outreach Center, University of Minnesota, Morris.*

Pressures from consumers concerning sow welfare in gestation stalls have encouraged producers to consider how to transition from individual gestation stalls to pens. The aim of this study was to evaluate performance and welfare of sows in pens which were retrofitted from stalls (2.1 m × 0.55 m). Large pens (5.5 m × 7.3 m) housed 26 sows and small pens (5.5 m × 1.7 m) housed 6 sows, with equal floor space allowance for all sows (1.5 m^2/sow) in both pens. Data were collected on 815 sows (parity 1 to 8) in 13 large pens, 26 small pens, and 326 stalls which served as control. All sows were mated in stalls, and pen-housed sows were moved to pens after pregnancy confirmation at 5 wk after mating. Daily feed allowance for sows was dropped on a solid floor and was equal in all three housing systems. Sow weight 5 weeks after mating, before farrowing and at weaning, farrowing performance, removal rate and reasons for removal were recorded. Data were analyzed using the Proc FREQ and the Proc MIXED procedures of SAS. Sows in large pens gained less weight during gestation than sows in stalls and in small pens (73.6 vs. 91.4 and 87.0 kg, SE = 3.6; $P = 0.01$). In addition, the proportion of sows that farrowed was lower in large pens (92%, $\chi^2 = 9.52$; $P < 0.01$) than in stalls (98%), with sows in small pens being intermediate (95%). Consequently, a greater percentage of sows were removed from large pens (15.8%, $\chi^2 = 6.75$; $P < 0.05$) than from stalls (9.2%), with sows in small pens being intermediate (11.7%) during the study period. Poor reproductive performance was the main reason for culling in all three housing treatments. A higher proportion of sows died in small pens (3.2%, $\chi^2 = 4.34$; $P = 0.11$) compared to large pens (1.5%) or stalls (0.6%). Housing treatment did not affect live litter sizes at birth (12.5, 12.2 and 12.3 piglets for large pens, small pens and stalls respectively, SE = 0.21), at weaning (10.2, 10.1 and 10.3 piglets, SE = 0.20) or mean litter weight at weaning (71.7, 72.3 and 71.3 kg/litter, SE = 1.39). These results suggest that welfare of sows was comprised in pens under the conditions of this study, as indicated by decreased farrowing rates and high sow removal rates.

Key Words: gestation housing, reproductive performance, sows

O055 **Is analgesic transfer to piglets via the sow's milk an option for pain mediation at castration?** J. A. Brown [1, 1,*], Y. M. Seddon [1], J. Stookey [2], J. Alcorn [3], *[1]Ethology, Prairie Swine Centre, [2]Western College of Veterinary Medicine, [3]Department of Pharmacy, University of Saskatchewan, Saskatoon, Canada.*

The cost of drugs and the additional labour required to administer analgesics to individual piglets reduces the likelihood of their adoption by producers when conducting painful procedures. This study examined the feasibility of a novel approach for providing analgesia at castration, using the sow as the vehicle to deliver analgesic to the entire litter. The work was completed in two parts. The first studied the kinetics of drug absorption and distribution. Twelve sows were injected with 0.5, 0.75 or 1.0 mg/kg of Meloxicam® at 7 days after parturition and serial, paired blood and milk samples were collected over a 5 hour period. Drug levels in plasma and milk were measured by HPLC. Meloxicam® concentrations in plasma peaked at 1 h post injection, averaging 468 ±136, 438 ±143 and 501 ±338 ng/mL for the 0.5, 0.75 and 1.0 mg/kg treatments, respectively. The average drug concentration in milk across treatments peaked at 215ng/L at approximately 3 h post injection, with concentrations of 105 ±18, 352 ±467 and 184 ±92 ng/mL, respectively, for the three treatments. Initial calculations based on the average drug concentration at 3 h, suggest a 7-day-old piglet weighing 2 kg and consuming 20 ml of milk will obtain roughly 0.002 mg/kg. This represents 1/200th of the standard intramuscular dosage of 0.5 mg/kg. In light of these concentrations, we do not expect piglets to benefit from pain relief using this approach. To confirm drug levels ingested by piglets at feeding, in a second study 12 sows were injected with 1.0 mg/kg of Meloxicam®. Over 5 hours, serial milk samples were collected from each sow and serial blood samples were collected from 3 male piglets per litter. This data will be presented at the meeting. Future work may include drug modification to increase excretion via the milk, or exploring the effect of increasing of the dose of drug injected per sow, on piglet pain relief, although the latter may be unfavourable due to cost.

Key Words: analgesia, castration, piglets

O056 **Effect of mannan oligosaccharide (Bio-Mos®) and outdoor access housing on pig growth, feed efficiency, ultrasound carcass composition and health.** B. A. Wenner [1,*], H. N. Zerby [1], W. A. Gebreyes [2], D. D. Boler [1], S. J. Moeller [1], *[1]Animal Sciences, [2]Veterinary Preventative Medicine, The Ohio State University, Columbus.*

The present study was conducted as a 3 x 2 factorial arrangement of treatments in 7 pen replications across 2 distinct farrowing groups (n = 360). Three dietary treatments evaluated the effects of feeding Bio-Mos® (BM; at 0.2%, 0.1% and 0.05% inclusion rates for phase 1 (30.2 to 63.5 kg), 2 (63.5 to 90.5 kg) and 3 (90.5 to 112.4 kg) swine finishing diets, respectively), a sub-therapeutic antibiotic (AB; tetracycline; at 0.0055% inclusion in all dietary phases) and standard, no additive control (C) diets. Housing treatments compared a conventional, indoor (IN) housing arrangement providing 1.0 m^2/pig covered solid concrete floor and 0.3 m^2/pig covered slatted floor, and an indoor with outdoor access (OUT) system providing 1.1 m^2/pig covered solid concrete floor and 1.9 m^2/pig solid concrete outdoor space. Pig growth, feed intake, feed efficiency, blood hematocrit (one farrowing group only), skin lesion scores, carcass composition, and pig health were measured. No significant dietary × housing treatment interactions were observed. Outdoor access housing increased pig average daily gain (ADG) by 0.04 kg/d ($P < 0.0005$), average daily feed intake (ADFI) by 0.1 kg/d ($P = 0.01$), decreased gain per unit of feed (G:F) by 0.01 kg gain/kg feed ($P = 0.05$), and reduced days to a standard 113.6 kg endpoint (DAYS) by 4.0 days ($P < 0.0005$) when compared to IN housed pigs. Dietary treatments BM and C had greater ADG (0.02 kg/d, $P < 0.05$) and required 3 fewer days to 113.6 kg ($P < 0.05$) when compared with pigs fed AB. Hematocrit was 2 units greater ($P < 0.05$) on d 84 for OUT housed pigs. Ultrasonic measures of carcass composition were not different across dietary or housing treatments. In the present study, the addition of sub-therapeutic antibiotics in swine finisher diets did not improve pig growth, efficiency or health, while the addition of BM to diets improved performance to a level equal to the C diet. Further, outdoor housing improved pig growth and health measures, with a slightly less efficient G:F ratio.

Key Words: growth and efficiency, housing, swine

O057 **Effects of management options on performance of gestating sows housed in an electronic sow feeder system.** Y. Li[1,*], H. Gonyou[2], *[1]West Central Research and Outreach Center, University of Minnesota, Morris, [2]Prairie Swine Center, Saskatoon, SK, Canada.*

A variety of management options exist for group-housed sows and these may affect performance and animal welfare. A study was conducted to examine the effect of two management options on the performance of gestating sows group-housed with electronic sow feeders. Multiparous sows (n = 1,569, Parity 1 to 9, PIC genetics) from 100 contemporary breeding groups were used for data collection, including 457 sows in stalls for reference. Group-housed sows (n = 1,112) were assigned to a 2×2 factorial arrangements of management treatments representing Stage of gestation at mixing (pre-implantation: < 9 days after breeding vs. post-implantation: 37-40 days after breeding) and Social management (static vs. dynamic). Each Static group consisted of 35 to 40 sows that were grouped simultaneously and no further animals were added to the group. Dynamic groups were approximately 110 animals, with 35-40 sows being added to the group every 5 weeks. The results indicate that pre-implant sows had a lower farrowing rate (82.3% vs. 86.7%, $P = 0.05$), and greater body weight after breeding (218 vs. 210 kg, SE = 3.3; $P < 0.01$) and before farrowing (286 vs. 275 kg, SE = 3.6; $P < 0.001$) compared with post-implant sows. Change in body weight during gestation was not affected by Stage of gestation at mixing. Social management did not affect farrowing rate, body weight and weight change during gestation. Neither Social management nor Stage of gestation affected wean-to-mating interval, change in body weight during gestation, total or live born litter size. Sows in stalls had a similar farrowing rate (86.2%) to that of post-implant sows. These results demonstrate that sows that were mixed after implantation performed similarly as sows in stalls. When sows were mixed before implantation, farrowing rate was reduced by 4% compared with sows that were mixed after implantation.

Key Words: group-housing, sows, static, dynamic, implantation

BILLY DAY SYMPOSIUM: CONSIDER SOW HOUSING

O058 **The history of gestation sow housing in the United States**. S. Niekamp[*], *Swine Welfare, Clive.*

The United States Department of Agriculture estimates the current national breeding herd inventory is approximately 5.79 million head, 3.11 million head less than 1968 when they first began publishing national statistics. In addition to changes in the national breeding herd size, the swine industry has also witnessed changes in farm size, genetics, management practices and how gestating sows are housed. Pig production began moving indoors in the 1960s and a variety of facility configurations were used for gestating sows including groups with feeding stalls, individual stalls during estrus detection, or individual stalls throughout gestation. Use of the individual stall decreased aggression among sows, allowed for individual feed delivery, care and observation, minimized labor requirements, and provided advantages in sanitation and animal health. For these reasons, the use of individual stalls for the entire gestation period became the preferred housing method with an estimated 82.7% of sows housed in individual gestation stalls in 2012. This percentage is estimated to decrease by 5.6% over the next two years largely due to state laws limiting the use of gestation stalls and increased pressure from the marketplace to move to group pen housing. Group housing for pregnant sows is often defined as a housing environment for more than one sow where, after confirmed pregnant, they have the ability to lie down and stand up unimpeded and to turn around. There are numerous combinations of facility designs, feeding systems and pig flows that fit this definition but it is ultimately the individual care given to each pig and the skills of the caretaker that determine the success of the housing system in terms of animal welfare and farm productivity.

Key Words: gestation, sow housing, stalls

O059 **Sow housing from the perspective of the pig.** E. Pajor[*], *Veterinary Medicine, Production Animal Health, University of Calgary, Canada.*

Sow housing is a controversial issue in agriculture. Concern over animal welfare has resulted in the banning of gestation stalls in numerous countries and within specific US states. Animal welfare involves functioning, affective states and natural behavior. Historically animal scientists have focused on functioning. From a public perspective good functioning is expected to be part of food production. For much of the public and many animal welfare scientists an animal's affective state is one of the most important aspects of animal welfare. Assessing how the animal perceives its environment involves the use of preference and motivation tests. In a series of experiments my lab has investigated sows preferences and motivation for various aspects of their gestational environment. We demonstrated that sows prefer to rest in stalls with rubber mats ($P< 0.05$), which resulted in decreased lesions ($P< 0.05$) and increased postural changes ($P< 0.001$). In another series of experiments, stalled and grouped housed sows were given a choice between opened or closed free-access stalls. Sows from group systems ($P<0.05$) and sows from stalls ($P<0.001$) both chose opened free-access stalls. A study, designed to examine sow welfare in free-access systems with varying amounts of group space found that as the group space increased, the percentage of sow spending time in the group area also increased ($P=0.05$) and that high ranking sows used the space more ($P< 0.0001$). The strength of an animal's preference can be addressed through motivational tests. My lab has demonstrated that sows have strong motivations for space and specific enrichments such as compost and straw. In the future, the importance of the affective states of animals will increase in the public policy arena and with consumers. This will require the development of additional scientific approaches to measure the positive and negative affective states of animals in specific housing systems.

Key Words: welfare, preference, motivation, affective states

O060 **Sow housing from the perspective of the consumer**. G. Tonsor[*], *Agricultural Economics, Kansas State University, Manhattan.*

The objective of this presentation is to provide a summary of research findings and economic implications of U.S. consumer knowledge, perceptions, and preferences regarding sow housing. The presentation will pull key findings together from multiple research projects with a focus on highlighting the economic implications for the U.S. swine industry. Specific points of discussion will include the relative importance of animal welfare, the disconnect between resident voting and consumer purchasing behavior, sensitivity to producer adjustment timetables, awareness of retail price

implications, impact of media attention on retail demand, and the possible role of mandatory labeling. The presentation will conclude with a summary of implications for the U.S. swine industry.

Key Words: consumer perspectives

O061 **Sow housing from the perspective of Dutch producers**. H. Feitsma [*], E. F. Knol, *Research and Development, TOPIGS Research Center IPG, Beuningen, Netherlands.*

After the 2nd World War, increase in mechanization and use of artificial fertilizers enabled intensification of agriculture and contributed to securing food supply for the Dutch population. Imports of cheap feed ingredients through the main harbor in Rotterdam enabled non land bound pig production. Many pig barns were built in the 1970s. However, the successful intensified production methods had severe negative environmental consequences. After several pollution scandals, the public became aware that food safety and their environment was at risk and that modern agricultural production methods caused the majority of environmental problems. Legislation was used to restrict the number of animals per hectare. This led to a switch from finishing pigs to sow production and increase in exports of piglets. Turning point in the public involvement in animal production was the Classical Swine Fever outbreak in 1997. This crisis led to the killing of 11 million animals. The killing of so many pigs, including young piglets, was reported on television every evening. Once the crisis was resolved, discussions about intensive pig production started. Topics like confinement systems for sows, teeth clipping, tail docking and castration were discussed. In 2003 EU legislation was accepted for welfare and environmental friendly production systems. Sustainable production policy came in to action. Politicians didn't always need scientific basis for decisions and producers had to adapt very fast to new requirements. Majority of Dutch farms are traditional family owned enterprises. Farmers are willing to invest when a successor is available and profitability on the long run is feasible. Per January 2013, loose housing of sows and air filtration are fully operational in Dutch pig production systems. Producers have learnt to be proactive and to get involved in discussions early on. Transparency to and cooperation with consumer and welfare organizations is leading to more sustainable production. This is better for animals, workable for producers and acceptable for society.

Key Words: housing, sows, welfare

O062 **Sow housing: Summary and perspectives from Australia.** P. H. Hemsworth [1, 2*], *[1]Department of Agriculture and Food Systems, University of Melbourne, Parkville, Australia, [2]Department of Animal Science, The Ohio State University, Columbus.*

Reducing aggression and, in turn, stress at mixing pre- or early post-insemination are key considerations in safeguarding sow welfare and reproduction. Research has shown that the effects of floor space are most pronounced early after grouping post-insemination, with a general decline in both aggression and cortisol but a general increase in farrowing rate with increasing space from 1.4 to 3.0m^2/sow. Furthermore, it appears that sows may adapt to reduced space as gestation proceeds. While floor space is important, group size appears to be less important. However skin injuries are generally lower throughout gestation in small groups (e.g., groups of 10 sows) than in larger groups (e.g., groups of 30 and 80 sows). Protecting individual sows at feeding will reduce aggression and stress, but space and pen layout outside the feeding area to facilitate pig flow also appear to be important in reducing aggression and stress. There is evidence that mixing sows directly after weaning affects sow sexual behaviour, particularly in subordinate sows, and clearly a better understanding of social effects is required. Very limited research and anecdotal industry reports suggest that mixing pens post-insemination providing considerable space (e.g. 3.0 m^2/sow), barriers to provide visual separation from others and foraging opportunities to provide distractions, may offer the potential to reduce aggression and stress at mixing. Sows are more aggressive when mixed in the first week after insemination than 5 weeks post-insemination and so effective strategies to reduce aggression when mixing pre- or early post-insemination are critical. It is clear that the design of the pen system (e.g., space, feeding system, pen layout, etc.) and stockmanship are critical in safeguarding sow welfare and reproduction. Training staff in appropriate observation, interpretation of animal behaviour and handling behaviour and ensuring appropriate opportunity for frequent animal inspection at mixing and over the first week post-mixing are also necessary in managing sow welfare.

Key Words: group housing, recommendations, sow welfare

BREEDING & GENETICS SYMPOSIUM: GENOTYPING TECHNOLOGIES AND THEIR APPLICATION IN BREEDING PROGRAMS

O063 **Development and applications of low-cost, high-throughput genotyping.** R. M. Thallman[1,*], A. K. Lindholm-Perry[1], J. D. Curry[2], V. Y. Fofanov[3], H. Koshinsky[2], *[1]USDA, Agricultural Research Service, U.S. Meat Animal Research Center, Clay Center, NE, [2]Eureka Genomics, Hercules, CA, [3]Eureka Genomics, Sugarland, TX.*

Most current genotyping systems are too expensive to justify routine genotyping of all animals in livestock breeding and/or production. Therefore, a low-cost genotyping method was developed in which barcodes identifying individuals are added to DNA fragments programmed by specific loci. Next generation sequencing of pools of these DNA fragments from more than 1,000 animals yields enough sequence reads to reliably determine genotypes. The method, referred to as Next Generation Genotyping (NGG), is an economical and highly versatile method that permits switching in and out of particular markers at will. Validation of the NGG method was performed using 95 *B. taurus* markers (commonly used for parentage testing) on 1080 cattle samples. Concordance with genotypes determined using the Illumina BovineSNP50 bead chip was 99.1% with a call rate of 96.1%. Potential applications of NGG in seedstock breeding include parentage testing, genetic defects, single gene traits (color, polledness, etc.), and prediction of economically relevant traits from small panels of SNP. Potential applications in livestock production include precision management of diets, growth promotants, marketing targets, and time-on-feed in fed cattle or assignment of specific carcasses to different marketing channels. Current efforts include development of a panel of 1,000 to 3,000 highly informative markers that is sufficiently inexpensive to make it practical to genotype all individuals in pedigreed beef cattle populations. Such a panel, with sufficient marker density to track inheritance throughout a completely genotyped population, and used in conjunction with higher density SNP chips on sires and genomic sequence on very influential ancestors, might be used to impute reasonably complete sequence to entire populations of seedstock.

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Key Words: genomic technologies, genotyping

O064 **Comparison of genomic predictions in Hereford using actual or imputed 50K genotypes.** M. Saatchi [1], E. Marques [2,*], S. Bauck [2], D. J. Garrick [1], *[1]Animal Science, Iowa State University, Ames, [2]GeneSeek, Lincoln.*

Genomic predictions have been routinely implemented in Hereford beef cattle using the Illumina BovineSNP50 BeadChip (50K). Costs associated with the 50K chip are still too high to have all the animals in the herd genotyped and genomically evaluated. GeneSeek recently released a low-density chip known as GeneSeek Genomic Profiler (GGP) including 9,181 SNP markers at a lower price than 50K. Some 8,156 GGP markers are in common with 50K markers and could be use for imputation. The objective of this study was to compare the accuracies of genomic predictions for 10 traits in Hereford cattle using actual 50K or 50K genotypes imputed from the GGP chip. A total of 1,081 animals were genotyped with 50K chip. Genotyped individuals were clustered into four groups using k-means clustering with the aim of increasing the within-group and decreasing the between-group pedigree relationships. For each clustered group, genotypes for 8,156 GGP markers in common were extracted from 50K genotypes. Those genotypes were imputed to 50K genotypes using phased marker information from the other three groups, based on the USDA-AIPL linkage map and BEAGLE phasing software. Four-fold cross-validation was performed using three groups for training (those with actual 50K genotypes) and the fourth group for validation (using either actual or imputed 50K genotypes). Deregressed estimated breeding values were used as observations in a weighted analysis that estimated marker effects to derive molecular breeding values (MBV). Bivariate animal models were used for each trait to estimate the genetic correlation between trait and MBV as a measurement of the accuracy of genomic prediction. The accuracies of MBV ranged from 0.20 to 0.44 (on average 0.32) and from 0.19 to 0.42 (on average 0.31) when applied to actual or imputed 50K genotypes, respectively. With the relatively small reductions in the accuracies of genomic predictions, it is safe to recommend the cheaper GGP chip for large-scale genotyping in Hereford cattle.

Key Words: genomic prediction, imputation, low density

O065 **Influence of accuracy of phasing on accuracy of imputation from 7k to 50k genotypes in cattle.** Z. Weng [1,*], M. Saatchi[1], R. Schnabel [2], J. Taylor [2], D. Garrick [1, 3], *[1]Animal Science, Iowa State University, Ames, [2]Division of Animal Science, University of Missouri, Columbia, [3]Institute of Veterinary, Animal and Biomedical Sciences, Massey University, Palmerston North, New Zealand.*

The objective of this study was to evaluate the relationship between the accuracy of haplotype phasing using high-density genotypes and the resultant accuracy of imputation from low-density genotypes. Accuracy of phasing can be quantified with the comparison between the number of expected and observed crossovers within sire/offspring pairs. A total of 2,778 parent-verified Angus sire/offspring pairs were genotyped with the Illumina BovineSNP50 BeadChip (50k). SNP with call rate <0.95, minor allele frequency <0.01, p value of a Hardy Weinberg Equilibrium test <0.001, and Mendelian inconsistency rate >0.002 were removed, leaving 39495 loci for analysis. Phasing and imputation of Bos taurus (BTA) chromosome 15 was obtained using the family-based algorithm in FImpute2.1 (Sargolzaei et al., 2010) with SNP location determined by USDA-AIPL linkage map. Genotypes for 7,345 markers from the low-density GGP panel (7k) were extracted from 50k panel. Bulls were clustered into five groups using K-means clustering (Saatchi et al., 2011). All five combinations of four of the groups were used for phasing 50k genotypes, and imputation were performed in the group not used in the phasing based on the 7k genotypes. The expected numbers of crossovers on BTA15 were (#cattlex#crossovers) 1,183x0, 1,009x1, and 430x2 according to the Haldane map function whereas observed crossovers were 851x0, 1,126x1, 439x2, 157x3, and 205x>3, indicating some individuals with 0 crossovers and all individuals with =>3 observable crossovers contained phasing errors. The average percentage of SNP imputed correctly in the five categories above were 98.97, 98.45, 98.20, 98.05 and 97.45%, respectively. Imputation accuracy declined with the number of crossovers, and bulls with >3 crossovers had lowest phasing accuracy. These results demonstrate that the accuracy of genotype imputation depends on the accuracy of phasing haplotypes from high-density SNP genotypes.

Key Words: phase, imputation

O066 **Incorporation of genomic predictions into the American Hereford Association (AHA) national cattle evaluation.** J. Ward[1,*], D. Garrick [2], M. Saatchi [2], D. Johnston [3], B. Crook [3], *[1]AHA, Kansas City, [2]NBCEC and Iowa State University, Ames, [3]AGBU, Abri, Australia.*

The AHA is using a Hereford specific prediction equation to generate genomic predictions used to enhance the EPD and increase the corresponding accuracies for its breeders. It is anticipated this will reduce generation intervals and increase rates of genetic improvement within the US Hereford population. The training and validation population was developed by 50K genotyping nearly 1,100 mostly high accuracy Hereford sires. A 4-fold cross validation method was used so that all animals contributed to both validation and training, but validation was on animals not closely related to those in training. The genomic predictions are referred to as molecular breeding values (MBV) and are produced using the 50K panel for each trait evaluated by AHA. The genetic correlations of MBV with each trait range from nearly 0.30 to 0.45, accounting for 10-20% of genetic variation of the trait. In the immediate future, a post evaluation blending incorporates the genomic information of the animal tested using an interim approach that updates the EPD and corresponding accuracies for each trait. This method does not allow the genomic information to influence non-genotyped relatives. The alternative of incorporating the MBV as correlated traits has proved problematic in the full multi-trait model that is used for the pan American evaluation that provides EPD for AHA. New procedures for incorporating genomic information are being investigated.

Key Words: none

O067 **Genomic-enhanced EPDs in the American Angus Association National Cattle Evaluation.** S. L. Northcutt[1,*], T. S. Amen[1], B. W. Brigham [2], D. Nkrumah [3], S. Bauck [4], *[1]Angus Genetics Inc., St Joseph, [2]Colorado State University, Fort Collins, [3]Pfizer Animal Genetics, Kalamazoo, [4]Igenity, Lincoln.*

Genomic technologies are used as part of the American Angus Association (AAA) National Cattle Evaluation on a weekly basis to generate genomic-enhanced EPDs. Angus Genetics Inc. (AGI), a wholly owned subsidiary of AAA, receives results from two genomic companies in the form of molecular breeding values to be incorporated into BLUP procedures. DNA samples are received and anonymously barcoded to relate to AAA animal identity before sending samples to company laboratories for extraction and genotyping. Molecular

breeding values are computed through respective company algorithms and results returned to AGI for incorporation into national cattle evaluation procedures. Genomic predictions from Igenity were first incorporated in October 2009, followed by inclusion of Pfizer genomic results in February 2011. Similar to methodology used to incorporate phenotypic indicator traits into evaluations, molecular breeding values are incorporated into BLUP procedures as correlated traits. Genetic correlations between the molecular breeding values provided and the AAA phenotypic trait database range from 0.24 to 0.65 for the Igenity 384 SNP test and 0.32 to 0.65 for the Pfizer HD 50k test. Mean additive genetic variance percentage explained is 0.21 and 0.30 for Igenity and Pfizer respectively, across 15 traits. The correlated trait model allows for inclusion of additional animal information of varying amounts into existing genetic evaluations. Only the economically relevant trait EPD and associated accuracy are reported. Average accuracy increases are 0.15 to 0.27 for non-parent animals with only genomic test results, depending on the test and trait. Molecular breeding values on 41,219 registered Angus animals are incorporated into 15 EPDs, which are then used in the calculation of 6 selection indexes.

Key Words: correlated trait, genomic technologies, molecular breeding value

O068 **Genomic prediction in red Angus beef cattle is improved by using a multi-breed reference population.** M. Saatchi*, D. J. Garrick, *Animal Science, Iowa State University, Ames.*

The objective of this study was to derive and evaluate the accuracies of direct genomic breeding values (DGV) for 9 traits in Red Angus beef cattle using single- or multi-breed reference populations derived from animals evaluated in the Red Angus population. The traits were birth, yearling and carcass weight; weaning weight direct and maternal; fat thickness; marbling; rib eye area and yield grade. A total of 1,274 Red Angus, 1,766 Black Angus and 3,372 animals from non-Angus breeds (mainly Simmental) were genotyped with the Illumina BovineSNP50 BeadChip. Genotyped Red Angus animals were clustered into five groups using k-means clustering with the aim of increasing the within-group and decreasing the between-group pedigree relationships. Five-fold cross-validation was performed within-breed using four groups for training and the fifth group for validation. Multi-breed cross-validation used the same four Red Angus groups for each of the five training runs, except that all the Black Angus were included, or all the non Red Angus animals were included. In multi-breed analyses only the accuracies of Red Angus predictions were of interest. Deregressed estimated breeding values were used as observations in a weighted analysis that estimated marker effects to derive DGV. Bivariate animal models were used for each trait to estimate the genetic correlation between trait and DGV as a measurement of the accuracy of genomic prediction. The accuracies of DGV training on Red Angus alone ranged from 0.54 to 0.85 (average 0.68), training on Red and Black Angus ranged from 0.52 to 0.92 (average 0.73) and training on all breeds ranged from 0.51 to 0.90 (average 0.74). Genomic predictions were more accurate using multi-breed reference populations than the single-breed Red Angus for all traits except weaning weight maternal. These results form the basis of commercial implementation of DGV for American Red Angus beef cattle.

Key Words: admixed reference population, genomic breeding values, genomic prediction

O069 **Application of genomics to genetic improvement at PIC**. M. Cleveland*, S. Forni, N. Deeb, *Genus plc, Hendersonville.*

Genomic information has been used in commercial pig breeding for the last two decades to increase the rate of genetic gain for a range of traits. PIC has incorporated genetic markers into the breeding program since 1991, but technological advances have dramatically increased the availability of genomic data in recent years. The introduction of the Illumina PorcineSNP60 Beadchip enabled a transition from marker-assisted selection using few markers to approaches that use many genome-wide markers. PIC has used genome-wide association studies to develop small marker panels to improve key traits. Genomic breeding values were calculated from these panels by blending marker effects with the usual pedigree breeding values. Such panels can be particularly useful for traits where phenotypes are not routinely recorded, such as disease resistance. Alternatively, all markers can be used in a multi-trait evaluation that combines information from genotyped and un-genotyped individuals. The statistical and computational challenges of such an approach have been addressed by implementing the single-step genomic evaluation, which uses markers to more accurately characterize relationships between individuals. When selection candidates are genotyped, an increase in accuracy of 50% to 75% has been observed for some traits. To increase the accuracy of breeding values at selection, all selection candidates would ideally be genotyped for all markers, but the cost of genotyping is prohibitive due to a large number of candidates in commercial pig populations. Approaches have been developed to impute 60k genotypes using small panels of evenly spaced markers that are available for a fraction of the cost of high-density chips. Accuracies of imputing high-density genotypes from a very low-density panel generally exceed 0.95 when parents are genotyped. A database of more than 25,000 high-density genotyped pigs and a high-performance computing cluster have enabled PIC to implement a cost-effective approach for genomic selection that routinely produces genomic breeding values population-wide.

Key Words: genomic selection, imputation, pig

O070 **Costs of implementing genome-enabled selection in swine**. C. Abell*, J. Dekkers, M. Rothschild, J. Mabry, K. Stalder, *Iowa State University, Ames.*

The objective of this study was to develop a tool to determine the cost structure associated with incorporating genome-enabled selection into maternal and terminal line breeding programs. Determining an animal's genetic merit using genome-enabled selection can improve the accuracy of estimated breeding values (EBV); however, this improved accuracy must be large enough to recover the costs associated with implementing genome-enabled selection. One way to reduce the genome-enabled selection costs is to genotype selection candidates using a low density chip and use high density chip genotyping for animals that are used as breeders in the nucleus herd. It was assumed that the training data consisted of 2000 animals genotyped at high density. Here, the top 5% based on genome-enabled EBV of the boars produced in the nucleus herd was assumed to be used as nucleus replacements in the maternal and terminal lines. The top 60% of boars were used in the commercial production system for the terminal line. Assuming a 1000 sow nucleus herd for the maternal line genetic program and genotyping all male and females selection candidates at low density and all animals used for breeding at high density, it was determined that genome-enabled selection cost would be approximately $0.08 per weaned pig in the commercial production system assuming that the boars produced in the nucleus are used at capacity. For a 600 sow terminal line nucleus

herd and genotyping only male selection candidates at a low density, the cost per weaned pig in the commercial herd was determined to be $0.05. This means that $0.13 per weaned pig from boars produced in the nucleus would need to be added to genetic merit of each market pig in order to break even on the cost of genome-enabled selection. A flexible spreadsheet tool developed from this work can be utilized to estimate the returns needed to recover additional costs associated with genome-enabled selection by modifying the input values such as herd size and genotyping strategy to represent the specific design of any production system.

Key Words: economic value, genomic selection, swine

O071 **Genomic selection in layer chickens outperforms pedigree-based selection**. A. Wolc [1, 2, 3,*], J. Arango [1], P. Settar [1], J. E. Fulton [1], N. P. O'Sullivan [1], R. Preisinger [4], D. Habier [2], R. L. Fernando [2], D. J. Garrick [2], S. J. Lamont [2], J. C. Dekkers [2], *[1]Hy-Line Int., Dallas Center, [2]Department of Animal Science, Iowa State University, Ames, [3]Department of Genetics and Animal Breeding, Poznan University of Life Sciences, Poznan, Poland, [4]Lohmann Tierzucht GmbH, Cuxhaven, Germany.*

Genomic selection has revolutionized animal breeding by promising increased selection accuracy and shortening generation interval. The objective of this study was to compare response to selection in two sub-lines derived from a common base population of brown egg layers. One sub-line was selected based on own performance and pedigree information with a traditional one-year generation interval, whereas the other was selected based on genomic-based information with generation interval reduced to six months. To reduce costs, the size of the genomic-based selected sub-line was reduced five-fold and cross-classified mating was introduced to compensate for the decrease in effective population size. Both sub-lines were selected using an index combining 16 traits. Genomic BLUP and BayesB methods were used to estimate genomic breeding values. Selected parents from generations preceding the base population were genotyped with a 42K Illumina SNP chip to provide information about marker effects as were all selection candidates. Retraining was performed every round of selection. Inbreeding level was monitored and matings of close relatives were avoided in both sub-lines. The accuracy of predictions varied substantially between traits and generations, but was higher and more persistent across generations for genomic breeding values than that of pedigree-based breeding values. Genomic regions explaining the largest proportion of genetic variation were identified for all studied traits. By the end of the 3-year experiment, the genomic selection sub-line was slightly more inbred but outperformed the pedigree-selected sub-line for the majority of traits. Cross-classified mating improved population structure and effective population size. The experiment has demonstrated that genomic selection can be successfully implemented in a chicken breeding program in the commercial environment.

Key Words: genomic selection, layer chickens

NONRUMINANT NUTRITION: CO-PRODUCTS FEEDSTUFFS

O072 **Carbohydrate composition and in vitro digestibility of dry matter and non-starch polysaccharides in grains and grain co-products.** N. W. Jaworski [1,*], H. N. Lærke [2], K. E. Bach Knudsen [2], H. H. Stein [1], *[1]Animal Science, University of Illinois, Urbana, [2]Animal Science, Aarhus University, Tjele, Denmark.*

Two experiments were conducted to investigate aspects of fiber composition and digestibility in 12 feed ingredients commonly fed to pigs. The 12 ingredients included 3 grains (corn, sorghum, and wheat), 3 co-products from the dry grind industry [corn distillers dried grains with solubles (DDGS) and 2 sources of sorghum DDGS], 4 co-products from the wet milling industry (corn gluten meal, corn gluten feed, corn germ meal, and corn bran), and 2 co-products from the flour milling industry (wheat middlings and wheat bran). In Exp. 1, the carbohydrate composition of the 12 ingredients was determined. Grains contained approximately 64.3% starch and 8.1% non-starch polysaccharides (NSP), whereas grain co-products contained approximately 12.6% starch and 28.1% NSP. The concentration of soluble NSP was minimal in all ingredients and ranged from 0.4% in sorghum to 6.6% in corn germ meal. Non-starch polysaccharides from corn and corn co-products contained approximately 27% glucose, 22% arabinose, and 27% xylose, whereas NSP from sorghum and sorghum DDGS contained approximately 38% glucose, 26% arabinose, and 20% xylose, and NSP from wheat and wheat co-products contained approximately 25% glucose, 25% arabinose, and 40% xylose. Experiment 2 was conducted to determine in vitro ileal and total tract digestibility of DM and NSP in the 12 ingredients. In vitro ileal digestibility of NSP was close to zero in all feed ingredients, indicating that pepsin and pancreas enzymes have no effect on in vitro degradation of NSP. A strong correlation (R^2 = 0.97) between in vitro ileal digestibility of DM and NSP concentration in feed ingredients was observed. In vitro total tract digestibility of NSP ranged from 6.5% in corn bran to 57.3% in corn gluten meal, which indicates that the extent of fermentation of NSP in a feed ingredient depends on the amount and type of NSP in the ingredient. In conclusion, NSP composition of grains and grain co-products plays an important role in determining the extent of fermentation of NSP; therefore, NSP composition of each ingredient influences the energy value of grains and grain co-products.

Key Words: co-products, in vitro digestibility, non-starch polysaccharides

O073 **Energy concentration and amino acid digestibility in corn and corn co-products fed to growing pigs.** M. Song [1], J. K. Mathai [2,*], F. N. Almeida [2], O. J. Rojas [2], S. L. Tilton [3], M. J. Cecava [3], H. H. Stein [2], *[1]Animal Sciences, Chungnam National University, Daejeon, Republic of Korea, [2]Animal Sciences, University of Illinois, Urbana, [3]Archer Daniels Midland Company, Decatur.*

Two experiments were conducted to determine DE and ME and the standardized ileal digestibility (SID) of CP and AA in corn and corn co-products (corn fiber, full fat corn germ [CG], a mixture of corn germ meal and liquid corn extractives [CGM-LCE], and liquid corn extractives [LCE]) fed to growing pigs. In Exp. 1, 40 barrows (initial BW: 33.4 ± 5.77 kg) were housed individually in metabolism cages. A corn basal diet was formulated and 4 additional diets were formulated by mixing corn with each of the corn co-products. Each diet was fed to 8 pigs per diet. Concentrations of DE and ME in corn fiber, CG, CGM-LCE, and LCE were less ($P < 0.05$) than in corn (DE: 3,204, 3,631, 3,567, and 3,485 vs. 3,986 kcal/kg DM, respectively; ME: 3,077, 3,336, 3,272, and 3,102 vs. 3,871 kcal/kg DM, respectively). Among corn co-products, the concentration of DE in CG was greater ($P < 0.05$) than in corn fiber, but the DE in corn fiber was not different from DE values in CGM-LCE and LCE. No differences were observed in the ME among corn co-products. In Exp. 2, 6 barrows (initial BW: 96.6 ± 1.16 kg) with a T-cannula in the distal ileum were randomly allotted to a 6 x 6 Latin square design with 6 diets and 6 periods. A N-free diet and 5 diets that contained corn, corn fiber, CG, CGM-LCE, or LCE as

the sole source of CP and AA were formulated. Each period lasted 7 d and ileal digesta were collected on d 6 and 7 of each period. The SID of CP and all indispensable AA except Lys and Trp was greater ($P < 0.05$) in corn than in all corn co-products. Among corn co-products, the SID of CP, Lys, and Val were greater ($P < 0.05$) in CG, CGM-LCE, and LCE than in corn fiber, and the SID of Arg was greater in CG and CGM-LCE than in corn fiber and LCE, but for the remaining AA, no differences among corn co-products were observed. In conclusion, the corn co-products used in these experiments contain less ME and have reduced SID of most AA compared with corn, but there are no differences in ME among corn co-products and only few differences in SID of indispensable AA among corn fiber CG, CGM-LCE, and LCE.

Key Words: corn co-products, digestibility, pigs

O074 **Effects of diet form and fiber level before marketing on growth performance, carcass yield, and iodine value of finishing pigs.** J. Nemechek*, M. Tokach, J. DeRouchey, S. Dritz, R. Goodband, J. Nelssen, *Animal Science and Industry, Kansas State University, Manhattan.*

A total of 288 pigs (PIC 327 × 1050, 49.6 kg BW) were used in an 81-d trial to determine the effects of diet form and fiber feeding regimen on growth, carcass yield, and iodine value (IV) of finishing pigs. Treatments were arranged in a 2 × 3 factorial with main effects of diet form (meal vs pellet) and dietary fiber regimen. Fiber regimens were: 1) low fiber (corn-soybean meal) from d 0 to 81, 2) high fiber (30% DDGS and 19% wheat midds) from d 0 to 64 followed by low fiber from d 64 to 81 (fiber withdrawal), and 3) high fiber from d 0 to 81. There were 8 pigs per pen and 6 pens per treatment. No interactions ($P>0.13$) were found. Overall, feeding pelleted diets increased ($P<0.03$) ADG and G:F compared with feeding meal diets, with no difference ($P>0.12$) in ADFI. Pigs fed low fiber throughout the trial had decreased ($P<0.001$) ADFI and increased ($P<0.001$) G:F compared with pigs fed the withdrawal regimen or high fiber throughout. Fiber regimen did not influence ($P>0.35$) ADG. Pigs fed low fiber throughout or pigs withdrawn from high fiber diets had increased ($P<0.001$) carcass yield compared to pigs fed high fiber throughout. Pigs fed meal diets had decreased ($P<0.001$) belly fat IV compared with pigs fed pelleted diets. Compared with pigs fed high fiber throughout the trial, pigs fed the low-fiber regimen had decreased ($P<0.001$) IV, with those fed the withdrawal regimen intermediate. In summary, feeding high-fiber diets increased ADFI and decreased G:F, regardless of withdrawal. Withdrawing DDGS and wheat midds allowed pigs to recover fully from losses in carcass yield, but only an intermediate improvement in belly fat IV was observed. Pelleting diets improved ADG and G:F, but worsened belly fat IV.

Diet form								
	Fiber level		Meal			Pellet		
	d 0 to 64:	Low	High	High	Low	High	High	
	d 64 to 81:	Low	Low	High	Low	Low	High	SEM
d 0 to 64:	ADG, kg	0.95	0.97	0.96	0.97	0.98	0.99	0.02
	G:F	0.386	0.368	0.362	0.405	0.393	0.391	0.01
d 64 to 81:	ADG, kg	0.93	0.97	0.88	1.02	1.03	0.97	0.03
	G:F	0.317	0.296	0.273	0.322	0.303	0.306	0.00
d 0 to 81:	ADG, kg	0.95	0.97	0.94	0.98	0.99	0.98	0.01
	G:F	0.369	0.350	0.340	0.384	0.370	0.370	0.01
Carcass yield, %		75.1	74.7	74.1	75.0	74.8	73.4	0.24
Belly fat IV		65.7	71.7	74.7	67.0	75.5	78.4	0.37

Key Words: dried distillers grains with solubles, finishing pig, pellet

O075 **The effects of medium-oil dried distillers grains with solubles on growth performance and carcass traits in finishing pigs.** A. B. Graham*, R. D. Goodband, J. M. DeRouchey, M. D. Tokach, S. S. Dritz, J. L. Nelssen, S. Nitikanchana, *Kansas State University, Manhattan.*

An experiment was conducted to determine the effects of increasing medium-oil dried distillers grains with solubles (DDGS; 7.4% fat, 28.1% CP, 10.8% ADF, and 25.6% NDF) on growth performance and carcass traits in finishing pigs. A total of 288 pigs (PIC 327 × 1050; initially 68.9 kg) were allotted to 1 of 4 dietary treatments in a 61-d study. Treatments consisted of a corn-soybean meal control diet or the control diet with 15, 30, or 45% medium-oil DDGS. There were 8 pigs per pen and 8 replications per treatment. Diets were fed over 2 phases (69 to 100 and 100 to 126 kg) and not balanced for energy. Increasing medium-oil DDGS decreased (linear, $P<0.02$) ADG and G:F. In addition, final BW, HCW, carcass yield, and loin-eye depth decreased (linear, $P<0.03$), and jowl iodine value (IV) increased (linear, $P< 0.001$) with increasing medium-oil DDGS. The NRC 2012 values for ME and NE were assigned for the medium-oil DDGS. Caloric efficiency (CE) increased when expressed on an ME basis indicating it over-estimates the energy value of this medium-oil DDGS source. However on a NE basis, there was no difference in CE, suggesting that the NRC 2012 NE value (2,343 kcal/kg; 88% the value of corn) was a better estimate of the energy content of medium-oil DDGS. Typically, for every 10% traditional (> 10% fat) DDGS added to the diet, jowl IV increases approximately 2 mg/g; however, in this study, IV increased only 1.4 mg/g for every 10% inclusion. Thus, the IV increase for medium-oil DDGS is approximately 70% of the increase with high-oil DDGS. This difference was expected because the oil content in the medium-oil DDGS (7.4%) is approximately 70% of the oil content in high-oil DDGS (10.5%).

	Medium-Oil DDGS, %					Probability, $P <$	
Item	0	15	30	45	SEM	Linear	Quadratic
d 0 to 67							
ADG, g	875	848	838	817	10.44	0.01	0.77
G:F	0.320	0.313	0.313	0.307	0.004	0.02	0.99
Final BW, kg	127.3	125.8	125.2	124.0	1.06	0.03	0.87
Carcass yield, %	73.98	73.16	72.36	71.84	0.16	.001	0.35
HCW, kg	93.4	91.4	90.1	88.5	0.83	.001	0.82
Lean, %	53.1	52.8	52.8	52.7	0.23	0.32	0.65
Jowl iodine value	70.2	71.1	73.7	76.3	0.27	.001	0.01
Caloric efficiency, Mcal/kg							
ME	10.45	10.68	10.71	10.92	0.13	0.02	0.93
NE	7.78	7.86	7.80	7.86	0.09	0.62	0.90

Key Words: dried distillers grains with solubles, finishing pigs, iodine value

O076 **Empiric narrowing of the net energy value of low-oil corn DDGS on pig growth performance and carcass characteristics.** V. Zamora[1], M. Young[1,*], N. Campbell[1], B. Uttaro[2], E. Beltranena[3], *[1]Gowans Feed Consulting, Wainwright, AB, [2]Agriculture and Agri-Food Canada, Lacombe, AB, [3]Alberta Agriculture and Rural Development, Edmonton, Canada.*

For the last 15 years, the North American ethanol industry has increased the availability of distillers dried grains with solubles (DDGS) for livestock feeding. However, in the last 2 years US ethanol plants have begun to partially remove the oil from corn DDGS, reducing it from 10–12 to 6–9%. Its dietary net energy (NE) value has therefore been reduced and needs re-establishing to properly consider the energetic contribution of this co-product to pig diets. To empirically narrow

down the NE value of low-oil corn DDGS, 1008 pigs (32 kg) housed in 48 pens by gender (barrows or gilts) were fed diets with 30% corn DDGS assuming NE values of 1.70, 1.85, 2.00, 2.15, 2.30, and 2.45 Mcal/kg over 5 feeding phases. Diets were formulated to equal g SID Lys:Mcal NE within phase. Canola oil was added at assumed low NE values and greater inclusions of barley replaced wheat grain as the assumed NE value of corn DDGS increased. For the entire trial (0 to 106 days), daily weight gain was not different ($P = 0.27$), but daily feed intake increased ($P < 0.01$) and feed efficiency decreased ($P < 0.01$) reaching a plateau between 2.00 and 2.15 and 2.15 and 2.30 Mcal NE, respectively. Carcass weight was heavier ($P < 0.05$) for the pigs fed diets with assumed lower (1.70 and 1.85 Mcal/kg) corn DDGS NE values. Backfat showed a trend ($P < 0.07$) to decrease and reached a plateau between 2.00 and 2.30 Mcal NE. Loin depth and estimated lean yield ($P < 0.05$) increased as the assumed NE value increased reaching a plateau between 2.15 and 2.30 Mcal NE. Days from the first to the last pig shipped to slaughter were different ($P < 0.01$) among NE values reaching a plateau above 2.00 Mcal NE. The results of this study suggest that the NE value of low-oil (7.8%) corn DDGS is between 2.15 and 2.30 Mcal/kg, lower than the 2.34 Mcal NE value referenced by the new swine NRC 2012 for corn DDGS with 6–9% oil.

Key Words: corn DDGS, net energy, pigs

O077 **Evaluation of various inclusion rates of dried distillers grain with solubles in sow lactation diets.** L. Greiner [1,*], Z. Jiang [2], C. Neill [3], J. Connor [1], G. Allee [4], *[1]Innovative Swine Solutions, LLC, Carthage, [2]Ajinomoto Heartland, Chicago, [3]PIC, Hendersonville, [4]Porktech, LLC, Columbia.*

Two experiments were conducted to evaluate the feeding of different levels of corn dried distillers grain with solubles (DDGS) in sow lactation diets. Lactation diets consisted of corn, soybean meal and either 20, 30, 40, and 50% DDGS. Diets were formulated to have 3.25 Mcal ME/kg, 1.05% SID lysine and all other nutrients to exceed NRC recommendations (NRC, 1998). Experiment one was conducted in the fall/winter (September-December) and experiment two was conducted during the summer (August) to evaluate the role of season in relationship to the experimental diets. In both experiments, sows (PIC, Camborough 1050) were fed 40% DDGS in gestation, allocated to a randomized complete block at the time of entry into the farrowing house, and fed ad libitum using a computerized Howema feed system that provided up to 13.6 kg of feed per day from day 3 post-farrow until weaning (20.7 ± 3 d). In experiment one, 256 gilts and multiparous sows were fed the randomly assigned diets. As DDGS inclusion increased from 20-50%, sow feed intake (6.68, 6.83, 6.26, 6.25 kg/d, P<0.01) and sow weight gain (13.63, 13.90, 12.19, 9.62 kg, P<0.09) decreased linearly. Litter gain decreased linearly (2.62, 2.67, 2.53, 2.55 kg/d, P<0.06) as DDGS inclusion increased. In experiment two conducted in the summer, 98 multiparous sows were randomly allotted to one of the four experimental diets. Sow feed intake was not influenced by DDGS inclusion (5.91, 6.29, 5.99, 5.86 kg/d, P>0.43). In addition, there were no differences in sow weight gain or litter gain (2.47, 2.67, 2.46, 2.65, P>0.13). This lack of response in experiment two could be related to the reduced intake associated with the high temperatures and humidity. These data suggest that feeding high levels of DDGS (40-50%) may reduce sow feed intake and litter performance. These results confirm our earlier studies that feeding 30% DDGS can be fed in lactation diets without influencing sow or litter performance.

Key Words: DDGS, lactation, sow

O078 **The effects of soybean hulls in corn-soybean meal and corn-soybean meal-DDGS diets on nursery pig performance.** D. Goehring [1,*], J. M. DeRouchey [1], M. D. Tokach [1], S. S. Dritz [1], R. D. Goodband [1], J. L. Nelssen [1], B. W. James [2], *[1]Kansas State University, Manhattan, [2]Kalmbach Feeds, Inc., Upper Sandusky.*

Two experiments were conducted to evaluate the effects of soybean hulls in diets with and without corn dried distillers grains with solubles (DDGS) on nursery pig growth performance. In Exp. 1, 600 pigs (BW 6.7 kg) were used in a 42-d study. Treatments were arranged in a 2×5 factorial with 0, 3, 6, 9, or 12% soybean hulls in corn-soybean meal diets without or with DDGS (15% from d 0 to 21, 30% from d 15 to 42). Pigs were blocked by initial pen weight, gender, and room location with 10 pigs/pen (6 replicate pens). Adding soybean hulls did not influence (P>0.21) ADG or ADFI, but adding DDGS reduced (P<0.04) ADG and ADFI, and tended to increase (P<0.06) G:F. There was a soybean hull × DDGS interaction (P<0.05) for G:F. Increasing soybean hulls worsened G:F quadratically (P<0.03) when added to diets without DDGS but linearly (P<0.01) when added to diets with DDGS. In Exp. 2, 304 barrows (BW 11.7 kg) were used in a 21-d study. Diets were arranged in a 2×4 factorial with 0, 5, 10, or 15% soybean hulls in either corn-soybean meal or corn-soybean meal-DDGS (20%) diets. Pigs were balanced by initial BW and randomly allotted to treatments with 9 replicate pens (4 pigs/pen). No soybean hull × DDGS interactions were observed. Increasing soybean hulls tended to worsen (linear, P<0.07) G:F but improved (linear, P<0.008) caloric efficiency on a ME and NE basis. The largest negative effect on G:F (linear, P<0.04) came from adding soybean hulls to diets without DDGS. In summary, feeding nursery pigs up to 15% soybean hulls did not affect ADG or ADFI, worsened G:F and improved caloric efficiency, indicating published energy values (INRA, 2004) undervalue the energy content of soybean hulls. (See table below.)

Key Words: DDGS, nursery pig, soybean hulls

O078 Table

Exp. 1	DDGS:	-	-	-	-	-		+	+	+	+	+
	Soybean hulls, %:	0	3	6	9	12	0	3	6	9	12	SEM
ADG, g		568	544	548	553	563	538	544	554	535	496	16.4
G:F		0.662	0.650	0.641	0.631	0.661	0.678	0.680	0.654	0.644	0.655	0.01
Exp. 2	DDGS:	-	-	-	-	+	+	+	+			
	Soybean hulls, %:	0	5	10	15	0	5	10	15	SEM		
ADG, g		531	537	525	512	514	520	518	499	14.5		
G:F		0.649	0.651	0.632	0.623	0.638	0.636	0.640	0.630	0.01		
Caloric efficiency, Mcal/kg												
ME		5.11	4.99	5.01	4.97	5.21	5.11	4.96	4.92	0.08		
NE		3.65	3.53	3.51	3.44	3.76	3.65	3.51	3.44	0.06		

O079 **The effects of soybean hulls on nursery pig growth performance.** D. Goehring*, J. M. DeRouchey, M. D. Tokach, S. S. Dritz, R. D. Goodband, J. L. Nelssen, *Kansas State University, Manhattan.*

Two experiments were conducted to evaluate the effects of soybean hulls on growth performance of nursery pigs. In both experiments, pens of pigs were balanced by initial BW and randomly allotted to 1 of 5 dietary treatments (7 pigs per pen and 6 replicates per treatment). In Exp. 1, 210 nursery pigs (6.6 kg and 28 d of age) were used in a 34-d study. Corn-soybean meal diets (meal form) contained increasing amounts of soybean hulls (0, 5, 10, 15, and 20%) and were not balanced for energy. Increasing soybean hulls decreased (linear, $P<0.01$) ADG and G:F, with no change in ADFI ($P>0.23$). In Exp. 2, 210 nursery pigs (13.6 kg and 41 d of age) were used in a 20-d study. Treatments were arranged in a 2×2+1 factorial, including a corn-soybean meal control diet without soybean hulls and corn-soybean meal diets containing 10 or 20% soybean hulls either balanced on a NE basis or not. Diets balanced for NE contained 3.6 and 7.15% added soybean oil in the 10 and 20% soybean hull diets to achieve the same NE as the control diet. Increasing soybean hulls decreased ADG (linear, $P<0.01$) regardless of formulation method; however, pigs fed increasing soybean hulls without added fat had similar ADFI but decreased (linear, $P<0.01$) G:F. Pigs fed diets containing soybean hulls balanced for NE had decreased ($P<0.01$) ADFI, but improved ($P<0.001$) G:F compared with pigs fed soybean hulls with no added fat, resulting in G:F similar to the control pigs. In conclusion, soybean hulls can be included in nursery pig diets up to 5% with no negative effects on ADG, ADFI, and G:F. Higher amounts, up to 20% soybean hulls, can be included in nursery pig diets with G:F similar to pigs fed corn-soybean diets if diets are formulated on a NE basis, but there are reductions in ADFI and ADG.

Exp. 1	Soybean Hulls, %					
Item	0	5	10	15	20	SEM
ADG, g	441	440	429	415	382	10.9
ADFI, g	680	673	698	685	638	18.4
G:F	0.651	0.656	0.616	0.609	0.601	0.01
Exp. 2	Soybean Hulls, %:					
	0	10	20	10	20	
NE, Mcal/kg:	2.37	2.21	2.05	2.37	2.37	SEM
ADG, g	680	663	625	671	636	9.6
ADFI, g	1070	1109	1094	1046	1006	17.4
G:F	0.637	0.597	0.570	0.641	0.631	0.008

Key Words: net energy, nursery pig, soybean hulls

O080 **Nutritional value of lentil and micronized full-fat soybean fed to growing pigs.** T. A. Woyengo[1,*], R. Jha[1, 2], E. Beltranena[1, 3], A. Pharazyn [4], R. T. Zijlstra [1], *[1]University of Alberta, Edmonton, Canada, [2]University of Hawaii at Manoa, Honolulu, [3]Alberta Agriculture and Rural Development, Edmonton, [4]Nutreco Canada Inc, Guelph, Canada.*

A study was conducted to determine the standardized ileal digestibility (SID) of AA and calculate NE for micronized regular full-fat soybean (R-FFSB) and low stachyose and raffinosefull-fat soybean (LSR-FFSB), and lentil for growing pigs. Six ileal-cannulated barrows (31.4 kg BW) were fed 6 diets in a 6 × 6 Latin square. The 6 diets were cornstarch-based with soybean meal (SBM), LSR-FFSB, LSR-FFSB, or lentil as the sole source of protein; N-free diet (NFD); and enzymatically hydrolyzed casein diet (EHC). Energy digestibility in SBM, R-FFSB and LSR-FFSB was determined by difference from the NFD, whereas energy digestibility in lentil was determined by direct method. The SID of AA for SBM and test ingredients was calculated using NFD or EHC. The SID of AA for feedstuffs was similar between 2 methods (NFD vs. EHC). The SID of Lys for SBM (93%) was higher ($P < 0.05$) than that for R-FFSB or LSR-FFSB, which were similar in SID of Lys (76 vs. 79%). The SID of other indispensable AA for SBM was also higher ($P < 0.05$) than that for R-FFSB or LSR-FFSB, which were similar in SID of the same AA. The SID of Lys for lentil (81%) was lower ($P < 0.05$) than that for SBM with a similar trend for SID of other indispensable AA in SBM and lentil except for Met and Thr whose SID values were similar between SBM and lentil. Lentil and SBM were similar in NE content (2.61 vs. 2.62 Mcal/kg of DM). However, SBM had lower ($P < 0.05$) NE content than R-FFSB or LSR-FFSB, which were similar in NE content (2.96 vs. 3.07 Mcal/kg of DM). In conclusion, variety of FFSB (regular vs. LSR) may not affect the NE and SID of AA for micronized FFSB fed to pigs. Micronized FFSB (regardless of their variety) is better source of dietary energy but not AA for pigs than SBM. Combined with our previous growth experiments, lentil can serve as another local pulse feedstuff for pigs.

Key Words: full-fat soybean, lentil, pig

O081 **Concentration of metabolizable energy and digestibility of amino acids in chicken meal, poultry by-product meal, Ultrapro, AV-E Digest, and conventional soybean meal fed to pigs.** O. J. Rojas Martinez*, H. H. Stein, *Animal Sciences, University of Illinois, Urbana.*

Two experiments were conducted to determine the ME and the standardized ileal digestibility (SID) of AA in chicken meal (CM), poultry by-product meal (PBM), Ultrapro, AV-E Digest, and soybean meal (SBM) fed to growing pigs. In Exp. 1, 48 barrows (BW: 14.6 ± 2.2 kg) were place in metabolism cages and allotted to a randomized complete block design with 6 diets and 8 pigs per diet. The basal diet contained 98.1% corn and 5 diets contained corn and each of the experimental ingredients. The ME was 3,957, 3,816, 4,586, 4,298, 4,255, and 4,091 kcal/kg DM for corn, CM, PBM, Ultrapro, AV-E Digest, and SBM, respectively. The ME in PBM was greater ($P < 0.01$) than in corn, CM, AV-E Digest, and SBM, and the ME in Ultrapro and AV-E Digest was greater ($P < 0.01$) than in corn and CM, but there was no difference ($P > 0.05$) among Ultrapro, AV-E Digest, and SBM. In Exp. 2, 12 barrows (BW: 12.2 ± 1.5 kg) were equipped with a T-cannula in the distal ileum and randomly allotted to a replicated 6 × 6 Latin square design with 6 diets and 6 periods in each square. A cornstarch-SBM based diet and 4 diets that contained SBM and CM, PBM, Ultrapro, or AV-E Digest as the only sources of AA in each diet were formulated. A N-free diet was used to determine endogenous losses of CP and AA. The SID of CP and all AA except Trp and Pro was greater ($P < 0.01$) in SBM than in all other ingredients. The SID of CP and all indispensable AA in AV-E Digest was also greater ($P < 0.01$) than in CM and Ultrapro, and with the exception of CP, Arg, and Val, SID values of all indispensable AA in AV-E Digest were also greater than in PBM. With the exception of Val and Lys, there were, however, no differences between CM and PBM in the SID of CP and AA. In conclusion, the ME in Ultrapro and AV-E Digest is greater than in CM, but not different from the ME of SBM, but PBM contains more ME than SBM, CM, and AV-E Digest. The SID of most indispensable AA is greater in AV-E Digest than in CM, PBM, and Ultrapro, but less than in SBM.

Key Words: animal proteins, pig, poultry meal

O082 **Amino acid digestibility in canola meal, 00-rapeseed meal, and 00-rapeseed expellers fed to growing pigs**. T. Maison*, H. Stein, *Animal Science, University of Illinois, Urbana.*

The objective of this experiment was to determine the standardized ileal digestibility (SID) of CP and AA in canola meal, 00-rapeseed meal, and 00-rapeseed expellers fed to growing pigs. Twenty-three barrows (initial BW: 28.8 ± 2.64 kg) had a T-cannula installed in the distal ileum and were allotted to a 9 × 23 Youden square design with 9 periods and 23 animals. Twenty-three diets were prepared; 7 diets were based on 7 samples of canola meal from solvent-extraction crushing plants in North America; 10 diets were based on 10 samples of 00-rapeseed meal from solvent-extraction crushing plants in Europe; and 5 diets were based on 5 samples of 00-rapeseed expellers from mechanical-press crushing plants in Europe. A N-free diet was also used. Each source of canola meal, 00-rapeseed meal, or 00-rapeseed expellers contributed all CP and AA in the diets they were used in. Chromic oxide (0.5%) was included in all diets as an inert marker. Pigs were fed at 3 times their estimated energy requirement for maintenance. Each period lasted 7 d, and digesta were collected during the final 2 d of each period. Results of the experiment indicated that the SID of CP and all AA except Val, Cys, and Glu were not different between canola meal and 00-rapeseed meal, but 00-rapeseed expellers had greater ($P < 0.01$) SID of CP and all AA except Thr, Trp, and Gly compared with 00-rapeseed meal. For Lys, Met, Thr, and Trp, SID values of 70.6, 84.5, 73.0, and 82.6%, and 71.9, 84.6, 72.6 and 82.6% were obtained in canola meal, and 00-rapeseed meal, respectively, whereas values for 00-rapeseed expellers were 74.7, 87.1, 74.0, and 83.4%, respectively. It is possible that the reason for the reduced SID of most AA in 00-rapeseed meal compared with 00-rapeseed expellers is that 00-rapeseed meal may be slightly heat damaged during the desolventizing process. In conclusion, AA digestibility is not different between canola meal and 00-rapeseed meal, but 00-rapeseed expellers have greater digestibility of most AA than 00-rapeseed meal.

Key Words: canola meal, rapeseed expellers, rapeseed meal

O083 **The effect of feeding solvent-extracted juncea canola meal on growth performance and diet nutrient digestibility of weaned pigs.** J. L. Landero[1,*], E. Beltranena[1,2], R. T. Zijlstra[1], *[1]University of Alberta, [2]Alberta Agriculture and Rural Development, Edmonton, Canada.*

Effects of substitution of soybean meal (SBM) with increasing dietary inclusion novel *Brassica juncea* canola meal (CM) were evaluated on diet nutrient digestibility and growth performance of pigs. Starting 1 wk after weaning at 19 d of age, 240 pigs with an initial BW of 7.7 kg were fed Phase 1 diets for 2 wk (d 0 to 14) and sequentially Phase 2 diets for 3 wk (d 15 to 35). Five pelleted wheat-based diets containing 0, 6, 12, 18, or 24% juncea CM were formulated to contain 2.39 and 2.31 Mcal NE/kg and 5.0 and 4.5 g standardized ileal digestible (SID) Lys/Mcal NE, for Phase 1 and 2 diets, respectively. Juncea CM replaced SBM and diets were balanced for NE using 5.6 to 8.0% and 2.6 to 5.0% canola oil for Phase 1 and 2 diets, respectively and for AA using crystalline Lys, Met, Thr, and Trp. Increasing inclusion of juncea CM linearly reduced ($P<0.05$) apparent total tract digestibility of GE, DM, and CP and diet DE content during both phases. For the entire trial (d 0-35), increasing inclusion of juncea CM linearly reduced ($P < 0.01$) ADG, ADFI, and G:F. The data [chemical composition of diets and growth performance of pigs] of the present study was combined with data of a similar study replacing SBM with up to 20% conventional *Brassica napus* CM (data reported previously) to conduct a principle component analysis and determine diet factors associated with growth performance changes. Dietary crude fat content and content of the glucosinolate gluconapin that is most abundant in juncea CM was tightly associated with the reduced growth performance observed. In conclusion, substitution of SBM with juncea CM linearly reduced diet nutrient digestibility and growth performance of weaned pigs in a dose-response manner. The reduced growth performance was associated with increased dietary crude fat and the glucosinolate gluconapin but could also have been caused by an overestimated NE and SID amino acid content of juncea CM for young pigs.

Key Words: canola meal, performance, pig

O084 **Effects of heat damage on the nutritional composition and on the amino acid digestibility of canola meal, sunflower meal, and cottonseed meal fed to pigs.** F. N. Almeida[1,*], J. K. Htoo[2], J. Thomson[3], H. H. Stein[1], *[1]Animal Sciences, University of Illinois, Urbana, [2]Evonik Industries AG, Hanau, Germany, [3]Evonik Degussa Corporation, Kennesaw.*

Three experiments were conducted to determine the effects of heat damage, achieved by autoclaving, on the nutritional composition and on the standardized ileal digestibility (SID) of AA in canola meal (CM), sunflower meal (SFM), and cottonseed meal (CSM) fed to growing pigs. The second objective was to develop regression equations that may be used to predict the concentration of SID AA in CM, SFM, and CSM from their nutritional composition. In Exp. 1, the SID of Lys was reduced (quadratic, $P < 0.05$) from 70.7 to 26.5% in CM that was not autoclaved or CM autoclaved for 45 min at 130°C, respectively. The concentration of SID Lys in CM may be best predicted by an equation that includes the concentrations of lignin, acid detergent insoluble N (ADIN), and reducing sugars in the model ($r^2 = 0.97$). In Exp. 2, the SID of Lys in SFM was reduced (linear, $P < 0.05$) from 83.2 to 63.5% in SFM that was not autoclaved or SFM autoclaved for 60 min at 130°C, respectively. The concentrations of Lys and reducing sugars in SFM may be used as good predictors ($r^2 = 0.86$) for the concentration of SID Lys in SFM. In Exp. 3, the SID of Lys in CSM was higher ($P < 0.05$) in CSM that was not autoclaved (66.2%) than in autoclaved (60 min at 130°C) CSM (54.1%). The equation ($r^2 = 0.68$) that best predicted the concentration of SID Lys in CSM includes the concentrations ADIN. In all 3 exp., the SID of most AA was reduced (linear or quadratic, $P < 0.05$) as a result of heat damage. In conclusion, heat damage reduces the SID of AA in CM, SFM, and CSM, and the concentration of SID Lys in these ingredients may be accurately predicted from the concentrations of lignin, ADIN, reducing sugars, and AA, separately or in combination.

Key Words: amino acids, digestibility, heat damage

O085 **Performance, organ weights and blood parameters in growing pigs fed diets containing expeller extracted canola meal.** J. S. Sands[1,*], K. Schuh[1], T. A. Woyengo[2], C. M. Nyachoti[1], *[1]Animal Science, University of Manitoba, Winnipeg, [2]Animal Science, University of Alberta, Edmonton, Canada.*

The aim of this study was to assess the effects of increasing levels of expeller extracted canola meal (EECM) in diets for growing pigs on performance; gastrointestinal tract weight, thyroid gland weights; blood plasma concentration of triiodothyronine and tetraiodothyronine; red blood cell count; haemoglobin content in blood

and haematocrit. Four diets were fed to 48 pigs (initial BW 20 ±1.6) in 24 pens (6 pens per diet) for 4 wks in a completely randomized design. A control corn-wheat-soybean meal basal diet was formulated and 3 additional diets produced by replacing 33, 66 or 100% of soybean meal with EECM to achieve inclusion levels of 0, 10, 20 and 30%. Diets were formulated to be similar in NE and nutrient composition, and to meet NRC (1998) nutrient requirements. Pigs were allowed ad libitum access to feed and water for the duration of the Exp. Feed intake and BW of pigs were determined on a weekly basis; whereas organ weights and blood parameters were determined at the end of the study. ADFI was linearly decreased (P= 0.006) whereas ADG tended to decline linearly (P=0.084) with increasing levels of EECM in the diet, whereas G:F was not affected (P>0.05). Thyroid weight and serum T3 were linearly increased (P<0.05), whereas serum T4 was linearly reduced with higher inclusion of EECM. Other blood parameters and organ weights were not affected by increasing inclusion of EECM. The analyzed concentration of glucosinolate in the EECM used in this study was 9.27µmoles/g, with values in the diets ranging from 1.02 to 2.75µmoles/g for the lowest to highest inclusion levels, respectively. The increased thyroid weight and changes in thyroid hormones, indicates that higher glucosinolate concentrations in EECM may adversely affect performance in growing pigs.

Key Words: expeller extracted canola meal, performance, pigs

O086 **Feeding value of green canola seed fed to growing-finishing pigs.** T. A. Woyengo [1,*], J. Yáñez [1], M. Young [2], G. Lanz [2], E. Beltranena [1, 3], R. T. Zijlstra [1], *[1]University of Alberta, Edmonton, [2]Gowans Feed Consulting, Wainwright, [3]Alberta Agriculture and Rural Development, Edmonton, Canada.*

Green canola seed (GCS) is immature seed that is not used for production of human oil grade, but due to its oil content (20–40%) might be a good energy source in pig diets. In 2 studies, we determined the nutritive value of GCS for pigs. In Study 1, 6 ileal-cannulated barrows (46 kg) were fed 3 diets (wheat, wheat+GCS, and N-free) as a double 3 × 3 Latin square to calculate NE value and standardized ileal digestibility (SID) of AA for GCS. Nutrient digestibility in GCS was calculated by difference from the wheat diet. In Study 2, 1,100 pigs (32.9 kg) housed in 50 pens (22 pigs) by sex were fed 5 dietary regimens: 4 constant dietary levels of 0, 5, 10, and 15% GCS, and the fifth, declining amounts (15, 10, 5, 0, and 0%, respectively) of GCS over 5 growth phases to determine effects of GCS on performance and carcass traits. Phase diets were formulated to provide 4.0, 3.6, 3.25, 2.9 and 2.65 g SID Lys/Mcal NE for d 0 to 21, 22 to 42, 43 to 62, 63 to 74, and 75 to 123 kg market weight. The GCS contained (DM basis) 25% CP, 43% ether extract, 22% NDF, 9.97 µmol/g glucosinolates, and 3.50 Mcal/kg NE value. The SID of Lys, Met, Thr, and Trp was 86.9, 87.3, 76.9, and 84.3%, respectively. Increasing dietary GCS from 0 to 15% linearly decreased (P < 0.05) overall G:F from 0.384 to 0.373 kg/kg, carcass dressing percent from 78.4 to 77.8%, and feed cost from 213 to 207 $/ton. Pigs fed declining amounts of GCS by growth phase compared with pigs fed 0% GCS had lower (P = 0.015) overall G:F. Diet did not affect overall ADG and ADFI, carcass backfat thickness, loin depth, pork yield, and revenue minus feed cost. In conclusion, GCS fed was a rich source of dietary energy and AA, but increasing its dietary inclusion in diets for pigs reduced G:F and carcass dressing percentage due to increased dietary fiber. Thus, inclusion of GCS in swine diets should be based on targeted G:F and relative cost to other feed commodities.

Key Words: green canola seed, nutritive value, pig

O087 **Effect of levan supplementation on the growth performance, nutrient digestibility, fecal microflora, and fecal noxious gas content in weaning pigs.** J. Li*, B. R. Lee, I. H. Kim, *Department of Animal Resource & Science, Dankook University, Cheonan, Republic of Korea.*

Levan is one type of fructans. Bio-Mos® contains mannanoligosaccharides and is a prebiotic. A total of 120 weanling pigs [(Yorkshire × Landrace) × Duroc] with an average BW of 7.22 ± 0.80 kg were used in a 35-d trial to determine the effects of levan inclusion on performance. Pigs were randomly allotted to 4 experimental diets by BW and sex (2 gilts and 3 barrows/pen; 6 pens/treatment). Dietary treatment groups were: CON, control diet; BM, CON + 0.1% bio-mos®; LE1, CON + 0.1% levan; LE2, CON + 0.2% levan. All data were subjected to the GLM procedures of SAS (1996) as a randomized complete block design, with pen as the experimental unit. Differences among dietary treatments were separated by Duncan's multiple range test, and P < 0.05 was considered statistically significant. Pigs fed the BM and LE2 diet had greater (P<0.05) ADG than pigs fed the CON diets (512 or 504 vs. 479g), and G/F ratio was increased (P<0.05) in LE2 compared with CON (0.830 vs. 0.781). The apparent total tract digestibility (ATTD) of DM in pigs fed the LE1 and LE2 diets was greater (P<0.05) than pigs fed the CON diet (91.53 or 91.84 vs. 88.6%) at wk 2. The ATTD of N in LE2 treatment was greater (P<0.05) than that in CON treatment (93.74 vs. 88.80%) at wk 5. Pigs fed the LE1 and LE2 diet decreased (48.1%, 47.8%; P<0.05) fecal *E. coli* concentration compared with pigs fed the CON diet at the end of 2 wk. However, no difference (P>0.05) was observed on the fecal *Lactobacillus* concentration. Fecal score was highest (P<0.05) in CON compared with other treatments (3.8 vs. 3.2 or 3.2 or 3.0) at d 7. LE2 had lower (P<0.05) hydrogen sulfide concentration than CON (4.40 vs. 5.22 ppm) at d 5. Fecal total mercaptans emission in LE2 was decreased (28.7%, 29.0%, 25.5%; P<0.05) compared with CON at d 3, 5 and 7. Pigs fed the LE1 diets also had lower total mercaptans concentration compared with those fed the CON diet at d 5 and 7(7.33 vs. 9.53 ppm, 6.15 vs. 9.15 ppm). In conclusion, results indicated that dietary inclusion of 0.2% fructan improved ADG (5.2%), G/F ratio (6.3%), ATTD of DM (3.4%) and N (5.6%), decreased fecal *E. coli* concentration (47.8%), fecal score (21.1%), fecal Hydrogen sulfide emission (15.7%) and total mercaptans (28.7%) in weanling pigs.

Key Words: fructan, growth performance, weanling pigs

O088 **The effects of wheat and crystalline amino acids on nursery and finishing pig growth performance and carcass characteristics.** D. Goehring*, J. M. DeRouchey, M. D. Tokach, R. D. Goodband, S. S. Dritz, J. L. Nelssen,*Kansas State University, Manhattan.*

Two experiments were conducted to evaluate the effects of wheat and crystalline amino acids on growth performance of nursery and finishing pigs. Treatments in both studies included: (1) corn-soybean meal diet, (2) diet 1 with wheat replacing 50% of the corn, (3) wheat replacing 100% of the corn in diet 1 with high amounts of crystalline amino acids, and (4) diet 3 with soybean meal (SBM) replacing a portion of the crystalline amino acids in diet 3 (5% in nursery; 2.5% in finisher). In Exp. 1, 192 pigs (12.1 kg BW) were used in a 21-d nursery study. Pigs were allotted to pens by initial BW and pens were randomly assigned to diets with 6 pigs/pen and 8 replicate pens. No growth differences were found when replacing 50% of corn with wheat (P>0.75*)*. There were tendencies for reduced ADG (linear, P<0.08) and improved (linear, P<0.07) caloric efficiency on an

NE basis when replacing 100% corn with wheat. Adding wheat to the diet did not influence G:F, but improved (linear, $P<0.05$) ME caloric efficiency. Increasing SBM in the wheat diets tended to improve ($P<0.07$) G:F and improved ($P<0.03$) NE caloric efficiency (Trt 3vs4). In Exp. 2, 288 pigs (72.5 kg BW) were used in a 61-d finishing study. Pens (8 pigs/pen) were randomly allotted by initial BW to diets with 9 replicate pens. Increasing wheat reduced ADG (linear, $P<0.04$) and worsened G:F (linear, $P<0.003$), but also reduced (linear, P<0.001) jowl fat iodine value. Replacing corn with wheat tended to improve (linear, $P<0.08$) caloric efficiency on an ME basis, but not on an NE basis. In summary, wheat can be used to replace 50% of corn in diets without negatively affecting growth performance. Use of high levels of crystalline amino acids in wheat-based diets did not significantly influence growth of nursery or finishing pigs.

Exp. 1 Treatment:	1	2	3	4	SEM
ADG, kg	0.550^{ab}	0.554^{a}	0.525^{b}	0.542^{ab}	0.009
G:F	0.636^{a}	0.636^{a}	0.629^{a}	0.648^{a}	0.007
Exp. 2					
ADG, kg	0.833^{a}	0.824^{ab}	0.793^{b}	0.788^{b}	0.01
G:F	0.307^{a}	0.303^{a}	0.295^{b}	0.297^{b}	0.003
Caloric efficiency, Mcal/kg					
ME	10.92^{a}	10.77^{ab}	10.69^{ab}	10.66^{b}	0.09
NE	8.18^{a}	8.15^{a}	8.15^{a}	8.09^{a}	0.07
Carcass yield, %	73.4^{a}	73.6^{a}	73.4^{a}	73.1^{a}	0.2
HCW, kg	91.8^{a}	91.8^{a}	90.0^{a}	89.7^{a}	1.1
Jowl fat iodine value	68.9^{a}	67.7^{b}	67.1^{b}	67.5^{b}	0.2

Key Words: crystalline amino acids, nursery pig, wheat

NONRUMINANT NUTRITION: NURSERY PIG NUTRITION AND MANAGEMENT

O089 **Effects of increasing wheat middlings (midds) and NE formulation on nursery pig growth performance.** J. A. De Jong*, J. M. DeRouchey, M. D. Tokach, R. D. Goodband, S. S. Dritz, J. L. Nelssen, *Animal Science, Kansas State University, Manhattan.*

A total of 210 pigs (PIC 327 × 1050, 6.87 kg BW) were used in a 29-d trial to evaluate the effects of dietary midds and NE formulation on nursery pig performance. Pens of pigs were balanced by initial BW and randomly allotted to 1 of 5 dietary treatments (6 pens/treatment and 7 pigs/pen). Wheat midds (0, 10, or 20%) were added to the first 3 diets without balancing for energy. The last 2 diets contained 10 and 20% midds but were balanced to contain the same NE (INRA, 2004) as the positive control (0%) midds by adding soybean oil (1.4 and 2.8%). Overall (d 0 to 29), no midds × fat interactions were observed ($P>0.34$). Pigs fed increasing midds tended to have poorer (linear; $P<0.07$) G:F and ME caloric efficiency, but when balanced on NE, increasing midds had no effect on pig performance. Regardless of formulated energy value, caloric efficiency and G:F were poorer ($P<0.01$) on an ME basis as midds increased from 10 to 20% of the diet. However no differences were observed for energetic efficiency on an NE basis. This suggests that ME values slightly overestimated the energy value of the soybean oil or midds and that the NE values provided by IRNA (2004) are a closer approximation of the true energetic value of the feed ingredients. In summary, 10% midds can be added to nursery diets without influencing performance. Formulating on an equal NE basis did not improve growth; however, energetic efficiency values indicate that NE may value the energy content in midds more appropriately. (See table below.)

Key Words: net energy, nursery pig, wheat middlings

O090 **Effects of dietary oxidized lipid on the growth performance and metabolic oxidative status of nursery pigs.** A. R. Hanson[1,*], L. J. Johnston[2], S. K. Baidoo[3], J. L. Torrison[4], C. Chen[5], G. C. Shurson[1], *[1]Animal Science, University of Minnesota, St Paul, [2]West Central Research and Outreach Center, University of Minnesota, Morris, [3]Southern Research and Outreach Center, University of Minnesota, Waseca, [4]Veterinary Diagnostic Laboratory, [5]Department of Food Science and Nutrition, University of Minnesota, St Paul.*

Dietary inclusion of oxidized lipids (Ox-L) can reduce ADFI and ADG, and reduce antioxidant status of pigs. Levels of Ox-L in dried distillers grains with solubles (DDGS) vary, but some sources have higher levels than corn as measured by the thiobarbituric acid reactive substances (TBARS) and peroxide value (PV) assays. This experiment evaluated if dietary inclusion of DDGS high in Ox-L (Ox-DDGS) compromised vitamin E (VE) and Se status (as measured by serum and liver concentrations) and increased incidence of Mulberry Heart Disease (MHD). Sows (n = 12) were fed corn-soybean meal diets (0% DDGS) or diets with DDGS (40 and 20% in gestation and lactation, respectively) for 3 parities. In the third parity, 108 weaned pigs were penned (2 littermates/pen) and fed 1 of 3 nursery diets (ND): 1) 0% DDGS, 2) 30% Ox-DDGS, and 3) 30% Ox-DDGS with 5x NRC (1998) level of VE for 7 wks, in a 2 x 3 factorial arrangement (n = 9 pens/treatment). Diets were formulated to contain similar SID Lys:ME. Concentrations of TBARS and PV in the Ox-DDGS source used were 25 and 27 times greater, respectively, than corn. Data were analyzed using the MIXED procedure of SAS for a split plot design with repeated measures in time when appropriate. Several 2-way and 3-way interactions were observed. No evidence of MHD was found. Inclusion of DDGS in sow diets reduced ($P < 0.01$) VE in pig serum at weaning (5.6 vs. 6.7 ± 0.1 μg/mL) compared with 0% DDGS. Glutathione peroxidase activity and TBARS concentration of pig serum were not affected by ND ($P > 0.05$). The concentration of sulfur amino acids (SAA) in serum from pigs fed ND 2 or ND 3

O089 Table

Treatment:	1	2	3	4	5					
Midds, %:	0	10	20	10	20				Midds	
Item, Fat, %:	0	0	0	1.4	2.8	SEM	Midds x Fat	Lin	Quad	10 vs 20%
ADG, g	442	440	425	454	440	9.30	0.95	0.41	0.25	0.12
ADFI, g	690	683	698	705	701	14.6	0.54	0.60	0.96	0.71
G:F	0.641	0.645	0.610	0.644	0.627	0.01	0.34	0.06	0.11	0.01
Caloric efficiency, mcal/kg										
ME	5.17	5.09	5.33	5.20	5.40	0.08	0.82	0.06	0.11	0.01
NE	3.74	3.62	3.74	3.73	3.81	0.06	0.76	0.64	0.17	0.11

was 40 to 50% greater ($P < 0.01$) than pigs fed ND 1, which was likely due to greater ($P < 0.01$) SAA intake for pigs fed ND 2 or 3 compared to pigs fed ND 1. Some SAA act as antioxidants, which may have spared VE and Se and masked any effect of Ox-L DDGS. Therefore, increased VE was unnecessary in nursery pig diets with Ox-DDGS. The inclusion of DDGS in sow diets reduced the Se and VE status of pigs, but not after weaning when MHD is a concern. It is unclear if antioxidant supplementation is needed in diets with Ox-L without increased levels of SAA.

Key Words: antioxidant, DDGS, oxidative stress

O091 **Effect of pellet quality and feeder adjustment on growth performance of nursery pigs.** J. Nemechek[1,*], M. Tokach[1], E. Frugé[2], E. Hansen[2], S. Dritz[1], R. Goodband[1], J. DeRouchey[1], J. Nelssen[1], *[1]Animal Science and Industry, Kansas State University, Manhattan, [2]Hubbard Feeds, Inc., Mankato.*

Two experiments were conducted to determine the effect of feeder adjustment and diet form on growth performance of nursery pigs. In Exp. 1, a total of 210 pigs (PIC 1050 × 327, 11.9 kg BW) were used in a 21-d trial with 7 pigs per pen and 5 pens per treatment. In Exp. 2, a total of 1,005 pigs (Fast × PIC sows × TR4 boars, 14.1 kg BW) were used in a 28-d trial with 26 to 28 pigs per pen and 6 pens per treatment. Treatments were arranged as 2 × 3 factorials with main effects of feeder adjustment and diet form. The 2 feeder adjustments were a narrow and wide adjustment (minimum gap opening of 1.27 and 2.54 cm, respectively). The 3 diet forms were meal, poor-quality pellets (70% pellets and 30% fines), and screened pellets with minimal fines. There were no interactions (P>0.19) between feeder adjustment and diet form.In Exp. 1, no differences (P>0.13) were observed in ADG (599 vs 612 g), ADFI (875 vs 898 g), or G:F (0.684 vs 0.682) among pigs fed from feeders with narrow or wide settings, respectively. Pigs fed the meal diet had increased (P<0.001) ADG (630, 594, 594 g) and ADFI (939, 875, 844 g) compared with pigs fed the poor quality or screened pellets. Pigs fed meal or poor quality pellets had decreased (P<0.004) G:F (0.671, 0.679, 0.704) compared with pigs screened pellets. In Exp. 2, pigs fed from the narrow adjustment had decreased (P<0.03) ADG (708 vs 730 g) and ADFI (1098 vs 1139 g) compared to pigs fed from the wide adjustment. There was no difference (P>0.70) in G:F (0.645 vs 0.641) among pigs fed from the wide or narrow adjustments. Pigs fed meal had decreased (P<0.03) ADG (703, 726, 730 g) compared with pigs fed poor quality or screened pellets, respectively, with no difference (P>0.25) in ADFI (1116, 1134, 1102 g) among diet forms. Pigs fed meal or poor quality pellets had decreased (P<0.01) G:F (0.630, 0.640, 0.663) compared with pigs fed screened pellets. Thus, feeding nursery pigs from a wide feeder gap may provide benefits in ADG and ADFI with no negative effects on G:F. Improved G:F was observed only in pigs fed the screened pellets. The percentage of fines in the diets must be minimized to obtain the expected benefits to feed efficiency from pelleting.

Key Words: diet form, feeder adjustment, nursery pig

O092 **Feed preference of nursery pigs fed diets with soybean meal, napus canola meal or juncea canola meal.** J. L. Landero[1,*], E. Beltranena[1, 2], R. T. Zijlstra[1], *[1]University of Alberta, [2]Alberta Agriculture and Rural Development, Edmonton, Canada.*

Inclusion of conventional dark-seeded (*B. napus*) and novel yellow-seeded (*B. juncea*) canola meal (CM) can potentially replace soybean meal (SBM) in pig diets. The aim of this study was to examine the preference of nursery pigs for diets containing 20% of either SBM, napus CM or juncea CM. Diets formulated to contain 2.36 Mcal NE/kg and 4.5 g standardized ileal digestible Lys/Mcal NE were offered in a paired choice as mash (Exp. 1) or pellets (Exp. 2) for 3 consecutive 7-d periods. Each period consisted of 4-d double-choice test and 3-d non-test. Dietary treatments were provided in 2 separate 4-space feeders in each pen: 1) SBM vs. napus CM, 2) SBM vs. juncea CM, or 3) napus CM vs. juncea CM. Position of the 2 feeders within and among pens was not or was switched daily in Exp. 1 and 2, respectively. Previous to the experiment and during adaptation periods, pigs were fed diets containing SBM (Exp. 1) or none of the feedstuffs tested (Exp 2). In Exp. 1, 216 pigs (9.4 ± 1.6 kg) were housed in 27 pens of 8 pigs (4 gilts and 4 barrows) and randomly allocated to the 3 dietary treatments in a 3 × 3 Latin square. In Exp 2, 144 pigs (8.9 ± 1.1 kg) were housed in 36 pens of 4 pigs (2 gilts and 2 barrows) and randomly allocated to the 3 dietary treatments in a 3 × 3 Latin square. Total glucosinolate and gluconapin content in juncea CM (10.8 and 9.4 μmol/g, respectively) were 2.2 and 7.3 times greater, respectively than in napus CM. Pigs preferred SBM over napus CM diet ($P < 0.001$; 83.9% vs. 16.1% and 80.9% vs. 19.1% for Exp 1 and 2, respectively) and pigs preferred SBM over juncea CM diet ($P < 0.001$; 89.9 vs. 10.1% and 84.2 vs. 15.8% for Exp 1 and 2, respectively). Napus CM was preferred on the 2-way choice with juncea CM diet ($P < 0.001$; 64.0% vs. 36.0% and 81.4% vs. 18.6% for Exp 1 and 2, respectively). In conclusion, high content of the glucosinolate gluconapin in juncea CM was associated with the reduced feed preference for juncea CM vs. napus CM.

Key Words: canola meal, diet preference, weaned pig

O093 **Simple assessment of piglet robustness in relation to nursery diet quality and feeding antibiotics.** C. Levesque[*], E. Miller, J. Zhu, K. de Lange, *Animal and Poultry Science, University of Guelph, Canada.*

Seventy-two pigs were used to assess the impact of nursery feeding program on the pig's ability to mount an immune response, e.g. robustness, based on delayed-type hypersensitivity (DTH) to *Candida albicans* and production of anti-ovalbumin (OVA) antibodies. Pigs were randomly assigned to: High (H), Low (L), and Very Low (VL) quality diets, with or without in-feed antibiotics (2750 ppm chlortetracycline) from weaning to 6 wk post-weaning. The H diets contained typical levels of blood plasma, fishmeal, whey and acidifiers. The L diets were based on corn and soybean meal with minimal fishmeal and whey for the first 7d post-weaning only; the VL diets were based solely on corn and soybean meal. Within dietary treatment, 6 pigs were assigned as Control and 6 as Vaccinated. Vaccinated pigs were immunized, by intramuscular injection, to induce antibody response and DTH as follows: on d 5 and 19 post-weaning pigs received 0.5 mg OVA, 0.5 mg killed *C albicans*, and 0.5 mg Quil A adjuvant in 1 mL phosphate buffer. Blood samples were obtained on d 4, 18, and 32 for determination of anti-OVA antibodies. The DTH was determined on d 17, where all pigs were given, by intradermal injection in the ear, 0.1 mg candin in 0.1 mL saline and ear thickness measurements were made using a spring-loaded caliper at 6, 24, and 48 h after injection. The immunization protocol induced an antibody response to OVA ($P < 0.001$) where the optical density increase was 0.08 for control pigs and 0.24 and 1.31 for the primary and secondary antibody response, respectively, in Vaccinated pigs. There was no effect of nursery diet on the antibody response to OVA. The DTH response following candin administration was greater ($P < 0.01$) for Vaccinated than Control pigs. Within Vaccinated pigs,

there was no difference in the DTH response between pigs fed H (21%) or L (20%), but the DTH response was greater ($P = 0.005$) in H than VL (9%) pigs. Inclusion of antibiotics had no effect on the DTH response. Reduced nursery diet quality negatively affected the innate immune response and diet quality had a greater effect on piglet robustness than antibiotic inclusion.

Key Words: immune response, pigs, robustness

O094 **Effect of dietary lysine and sanitary condition on performance of weaned pigs fed antibiotic-free diets.** R. K. Kahindi[1,*], J. Sands [1], J. Htoo [2], M. Nyachoti [1], *[1]Animal Science, University of Manitoba, Winnipeg, Canada, [2]Evonik Industries, Hanau, Germany.*

Lysine requirement of piglets could change with exposure to unsanitary condition. An experiment was conducted to determine lysine requirement for piglets reared in unsanitary conditions fed antibiotic-free diets. [Duroc x (Yorkshire x Landrace)] piglets, weaned at 21±1 d with an average initial BW of 7.2 ± 0.50 kg, were randomly assigned to 8 dietary treatments in a 2 x 4 factorial setting for a 42-d study. The main factors were sanitation status (clean, CL; and unclean, UCL) and 4 Lys levels (70, 85, 100 and 115% SID Lys) recommended by NRC (1998) for 5 to 10 kg pigs. All other nutrients met or exceeded NRC (1998) requirements. The CL group occupied the room for the first 21 days, followed immediately by the UCL group. In addition, manure slurry from a sow herd was spread (5 kg/pen) on d 0 and 7 of the UCL phase of the study. The piglets were housed in groups of 4 per pen (1.2 x 1.8 m) and allowed free access to feed and water. The response criteria was average daily gain ADG, ADFI and G:F. There was no significant interaction ($P > 0.10$) between sanitation status and dietary Lys level on any of the response criteria measured. Sanitation status had a significant ($P < 0.05$) effect on ADG and ADFI but not G:F. The overall ADG was 267 vs. 314 g while ADFI 420 vs. 484 g, for UCL and CL groups, respectively. Increasing dietary Lys content linearly increased ($P < 0.05$) ADG and G:F, but not ADFI and this effect was similar for both sanitary conditions. There was no quadratic response ($P > 0.05$) on ADG and G:F with increasing dietary Lys content. The results show that unsanitary condition led to a reduction in growth rate and feed intake by 18% and 15% but did not affect feed efficiency of the piglets. The Lys requirement of piglets fed antibiotic free-diet is at or higher than 115% of NRC (1998) regardless of the sanitary condition.

Key Words: lysine, antibiotic-free diets, sanitation, pig

O095 **Soybean meal level in diets for pigs challenged with porcine reproductive and respiratory syndrome (PRRS) virus.** G. C. Rocha [1], R. D. Boyd [2], J. A. S. Almeida [1,*], Y. Liu [1], T. M. Che [1], R. Dilger [1], J. E. Pettigrew [1], *[1]Animal Sciences, University of Illinois, Urbana, [2]Hanor, Franklin, KY.*

An experiment was conducted to determine whether pigs challenged with porcine reproductive and respiratory syndrome (PRRS) virus in a controlled environment benefit from inclusion of high levels of soybean meal (SBM) in the diet, as indicated in previous studies conducted on commercial farms. Sixty-four weaned pigs (initial BW = 6.5 ± 0.9 kg; 21d of age) were used in a randomized complete block design, with 2 treatments (Low-SBM and High-SBM diets) and 32 replicates. Pigs were housed in individual pens in disease-containment chambers for 6 wk, 2 wk before and 4 wk after the intranasal inoculation (d0). The pigs were phase-fed a series of 3 diets appropriate for their age and formulated to provide 3450, 3365, 3363 kcal ME/kg and 1.45, 1.44, 1.38 % SID lysine for the 3 phases, respectively, and,adequate amounts of all amino acids. During phase 1 (wk -2), all pigs were fed the same diet. During phase 2 (wk -1 and 1) and phase 3 (wk 2, 3 and 4), they received the 2 experimental diets. The SBM levels in Low-SBM and High-SBM were 12.5 and 22.5% in phase 2 and 19.5 and 32.5% in phase 3. Growth performance was measured weekly and rectal temperature on d 0, 3, 5, 7, 10, 12, 14, 17, 21 and 28 after challenge. Data were analyzed by ANOVA in PROC MIXED. Growth rates were similar to previous PRRS-challenged pigs. Dietary treatments did not affect ADG or ADFI at any time, but G:F was greater on High-SBM during the 1st wk post-inoculation (Table 1). Rectal temperature was lower ($P < 0.05$) on d 3, 5 and 7 after challenge in pigs fed High-SBM (40.1, 40.0, 40.1 C) than in those fed Low-SBM (40.3, 40.2, 40.3 C), suggesting a differential immune response. In summary, these data provide modest support for the previous indication that high levels of dietary SBM may benefit pigs infected with PRRS.

Table 1. Gain:Feed (g/kg) by week and treatment

	Wk from challenge					
	-2	-1	1	2	3	4
Low-SBM	804	672	642	784	632	602
High-SBM	830	708	746	788	641	592
SEM	26	28	34	26	23	23
P	0.47	0.37	0.04	0.99	0.78	0.78

Key Words: disease, pigs, soybean meal

O096 **Effects of spray-dried porcine plasma on growth performance, immune responses, total antioxidant capacity, and gut integrity of nursery pigs.** H. Tran*, J. W. Bundy, Y. S. Li, E. E. Hinkle, T. E. Burkey, P. S. Miller, *Animal Science, University of Nebraska, Lincoln.*

A 4-wk feeding experiment was conducted to evaluate the effects of feeding spray-dried porcine plasma (SDPP) on growth performance, immune response, total antioxidant capacity, and gut integrity of nursery pigs. Ninety-six weaned barrows and gilts (age, 20 ± 1.2 d; initial BW, 6.06 ± 0.02 kg) were assigned to 16 pens (8 pens/treatment) which were randomly allotted to 1 of the 2 treatments: 1) control (no SDPP); and 2) control + SDPP. Antibiotics were excluded from all diets. The experiment consisted of 2 phases: phase 1 (wk 1 and 2; 5% SDPP) and phase 2 (wk 3 and 4; 2.5% SDPP). Blood samples were collected from all pigs at the beginning (1 d before weaning) and weekly thereafter to measure immunoglobulin (Ig) G, A, and total antioxidant capacity. On d 14, 1 pig/pen was selected and euthanized for small intestine tissue sampling and histological analyses. Pigs fed SDPP had greater BW (7.46 vs. 7.05 kg; $P = 0.001$); ADG (200 vs. 140 g; $P < 0.001$), ADFI (294 vs. 229 g; $P = 0.001$), and GF (682 vs. 603 g; $P = 0.02$) compared to control pigs on d 7. At the end of the study (d 28), pigs fed SDPP had greater (18.15 vs. 17.19 kg; $P = 0.02$) BW and tended to have greater ADG ($P = 0.07$) and ADFI ($P = 0.06$) compared to the control pigs. There were no differences between treatments for serum IgG, IgA, and total antioxidant capacity; however, these measurements changed over time (age) where IgA increased from weaning to d 28 but IgG steadily decreased from d 0 to 21 and tended to increase on d 28. For histological analyses at d 14, greater villus height (699 vs. 503 μm; $P = 0.01$) and villus:crypt ratio (2.05 vs. 1.40; $P = 0.01$) was observed in duodenal tissue sections obtained from SDPP-fed pigs

compared to the control pigs. In conclusion, feeding SDPP increased growth of nursery pigs during the first week postweaning and may provide benefits with respect to gut integrity.

Key Words: gut integrity, immunity, spray dried porcine plasma

O097 **Spray-dried animal plasma mitigates the negative impact of deoxynivalenol (DON) in nursery pigs.** L. Eastwood*, J. Shea, D. Gillis, D. Beaulieu, *Prairie Swine Centre Inc., Saskatoon, Canada.*

Deoxynivalenol (DON) is a mycotoxin produced by *Fusarium graminearum or Fusarium culmorum*, and grains infected with *Fusarium* are often contaminated with DON. Swine are highly susceptible to the effects of DON, specifically reductions in feed intake. The objective of this study was to determine if adding spray dried animal plasma (SDAP) and/or activated clays to DON contaminated diets during the nursery phase of growth would mitigate the negative effects of DON. A total of 200 pigs (6.9 ± 0.92 kg, mean ± SD) were assigned to one of five treatments for a 21 day experiment. There were eight pens per treatment with five pigs per pen. Dietary treatments included 1) NC (negative control containing 0.3 ppm DON), 2) PC (positive control containing 3.9 ppm DON), 3) PC-clay (PC plus 0.2% activated clay), 4) PC-plasma (PC plus 0.8% SDAP) and 5) PC-both (PC plus activated clay and SDAP). Overall, relative to the NC, ADG and ADFI of pigs fed the PC were each reduced by 60 g/d ($P < 0.01$). ADFI of pigs fed the PC-clay was the same as the PC but was less than the NC (PC-clay 440 g/d, PC 430 g/d, NC 490 g/d; $P < 0.01$). ADG of pigs consuming PC-clay was similar to the PC ($P > 0.05$). ADG of pigs consuming the PC-plasma was similar to the NC pigs (420 g/d vs. 390 g/d; $P > 0.05$). ADFI was also similar for pigs consuming PC-plasma and those consuming the NC (530 g/d vs. 490 g/d; $P > 0.01$). Gain:feed averaged 0.79 and was unaffected by DON, SDAP or the activated clay ($P > 0.05$). Relative to the positive DON control, inclusion of SDAP improved ($P < 0.05$) ADFI (PC 400 g/d, PC-plasma 550 g/d) and ADG (PC 330 g/d, PC-plasma 410 g/d), and pigs consuming SDAP with DON performed as well as the negative controls ($P > 0.05$; NC ADFI 490 g/d, NC ADG 390 g/d). SDAP alleviated the negative effects of DON. In this experiment, SDAP was more effective than the activated clay. SDAP should be included into nursery diets if DON contaminated feed is suspected or known.

Key Words: deoxynivalenol (DON), fusarium, nursery, spray-dried animal plasma

O098 **Growth performance, fecal consistency and intestinal function in weaned pigs fed diets containing spray dried porcine plasma or egg yolk antibodies.** J. S. Sands*, J. M. Heo, C. M. Nyachoti, *Animal Science, University of Manitoba, Winnipeg, Canada.*

Spray-dried porcine plasma (SDP) and egg yolk antibodies (EGG) may protect against weaning induced impairment of intestinal function in pigs. Ninety-six pigs (initial BW, 6.84 ± 0.81 kg) were used to determine growth performance, fecal consistency (FC), and intestinal function post-weaning. Three Exp diets were assigned to 24 pens (8 replicates of 4 pigs per pen) in a randomized complete block design for 12 d. Diets were produced by replacing casein (50 g/kg) with SDP or EGG in a semi-purified basal diet (Control) of cornstarch, dextrose, dried whey and casein. Pigs had unrestricted access to feed and water for the duration of the Exp. Feed intake and BW were assessed on d 4, 8 and 12 and fecal consistency visually scored daily using a scale of 0 to 5 (Heo *et al.*, 2008). The ADFI, ADG, G:F and FC were calculated for each 4-d period and overall. On d 4 and 8, one pig per pen was selected and sacrificed to assess indexes of intestinal membrane permeability and ion transport; trans-epithelial resistance (TER) and short circuit current (*I*sc) in Ussing chambers. Supplementing SDP improved ($P < 0.05$) d 5-8 ADG and final BW by 26.3 and 7.2% versus Control and by 45.7 and 12 % versus EGG groups, respectively. The ADFI of pigs fed diets with SDP and EGG was 27.3 and 8.2% higher than the Control group ($P < 0.05$) for the 5-8 d period. Feed efficiency was not affected ($P > 0.10$) by treatment. Pigs receiving SDP supplemented diets had better fecal consistency (22.3 vs 26.7; $P < 0.05$) compared to pigs receiving EGG, whereas, FC for pigs in Control and EGG groups were similar ($P > 0.05$). On d 8, intestinal TER was lowest in pigs fed diets with EGG (31.2 vs. 36.2 and 36.3 $\Omega.cm^2$; $P < 0$ .05) for SDP and Control, respectively. Intestinal *I*sc was improved ($P < 0.05$) for pigs fed SDP compared to pigs fed EGG and Control (-1.07 vs. 0.76 and 0.72 $\mu A/cm^2$) respectively. In summary, supplementing SDP improved body weight and indexes of intestinal barrier function and fecal consistency in post-weaned pigs.

Key Words: egg yolk antibodies, pigs, spray-dried porcine plasma

O099 **Mucosal bacteria associated with periods of reduced and compensatory growth in pigs.** C. Levesque [1,*], K. Swanson [2], K. de Lange [1], [1]*Animal and Poultry Science, University of Guelph, Canada,* [2]*Animal Science and Division of Nutritional Science, University of Illinois, Urbana.*

Previously we reported that growth was reduced in pigs fed low complexity starter diets and induced compensatory growth thereafter. Alterations in ileal mucosal-associated bacteria in pigs fed high (H) or Low (L) complexity starter diets with or without in-feed antibiotics during periods of reduced (wk 2 post-weaning) and compensatory (wk 8 postweaning) growth was evaluated using 16S ribosomal RNA (16S rRNA) gene pyrosequencing. Forty-eight pigs received test diets at weaning (21 d of age) for 6 wk and common grower diets thereafter. Six pigs per treatment were killed at wk 2 and 8 for collection of ileal mucosal bacteria. Ileal sections were rinsed to remove loose bacteria, washed vigorously to remove mucosal bacteria, and the wash was centrifuged to pellet the cells. Total DNA was extracted using a commercially available kit and amplified using eubacteria 16S rRNA primers. Amplicons were further sequenced according to standard procedures for 454 pyrosequencing. Pyrosequencing resulted in a total of 311,245 and 349,524 sequences at wk 2 and 8, respectively, for an average of 12,780 and 14,427 sequences per sample at wk 2 and 8, respectively. Mucosal bacteria clustered more closely by wk post-weaning than starter diet treatment and there was no starter diet effect on bacterial diversity at wk 2 or 8. Firmicutes made up 91 and 96% of total reads at wk 2 and 8, respectively. The proportion of *Clostridium paraputrificum* increased ($P = 0.003$) from wk 2 to 8 in pigs fed L (0.8 vs 13 ± 2%) but didn't change in pigs fed H (3 vs 6 ± 2%). The proportion of *Clostridium leptum* decreased ($P = 0.02$) from wk 2 to 8 in pigs fed L (27 vs 1 ± 6%) but didn't change in pigs fed H (11 vs 5 ± 6%). Furthermore, the proportion of *Sarcina* genus tended to decline from wk 2 to 8 in pigs fed Low but tended to increase with wk post-weaning in pigs fed High ($P = 0.08$). The increase in potentially beneficial bacteria and decrease in potentially pathogenic bacteria at wk 8 in pigs on L may, in part, explain the compensatory growth observed at wk 8 in these pigs.

Key Words: compensatory growth, mucosal bacteria, pigs

O100 **Rate of starch digestion influences glucose and short chain fatty acid signaling pathway mRNA abundance in the porcine intestine.** A. D. Woodward [1,*], P. R. Regmi [1], M. G. Ganzle [1], T. A. T. G. van Kempen [2], R. T. Zijlstra [1], *[1]Agricultural, Food, and Nutritional Science, University of Alberta, Edmonton, Canada, [2]North Carolina State University, Raleigh.*

Starch chemistry influences digestion and fermentation products in the intestinal lumen; however, limited data exist on mechanisms behind absorption. We hypothesized that inclusion of slowly- rather than rapidly-digestible starch in pig diets decreases glucose and increases SCFA transporter expression, and modulates signaling pathways, in the intestine. Weaned barrows (7.1 ± 0.2 kg; n = 32) were fed 1 of 4 purified starch diets at 3 × maintenance energy requirement for 21 d in a complete randomized design. Diets were: rapidly digestible (0% amylose, 1.06%/min rate of in vitro digestion), moderately rapidly digestible (20%, 0.73%/min), moderately slowly digestible (28%, 0.38%/min), and slowly digestible (63%, 0.22%/min). Intestinal mucosa scrapings were collected at 4 sites to quantify mRNA abundance of sweet taste receptor T1R3, Na^+-dependent glucose transporter-1 (SGLT1), proglucagon, and Na^+-coupled monocarboxylate transporter (SMCT). Messenger RNA was extracted and cDNA manufactured prior to relative quantification by PCR. Data were analyzed using the $2^{-\Delta\Delta C}{}_T$ method, with β-actin and GAPDH as reference genes, and analyzed by regression. As rate of digestion decreased, T1R3 tended to decrease linearly (P = 0.10) in jejunum. Contrary to T1R3, SGLT1 increased linearly (P < 0.05) in ileum with decreasing rate of digestion. Proglucagon increased linearly in ileum (P < 0.05) and tended to increase linearly in colon (P = 0.07) with decreasing rate of digestion. SMCT was most affected by decreasing rate of digestion, increasing linearly (P < 0.05) in duodenum, tending to increase linearly (P = 0.07) in ileum, and decreasing quadratically (P < 0.01) in colon. In conclusion, slowly-digestible starch influenced signaling for glucose and SCFA transport. Although studies indicate T1R3 is directly related to SGLT1 expression, multiple pathways may be responsible for absorption and metabolism of glucose and SCFA.

Key Words: nutrient transporter, pig, starch

RUMINANT NUTRITION SYMPOSIUM: ECONOMICAL AND ENVIRONMENTAL IMPACT OF MAXIMIZING FEED EFFICIENCY WHILE MINIMIZING RISK IN AN ERA OF $8 CORN

O101 **Maximizing forage resources in feedlot diets to offset expensive grains.** G. E. Erickson*, T. J. Klopfenstein, J. C. MacDonald, A. L. Shreck, J. M. Johnson, B. L. Nuttelman, C. J. Schneider, D. B. Burken, *Animal Science, University of Nebraska, Lincoln.*

Including corn silage or alkaline-treated crop residue are options to reduce cost of gain for feedlot cattle. Six studies have compared calcium oxide-treated residue to conventional (5%) or similar inclusions (20%) of native residue. Crop residues were treated with 5% calcium oxide (DM basis), and water added to equal 50% DM, mixed, and stored at least 7 d prior to feeding in all experiments. Two studies were similar whereby 20% treated, 20% native, or 5% native corn stalks were fed with 40% modified distillers grains plus solubles (DM basis). Calf-feds fed 20% treated stalks had similar ADG and G:F as steers fed 5% native stalks, and both treatments were greater than 20% native stalks. Yearlings fed 20% treated stalks had numerically lower ADG and slightly lower G:F than control fed steers, but both were greater than feeding 20% native stalks. Another experiment evaluated either a 2.5-cm or 7.6-cm grind to determine the impact of grind size on performance. No interactions were observed between treating residue and grind size. Feeding treated residue at 20% (0.156) resulted in similar G:F as the 5% native stalks (0.153). Reducing screen size improved G:F (P < 0.01) by 3.1%. Steers fed untreated residue were lowest in G:F (0.132). Across 4 experiments with 7.6-cm grind, feeding 20% treated stalks decreased G:F by 1.9% compared to control steers; whereas feeding 20% native stalks decreased G:F by 12.9%. Calcium oxide treatment improves digestibility of residues, with TDN increasing from 45% to 55%. However, feedlot performance suggests TDN of 75-80% for treated residue. Another option with expensive grains is to substitute corn with corn silage. Economic optimum diets with corn greater than $6.50 included 45% corn silage with 40% distillers grains despite a 6.9% decrease in ADG and a 5% decrease in G:F compared to 15% silage. Diets containing distillers grains were more economical than diets without when corn silage was included at 45% suggesting a synergistic effect of distillers with corn silage. Using crop residue (corn silage or calcium oxide treated stalks) to offset expensive corn may be economical in diets containing wet distillers grains plus solubles.

Key Words: alkaline treatment, crop residue, feedlot cattle

O102 **Environmental impact of new feeding choices in the feedlot industry.** K. E. Hales*, *Nutrition Research Unit, USDA, ARS, US Meat Animal Research Center, Clay Center.*

The feedlot industry is adapting to an economic environment that has fundamentally changed because of high corn prices. Developing strategies to improve the efficiency of feed utilization and reduce costs are important. Uses of agricultural commodity products for alternative fuels are rapidly increasing, resulting in an increase in the supply of coproducts. The replacement of concentrate grain with coproducts is appealing in finishing diets because of record high grain prices. Their utilization in livestock diets is complicated by a lack of information on the interactions with other ingredients in mixed diets. The evaluation of roughage concentration, and source in feedlot diets became more important in recent years because of the prolonged severe drought which occurred in the Plains. During such periods, traditional roughage sources like alfalfa hay and corn silage were not only difficult to procure, but extremely expensive. Typically, feedlot diets include between 8 and 9% roughage, which is more costly per unit energy than concentrate grain. As a result of the increased fiber in distillers grains, it is reasonable that dietary concentration of roughage could be slightly decreased when distillers grains are included in feedlot diets. Other coproducts are also more readily available as a result of the expansion of the biofuel industry. Glycerin is an energy-dense coproduct from soy diesel production that can be utilized by ruminant species. It is hypothesized that glycerin is primarily converted to propionate within the rumen, thus acting as a precursor for glucose synthesis. Coproducts such as glycerin can be included in feedlot diets as potential replacements for concentrate grain or roughage. The economical challenges present in today's cattle feeding industry set the stage for very dynamic decisions on new feed ingredients. Recent research from our location suggests that cost of gain can be decreased by reducing the roughage level in finishing diets including distillers grains and additionally by replacing corn grain or roughage with crude glycerin in growing and finishing diets fed to feedlot cattle.

Key Words: cattle, glycerin, roughage

O103 **Maintaining competitiveness with increasingly volatile markets.** L. Schulz*, *Economics, Iowa State University, Ames.*

The beef cattle industry is characterized by wide swings in profits. This inherent high profit volatility is due principally to multiple market price risks. Cattle producers bear the risk of unfavorable movements in both input and output prices. Current cattle conditions, namely the tight supply situation, and the reality of high feed prices sets the stage for a dynamic and challenging situation moving forward. As a result, there has been and will continue to be much focus and discussion regarding the importance and value of risk management to ensure economic sustainability. The increasing volatility in returns alludes to the value of protecting margins, i.e., the revenue stream as well as the major input costs. This presentation will first review the current beef cattle and feed situation and outlook to provide a backdrop of the unique market situation that has been developing for a number of years. The discussion will continue by examining existing risk management strategies and tools for reducing margin risks.

Key Words: commodity outlook, risk management

O177 **The application of feed efficiency in dairy cattle**. D. P. Casper*, *Dairy Science, South Dakota State University, Brookings.*

The cost of commodities (grains, proteins, and by-products) along with fats (oils), minerals and vitamins have all dramatically increased in recent years. The cost of these ingredients don't appear to be declining, in the foreseeable future, which means that from a historical perspective the feed costs to meet the nutrient requirements of the dairy cow are going to remain higher than normal. Meanwhile, future milk prices appear to be more favorable than in the past couple of years, however, maintaining profitability of the dairy operations is still going to be a challenge. Increasing the feed conversion (feed efficiency) of the dairy cow will be one way to sustain or improve profitability. To improve feed efficiency requires addressing the quality and digestibility of forages purchased or produced on the farm. Forages can be among the most economical sources of nutrients for the dairy cow when the quality and digestibility are high. The basis of high feed efficiency is feeding the highest quality forages possible in a high forage ration. For dairy producers to sustain profitability, forages are going to have to supply more nutrients to meet the nutrient requirements of the dairy cow than they have been expected to supply in the past. Forages are a very valuable nutrient source to sustain the profitability of feeding dairy cows.

Key Words: feed efficiency, dairy cattle

RUMINANT NUTRITION: DAIRY NUTRITION

O104 **Effects of diet energy levels fed during the dry period on performance parameters of dairy cows.** A. Pineda*, F. Cardoso, J. K. Drackley, *Animal Sciences, University of Illinois, Urbana.*

Metabolic disorders during early lactation are linked to energy intake during the dry period. Controversy arises whether controlling energy intake during the dry period would compromise cow performance after parturition. The aim of this study was to assess if controlling energy intake during the dry period has negative effect on cow performance during early lactation. Twenty-seven multiparous Holstein cows dried-off 50d before expected calving date were blocked by lactation, body weight (BW), body condition score (BCS) and randomly assigned to one of three dry period diets. Dietary treatments were: controlled-energy group (CE; n=11), fed a high-fiber diet to supply 100% of NRC requirements for energy and all nutrients ad libitum; high-energy group (HE; n=7), fed a diet formulated to supply 160-180% of energy (NEL) requirements at ad libitum intake; and restricted-energy group (RE; n=8), fed to 80% of their calculated NEL requirements by controlled intake of the high-energy ration. After calving a single lactation diet to supply 100% NRC requirements was fed to all cows. BW and BCS were measured weekly. Milk production and DMI were recorded daily. Milk samples were collected twice weekly and analyzed for fat, protein, lactose, urea nitrogen (MUN), and somatic cell count (SCC). Cows remained in the experiment until 28d after calving. Data were analyzed using the MIXED procedure of SAS. Cows fed HE diet ad libitum had greater DMI ($P < 0.001$) during the dry period while cows fed the same diet at RE intake had lower BW ($P = 0.08$). In addition, a significant ($P = 0.02$) interaction of treatment by wk was observed for DMI during the dry period. Despite no difference in milk production ($P = 0.83$), cows fed CE diet had higher milk protein content ($P = 0.04$) when compared RE fed cows. Fat, lactose, and SSC concentrations did not differ among treatments. A significant ($P < 0.05$) interaction of treatment by wk was observed for milk protein and MUN concentrations. After parturition, cows previously fed CE and RE diets during the dry period performed similarly to HE fed cows.

Key Words: dairy cow, dry period, transition period

O105 **Provision of non-immunoglobulin protein and rate of passage effects efficiency of Immunoglobulin G absorption in neonatal calves.** R. Cabral[1,*], P. Erickson[2], [1]*Molecular, cellular and biomedical sciences, University of New Hamsphire, Durham,* [2]*Biological Sciences, University of New Hamsphire, Durham.*

The mechanism of immunoglobulin (Ig) absorption is not well understood in the dairy calf. Though described as being passively absorbed, addition of non-Ig protein has demonstrated an impact on efficiency of IgG absorption and success of passive transfer. Previous work has utilized bovine serum albumin, whey proteins, and casein with results indicating either no effect or a decrease in absorption rates. The depression in absorptive ability was hypothesized to be a cause of competition for absorptive sites or the effect of rate of passage. Experiments altering rate of passage through either encouragement of curd formation or provision of injectables that effect abomasal emptying yielded significant changes in IgG absorption. Utilizing 80 calves we tested the effects of a single versus split feeding of colostrum replacer (CR) with or without 30 g of sodium bicarbonate ($NaHCO_3$) with or without a feeding of milk replacer (MR) 6 h after the final feeding of CR on IgG absorption. Previous data indicated a benefit of $NaHCO_3$ supplementation on IgG absorption. Our hypothesis was that MR would decrease IgG absorption due to an increase in rate of passage decreasing the residence time of the CR in the jejunum of the calf or possibly some competition between MR proteins and IgG for absorptive sites. Results indicated that supplementation with $NaHCO_3$ decreased IgG absorption ($P < 0.0001$) and that neither CR feeding regimen nor provision of MR had an effect on absorption of IgG from CR.

Key Words: calves, colostrum replacer, immunoglobulin G

O106 **Butyrate supplementation effects on metabolism and production in lactating dairy cows.** K. Herrick*, K. Kalscheur, *South Dakota State University, Brookings.*

Research investigating supplementation of individual VFA or intermediates of VFA metabolism has shown potential as a treatment for metabolic diseases in the post-partum ruminant. That research investigated treatments such as propylene glycol, glycerol, or calcium propionate which are related to glucose and propionate metabolism. Additionally, butyrate may be a viable energy supplement because of the greater energy content compared to the other major rumen VFA. However, rapid conversion of butyrate to ketone bodies at the rumen epithelium and in the liver makes it difficult to increase plasma butyrate concentration. Therefore, the objective of our research was to investigate the performance and metabolic responses in lactating dairy cows provided treatments designed to increase rumen butyrate concentration. In the first experiment, 4 ruminally-fistulated Holstein cows (152.5 ± 26.9 DIM) were ruminally dosed with 1of 4 treatments within a Latin square design: 1) 2 L of water, 2) 3.5 g/kg BW of lactose, 3) 1 g/kg BW of butyrate, or 4) 2 g/kg BW of butyrate. Animal health was not affected by treatment and there were no changes in DMI or milk production. However, butyrate treatments decreased plasma glucose and increased plasma β-hydroxy butyrate and rumen butyrate. In the second experiment, 5 ruminally-fistulated Holstein cows (94.2 ± 23.3 DIM) were infused for 24 h with one of 5 treatments: water (CON), 1 g/kg BW of butyrate infused into either the abomasum (A1) or rumen (R1), or 2 g/kg BW of butyrate infused into either the abomasum (A2) or rumen (R2). Plasma glucose (73.0, 67.2, 65.3, 69.6, and 62.1 mg/dL), plasma β-hydroxybutyrate (615, 965, 1454, 676, and 1235 m*M*), and plasma butyrate (0.08, 0.09, 0.11, 0.10, and 0.15 m*M*) for the CON, R1, R2, A1 and A2 treatments respectively, were affected by butyrate addition and treatment dose. Butyrate infused into the abomasum increased plasma butyrate more than rumen infusion of butyrate. Butyrate supplementation has the potential to improve the energy balance of lactating dairy cows**.** However, the potential negative effects of increased ketone bodies and response in lipid and carbohydrate metabolism need to be further investigated.

Key Words: butyrate, lactose

O107 **Effects of feeding fat from distillers grains on growth, metabolic profile, and long-term performance of dairy heifers.** J. L. Anderson*, K. F. Kalscheur, *Dairy Science Department, South Dakota State University, Brookings.*

Research has shown that distillers dried grains with solubles (DDGS) can be fed as a large proportion of dairy heifer diets, but consequently dietary fat content is increased. The objective of this research was to determine if increased dietary fat from DDGS affected growth, metabolism, and long-term performance of heifers. Thirty-three Holstein heifers (133 ± 18 d old) were used in a 24-wk randomized complete block design feeding trial. Heifers were fed one of the following treatment diets: 1) a control diet containing corn and soybean products (C), 2) a low-fat diet containing reduced-fat DDGS and corn (LFDG) and 3) a high-fat diet containing traditional high-fat DDGS (HFDG). All had 40% grass hay, 25% corn silage, and 35% concentrate mix (DM basis). Diets were balanced to be isonitrogenous and isocaloric, but not isolipidic. The HFDG contained 4.8% fat (DM basis) compared to 2.8% in C and LFDG, which had more starch. Body weights (BW), frame measurements, and blood samples for metabolite and hormone analyses were taken throughout the trial. Post-trial data were collected on reproduction and lactation. Body growth was similar among treatments. Total tract digestion of DM was similar among treatments, but CP and fiber digestion were greater in heifers fed HFDG compared to C and LFDG. Most metabolites and metabolic hormones analyzed were similar among treatments. Cholesterol increased in heifers fed HFDG compared to C and LFDG. Progesterone analysis indicated heifers fed HFDG were pubertal at lower BW and age compared to LFDG or C. Post trial, heifers fed LFDG or HFDG were similar to C for number of AI services for conception and age at first calving. Heifers fed HFDG tended to require fewer AI services compared to LFDG. Milk yields and components for the first 100 DIM were similar for heifers fed HFDG and C. Heifers fed LFDG had greater milk production and tended to have increased milk protein yields compared to C. Fat from DDGS can be fed in replacement of starch from corn to growing pre-pubertal dairy heifers and maintain growth performance, nutrient utilization, and subsequent reproductive and lactation performance.

Key Words: dairy heifers, dietary fat, distillers grains

O108 **Expression of mRNA for ureagenesis in early-lactation dairy cows is responsive to post-ruminal protein supply.** H. Tucker*, S. Donkin, *Animal Science, Purdue University, West Lafayette.*

Availability of amino acids (AA) to the mammary gland and other tissues is a function of the quantity and quality of metabolizable protein (MP), absorptive efficiency of AA, and postabsorptive hepatic AA metabolism. Post-ruminal infusion of protein and AA mixtures have increased milk and milk protein production but these responses have been variable due, in part, to differences in tissue responses to changes in MP supply. The objective of this work was to examine molecular responses in liver and mammary tissue with increased supply of MP and a modified profile of AA in MP. Early-lactation dairy cows fitted with rumen cannulae were used to determine the effects of post-ruminal infusion of milk protein isolate on expression of ornithine transcarbamoylase (OTC) and argininosuccinate synthase (ASS-1), key urea cycle enzymes, and aminoadipate semialdehyde synthase (AASS) a key regulator of hepatic lysine catabolism. Post-ruminal protein infusion increased milk and milk protein yield ($P < 0.05$), tended to increase ($P < 0.1$) OTC mRNA but did not alter ASS-1 and AASS mRNA. Rates of hepatic U[^{14}C] lysine oxidation to CO_2 were 127% higher in liver explants in cows receiving post-ruminal protein infusions. In a separate infusion study post-ruminal delivery of 63 g/d of lysine did not alter milk production, milk composition, or liver mRNA expression of OTC, AASS, or ASS-1 despite a 99% and 51% increase in plasma lysine and plasma α-aminoadipic acid, respectively. Together these data suggest increased utilization of MP for milk protein synthesis coupled with modulation of hepatic ureagenic mRNA in response to greater MP supply. However, supplying a modified plane of AA in MP does not alter production or mRNA abundance. This suggests that lysine alone is not responsible for changes in hepatic AA utilization or increased AA utilization by mammary tissue.

Key Words: gene expression, post-ruminal infusion, protein

O109 **Influence of the direct-fed microbial Bovamine on feed efficiency and milk production of lactating Holstein cows.** M. O'Neil[1,*], E. Testroet[2], M. Osman[1], W. Kreikemeier[3], D. Ware[3], D. C. Beitz[4], *[1]Department of Animal Science, [2]Department of Food Science and Human Nutrition, Iowa State University, Ames, [3]Nutrition Physiology Company, Guymon, OK, [4]Department of Biochemistry, Biophysics, and Molecular Biology, Iowa State University, Ames.*

Bovamine is a commercially available direct-fed microbial consisting of two organisms, *Lactobacillus acidophilus* and *Propionibacterium freudenreichii*, that has been shown to improve production efficiency of feedlot cattle. The objective of this study was to determine the effect of feeding Bovamine on milk production and feed efficiency of lactating dairy cows. Holstein cows (n = 87; parity 1 to 5) were randomly assigned to one of two treatment groups (Bovamine, 1 g/hd daily; Control, 1g lactose/hd daily). Each treatment was replicated three times. Both treatments were offered a basal TMR diet ad libitum and had ad libitum access to water. Individual feed intake was determined using a Calan gate system. Cows were acclimated to the treatment diets and Calan gates for 14 days followed by a treatment period of 84 days. Milk production was recorded daily, and rumen fluid was collected via esophageal tube on week, 0, 3, 6, 9, and 12 and analyzed for VFA concentration. Data were analyzed as a randomized complete block design. Increased ($P < 0.001$) milk production was observed in Bovamine cows (40.47 ± 0.13 kg/d) compared with Control cows (38.19 ± 0.12 kg/d). Whereas Bovamine increased milk production, there was a concurrent decrease in feed intake (as fed basis; $P < 0.001$) in cows fed Bovamine (45.79 ± 0.15 kg/d) compared with Control cows (46.66 ± 0.14 kg/d). The efficiency of milk production increased ($P < 0.001$) because of Bovamine (0.904 ± 0.004 kg milk/kg feed) compared with Control cows (0.827 ± 0.140 kg milk/kg feed). These results indicate that feeding Bovamine increases milk production and feed efficiency in lactating dairy cattle.

Key Words: direct-fed microbial, feed efficiency, milk production

TEACHING SYMPOSIUM: INVOLVING UNDERGRADUATE STUDENTS IN ANIMAL SCIENCE RESEARCH: BEST PRACTICES AND BENEFITS

O178 **Developing scholars and future employees: Building a sustainable undergraduate research program in agriculture.** T. Nichols*, *South Dakota State University, Brookings.*

Undergraduate research is recognized as a high impact activity contributing to retention, success and higher order learning outcomes for university students. Numerous studies have called for the strengthening of enrollments of talented, motivated students in agriculture-related disciplines, and organizations including the National Academy of Science have called for the transformation of agricultural education to broaden the student experience through wider integration of undergraduate research experiences. Departments of Animal and Dairy Science are often uniquely equipped with faculty research programs, laboratories and animal production/research facilities that can contribute to successful undergraduate research experiences. A collaborative program between the Honors College and College of Agriculture and Biological Sciences at South Dakota State University engages students seeking graduation with Honors College distinction in undergraduate research experiences throughout the college. Students work with faculty mentors to develop a research/grant proposal, execute a research project, and present it in a public scholarly venue. Modest funding through the Honors College and a United States Department of Agriculture Higher Education Challenge Grant provides resources for research supplies, student stipends and travel/presentation expenses. Students also participate in a research seminar series which emphasizes communication, critical thinking, creativity and multi-disciplinary perspectives—all skills highly valued in today's competitive workforce. Results of the program to date include increased agriculture student and faculty participation in undergraduate research, impressive student learning outcomes, and successfully executed student research projects—many of which have been presented regionally and nationally and submitted for publication. Enrollment of agriculture students in the Honors College has also increased dramatically. Collaboration and multiple sources of support have been critical to the project's sustainability and success and have resulted in synergistic impacts. The initiative's approaches, best practices and lessons learned will be discussed.

Key Words: none

O110 **Industry perspective: Engaging students in research in order to obtain skills and knowledge to make them more successful in the job market.** J. M. Rumph*, *Pfizer Animal Genetics, Kalamazoo, MI.*

The field of Animal Science has evolved over the years and as a result, the skill set preferred in Animal Science graduates has also changed. Although it continues to be desirable for graduates to have hands-on animal experience in conjunction with the scientific background of the biological principles of the field, it is becoming increasingly important for students to have hands-on research experience as well. Not only are employers eager for candidates that have research experience in their specific field so that they can bring an added level of expertise to the job, but employers are also looking for candidates that have the problem solving skills that research experience can provide. Regardless of the specific discipline the research experience is in, problem solving skills can be invaluable in any number of post-graduate careers. Animal Science students graduating with these skills are marketable in a large number of industry positions, both in and out of traditional agricultural fields. Furthermore, combining research experience with traditional Animal Science industry experience thru hands-on animal experiences and/or industry internships provides a unique perspective for graduating students. The different experiences complement each other to provide graduates with the knowledge and understanding of the needs of customers while also having the scientific background to efficiently and effectively work for solutions to those needs, thus making these students highly marketable to today's Animal Science industry employers.

Key Words: career, research, undergraduate

O111 **Best practices and benefits of involving students in animal sciences research—early career faculty perspective.** S. Hansen*, *Animal Science, Iowa State University, Ames.*

Involving undergraduate students in animal science research can be very rewarding for all parties; however, it also presents a unique set of challenges. While faculty are accustomed to working with graduate students with varying levels of experience and abilities, undergraduate students often have very limited research or lab experience, and today's student may not even have any animal experience! These challenges require that faculty who work with undergraduate students have patience, a well organized strategy for student success, and ideally, great people in the lab to provide additional structure and guidance to the undergraduate student. Undergraduate research is a major priority at many universities, and as such, programs offering financial support of student research are

frequently available. This presentation will focus on the speaker's experiences with undergraduate student researchers, through a variety of programs at Iowa State University, and will include some recommendations for best practices for success when involving undergraduate students in a research program in animal science.

Key Words: undergraduate researchers

O112 **Department initiatives to engage undergraduate students in Animal Sciences research.** E. Karcher*, *Animal Science, Michigan State University, East Lansing.*

Undergraduate research (UR) is a high impact practice that allows for increased student engagement and active learning. Benefits of participation include increased interest in postgraduate education as well as development of interpersonal skills. Involvement in undergraduate research allows for the further development of faculty-student relationships and gives students the sense of belonging to the science community. Based on the documented benefits, it is essential that undergraduates studying Animal Sciences have the opportunity for involvement in research projects. In the Department of Animal Science at Michigan State University, students may join the Animal Science Undergraduate Research Association (ASURSA). The club, founded in 2009, provides a social community for undergraduate students interested in animal science and research. Club activities include hosting the annual Animal Science Undergraduate Research Forum, engaging faculty and industry representatives in research discussions, annual club research project, as well as social activities. During the 2011-2012 school year, the club had 36 members. In 2012, club members were given voluntary access to a survey website designed to assess the impact of ASURSA on the enhancement of the overall undergraduate experience. The results of the survey indicated that the majority of members felt involvement allowed for better understanding of concepts discussed in the classroom and felt their level of interaction with livestock increased since joining the club. The majority also felt their connections and relationship with Animal Science faculty also improved, which is important for the retention of students. Individual Animal Science students completing a research project may also enroll for credit that is applied towards the program. Additionally, students may apply for financial support through the MSU College of Agriculture and Natural Resources Undergraduate Research Program. Development of novel methods to encourage participation in UR, such as a club, is an important step to increase the number of students graduating with research experience.

Key Words: research, teaching, undergraduate

EXTENSION – DAIRY SYMPOSIUM: RUMEN BYPASS FAT SOURCES AND THEIR EFFECT ON MILK PRODUCTION AND MILK FAT

O113 **Applied principles of feeding fat to lactating dairy cows, with emphasis on byproducts as the primary source.** P. Kononoff[1,*], K. F. Kalscheur[2], H. A. Ramirez[1], S. D. Ranathunga[2], *[1]Animal Science, University of Nebraska, Lincoln, [2]Dairy Science, South Dakota State University, Brookings.*

Current feeding practices in the dairy industry commonly involve feeding grains, vegetable oils, or animal fats to increase the energy density of the diet. Additionally supplemental fat may be added to improve body condition and production. When choosing a fat source producers and nutritionists should be mindful of the impacts on rumen microbes and ultimately metabolism of the dairy cow. The profile of fatty acids present for absorption in the hindgut is affected by ruminal microbial metabolism. This occurs through hydrolysis and biohydrogenation (BH). These processes result in the saturation of fatty acids and in an array of fatty acid isomers. After absorption of some of these isomers, they may then reach the mammary gland where they can reduce milk fat synthesis. When this occurs milk fat depression (MFD) may be observed. The condition of MFD is unique because it involves the interaction between gut microbes and the host animal's metabolism. Troubleshooting cases of MFD or preventing it requires understanding of this interaction. The rise of the corn-ethanol industry has resulted in a dramatic increase in the availability of byproducts. A major concern with feeding these byproducts is that they are high in polyunsaturated fatty acids (PUFA), primarily linoleic acid. When specific conditions in the rumen exists, we know that BH of PUFA results in increases flow of trans-18:1 CLA isomers that may affect milk fat synthesis. Over the years a number of risk factors which support these conditions have been identified and studied, and these factors include: low rumen pH, low forage fiber, and feeding high concentrations of unsaturated fat. Additionally the rate at which hydrolysis, BH, and even lipolysis differs across feeds and this may ultimately impact supply to the mammary gland. The aim of presentation is to highlight key studies of the diet, microbe and host-metabolism interactions while also discussing recommendations that will prove useful for the practicing dairy nutritionist.

Key Words: milk fat depression, DDGS

GROWTH, DEVELOPMENT, MUSCLE BIOLOGY, MEAT SCIENCE: MATERNAL NUTRITION SYMPOSIUM

O114 **Exposure to heat stress during pregnancy impairs metabolism in the ruminant fetus.** S. W. Limesand*, *Animal Sciences, University of Arizona, Tucson.*

Exposure to elevated ambient temperatures during gestation results in placental insufficiency (PI) in ruminants. At later stages of gestation, the fetus develops hypoxemia, hypoglycemia, hypoinsulinemia, and becomes growth restricted. The endocrine pancreas plays an important role in fetal life by secreting insulin, an anabolic hormone, that is regulated by nutrient availability and can coordinate fetal growth rate with the placental nutrient supply. The goal of our research is to understand developmental adaptations in insulin secretion and action in response to PI, and determine how they manifest to lower production traits. In fetal sheep PI-induced intrauterine growth restriction (IUGR) was created by exposing the pregnant ewe to hyperthermic conditions during mid-gestation. This treatment results in fetal hypoxemia and hypoglycemia at 0.9 of gestation. We also found that glucose stimulated insulin secretion (GSIS) was 82% lower in IUGR fetuses compared to controls. This impairment was due to a 78% reduction in β-cell mass and less insulin per β-cell. We did, however, find that the β-cells from IUGR fetuses were able to secrete more insulin relative to total insulin content, indicating stimulus-secretion coupling is improved in vitro. In contrast, a fetal sheep model with only hypoglycemia, produced by a chronic maternal insulin infusion, exhibited 45% lower GSIS response and blunted insulin secretion from isolated islets. Together,

these data indicate that hypoxemia can play an important role in fetal islet outcomes. One mechanism that we have explored for hypoxemia is elevated norepinephrine concentrations, which negatively correlated with blood oxygen content to inhibit insulin secretion. IUGR islets develop a compensatory enhancement in insulin secretion after removing norepinephrine indicating continued β-cell impairment.

Key Words: beta-cell, intrauterine growth restriction , norepinephrine

O115 **Impacts of fetal programming on cattle performance, carcass composition, and meat quality.** A. R. Taylor*, K. Underwood, D. Mohrhauser, A. Weaver, *Animal Science, South Dakota State University, Brookings.*

Fetal programming or developmental programming evaluates the effects of maternal nutrition on the developing fetus. These effects can manifest later in life, developing into disease-like conditions. Programming may be the result of a stimulus or an insult to the dam during development that has lasting effects on physiology, composition, and structure. A common insult in livestock is altered plane of nutrition during gestation. Most fetal programming research has focused on under-nutrition of the dam, as many cattle may experience a decrease in available forage during gestation due to seasonality. These restrictions can range from the first trimester through the last trimester and include energy or protein restrictions. Evaluating nutrient restriction is important because during development the fetus has a tremendous draw for nutrients from the dam. If these demands are not met altered composition of growth can occur in the subsequent progeny. Early in gestation organogenesis can be affected by fetal programming having consequences for the calf later in life. Implications for health and thriftiness can be found as a result from early gestational nutrient restriction. Mid and late gestation alterations in dam nutrient intake can affect myogenesis, adipogenesis, and fibrogenesis as these tissues are all derived from mesenchymal stem cells. These changes in mesenchymal stem cell differentiation can impact carcass composition and meat quality depending on the type of insult and the timing of the insult. These changes in composition can also affect cattle performance on feed. Data indicates nutrient restriction can increase marbling thus increasing beef quality grade. These data also suggest maternal altered planes of nutrition can impact calf performance and beef quality. Continued research in these areas will enhance our understanding of management strategies and their use to manipulate factors that affect beef meat quality.

Key Words: cattle, fetal programming

O116 **Implications of maternal nutrition on developmental programming of economically relevant traits in livestock production.** A. E. Radunz*, *University of Wisconsin, River Falls.*

Developmental programming is the concept that maternal stimulus or insult at critical periods in fetal or early postnatal development has long-term impacts on the offspring. In food animal species, sub optimal condition *in utero* during gestation has been well documented to have postnatal impacts of compromised health, slower growth rate, increased fat deposition, reduced muscle mass, and reduced meat quality in progeny. Recent studies have begun to build a body of evidence that maternal nutrition impacts several prenatal physiological parameters, but few studies have evaluated the long-term postnatal consequences in relationship to livestock production traits of economic importance. Recent studies in beef cattle have investigated specific diet components during gestation on postnatal progeny production traits, more specifically maternal protein content and energy substrate supply. Collectively, these studies have provided initial evidence that late gestation maternal nutrition can impact birth weights, postnatal growth, and postnatal adipose deposition. The underlying mechanisms that trigger such responses have not been completely elucidated. There is also growing evidence that maternal diet during the different stages of pregnancy can induce epigenetic changes in the fetus, which can lead to changes in gene expression and subsequent postnatal growth and body composition effects. Epigenetics encompasses changes to marks on the genome early in development that are copied from one cell generation to the next, which may alter gene expression, but do not involve changes in primary DNA sequence. Recent results from our lab provide evidence of the association of maternal nutrition during pregnancy and transcriptomic and epigenomic alternations of imprinted genes, which influence fetal growth and adiposity. New knowledge on factors impacting development and deposition of adipose tissue would be valuable not only to the beef industry but other meat animal industries to improve production efficiency and meet consumer demands.

Key Words: developmental programming, gestational nutrition

O209 **Impact of ractopamine hydrochloride on finishing pigs in a three phase marketing scheme.** G. D. Gerlemann [1], G. L. Allee [1], P. J. Rincker [2], D. D. Boler [3,*], S. N. Carr [2], *[1]Animal Sciences, University of Missouri, Columbia, [2]Elanco Animal Health, Greenfield, [3]Animal Sciences, Ohio State University, Columbus.*

The objectives were to determine performance and carcass traits of pigs fed RAC (7.4 mg/kg) in a 3-phase marketing scheme. One thousand seven hundred and forty pigs were used in 80 pens of 22 pigs per pen in 2 blocks. Sixteen percent of the population of pigs was sold during the first marketing period, 18% was sold during the second marketing period, and the remaining 66% was sold during the third marketing period. Data were analyzed as a split plot design in a randomized complete block arrangement of 2 treatments. There were no differences ($P = 0.52$) in starting BW between pigs fed (101.29 kg) and not fed RAC (101.40 kg). Interactions were detected among marketing periods and treatments which may be due to increased floor and feeder space as pigs were removed during marketing. Pigs fed RAC were 2.60 kg heavier ($P < 0.0001$), had 0.11 kg/d greater ($P < 0.0001$) ADG, and had 0.04 greater ($P < 0.0001$) gain to feed ratios than pigs not fed RAC. Hot carcass weights were 2.7% greater ($P < 0.0001$), carcass yields were 0.5 percentage units greater ($P < 0.0001$), fat depth was 6.2% less ($P < 0.0001$), loin depth was 4.4% greater ($P < 0.0001$), and estimated carcass lean was 0.79 percentage units greater in RAC fed pigs compared with pigs not fed RAC. By the end of the first marketing period, RAC carcasses (89.73 kg) were 2.1% heavier ($P < 0.01$) and gained 0.20 kg/d more ($P < 0.001$) weight than non-RAC carcasses (87.89 kg). By the end of the second marketing period, RAC carcasses (99.00 kg) were 3.1% heavier ($P < 0.0001$) and gained 0.15 kg/d more ($P = 0.01$) weight than non-RAC carcasses (96.02 kg). By the end of the third marketing period RAC carcasses (102.75 kg) were 3.7% heavier ($P < 0.0001$) and gained 0.10 kg/d more ($P = 0.05$) weight than non-RAC carcasses (96.02 kg). Although carcass gain/d decreased with extended RAC feeding duration, HCW advantages continued to increase as feeding duration was increased from 7 d to 35 d. Even though carcass benefits were not as evident in pigs sold during the first marketing period, advantages (particularly HCW) continued to increase with each marketing period.

Key Words: 3 phase marketing, Paylean, ractopamine hydrochloride

O210 **Effect of growth rate during the stocker period on satellite cell-mediated preadipocyte differentiation in beef cattle.** M. Vaughn[1,*], J. Starkey[1], K. Hutton[1], P. Lancaster[2], U. DeSilva[2], G. Horn[2], C. Krehbiel[2], *[1]Animal and Food Sciences, Texas Tech University, Lubbock, [2]Animal Science, Oklahoma State University, Stillwater.*

To assess the effect of growth rate during the stocker period on the ability of satellite cell-produced factors to influence marbling development, Fall-weaned Angus-cross steers (n = 72; 259 ± 28 kg) were randomly assigned to 1 of 4 stocker systems. Stocker systems included: 1) grazing dormant native range (NR) supplemented with cottonseed meal (1.0 kg·steer^{-1}·d^{-1}) followed by season-long grazing on summer pasture (CON); 2) grazing dormant NR supplemented with a corn-based supplement (1% of BW) followed by short-season grazing on summer pasture (CORN); 3) grazing winter wheat pasture (WP) at high stocking density (3.0 steers/ha) to produce a moderate ADG (LGWP); and 4) grazing winter WP at low stocking density (1.0 steers/ha) to produce high ADG (HGWP). Steers grazed until the average BW of the treatment group reached approximately 375 kg, at which time steers were transitioned to a common finishing diet and fed to a common backfat thickness of 1.27 cm. At the end of the stocker and finishing phases, satellite cells were isolated from the longissimus muscle of 4 steers per treatment (total n = 32). Satellite cells were cultured for 96 h and 14 d and all conditioned media were collected. 3T3-L1 mouse preadipocytes were grown to confluence and exposed to conditioned media from proliferating and differentiated satellite cells followed by assessment of lipid accumulation and adipogenic gene expression. Preadipocytes treated with media from proliferating satellite cells from NR steers expressed greater FABP4 (P = 0.04) and lower PPARγ (P = 0.05) mRNA abundance when compared to preadipocytes treated with media from satellite cells from WP steers at the end of the finishing phase. These data suggest that changes in marbling development produced by differing rates of gain during the stocker period may be mediated by satellite cell-produced factors acting in a paracrine fashion on marbling preadipocytes in beef cattle.

Key Words: beef cattle, marbling development, satellite cell

O211 **Effects of increasing hydrolysable tannin levels in diets of boars on growth, carcass traits, boar taint, and cytochrome P450 gene expression.** A. L. Wealleans [1], J. C. Litten-Brown [1], I. Mueller-Harvey [1], I. Givens [2], P. Silacci [3], G. Bee [3,*], *[1]School of Agriculture, Policy and Development, University of Reading, [2]School of Agriculture, Policy and Development, University of Reading, United Kingdom, [3]Agroscope, Posieux, Switzerland.*

Tannins have long been considered "anti-nutritional" factors in monogastric nutrition, shown to reduce feed intake and palatability. However, recent studies revealed that compared to condensed tannins in beans, hydrolysable tannins (HT) have far less impact on growth and feed efficiency. Thus, the objective of this study was to determine the effect of 2 levels of dietary HT on growth performance, carcass traits and boar taint compounds of group housed entire males. For the study, 36 Swiss Large White boars were assigned within litter to 3 treatment groups. Boars were offered *ad libitum* one of 3 finisher diets supplemented with 0 (C), 15 (T15) or 30 g/kg (T30) of HT from d 105 to 165 of age. Growth performance, carcass characteristics, boar taint compounds in the adipose tissue and CYP1A2 and CYP2A19 gene expression in the liver was assessed. Compared to C, feed efficiency but not ADG or ADFI was lower (P < 0.05) in T15 and T30 boars (363, 367 vs. 382 g/kg). Except for the percent carcass weight loss during cooling, which tended (P < 0.10) to be greater in T30 than C and T15 (2.86 vs. 2.64, 2.62%), carcass characteristics were similar for the 3 treatments. Compared to C and T15, the bulbo-urethral and salivary glands of T30 boars were lighter (183, 200, vs. 163 g and 86, 96 vs. 77 g; P<0.05). Similarly, kidney weight tended to be lower in the T30 than the C and T15 group (342 vs. 370, 375 g; P < 0.10). The androstenone but not skatole and indole levels tended (P = 0.10) to be lower in T30 than T15, with intermediate values for C (0.45, 0.81 and 0.68 mg/g, respectively). The CYP1A2 gene expression was negatively correlated with androstenone level (-0.51; P < 0.01) and CYP2A19 with androstenone (-0.49; P < 0.05) and skatole level (-0.62; P < 0.01). This matches with the non-significantly greater CYP1A2 and CYP2A19 expression levels in T30 compared to T15 and intermediate values for C (0.92, 0.43, 0.65 and 1.02, 0.41, 0.62; P > 10). The change in bulbo-urethral gland size in the T30 group reflects the lower androstenone level, indicating a possible potential of HT in the regulation of boar taint.

Key Words: boar, boar taint, tannin

O212 **Effect of skeletal muscle fiber heterogeneity on development of intramuscular fat in growing beef cattle.** S. L. Roberts*, P. A. Lancaster, U. DeSilva, G. W. Horn, C. R. Krehbiel, *Animal Science, Oklahoma State University, Stillwater.*

Previous research indicates that metabolism and fiber type of skeletal muscle is related to intramuscular lipid content. The objective of this study was to determine differences in the metabolism and intercellular signaling of skeletal muscle fibers within the same muscle group that could be responsible for the initiation of intramuscular adipose tissue development and differentiation. Longissimus dorsi (LD) muscle samples were collected from steers (n = 12; 385 days of age; 378 kg) grazing wheat pasture. LD samples were dissected under magnification and sorted into 3 categories based on visual stage of development: immature (MM), intermediate (ME) and mature (MA) intramuscular fat (IM). In addition, muscle fibers lying adjacent to each IM category and those not associated with IM tissue were collected and stored separately. Quantitative RTPCR was used to determine relative fold change in genes involved in metabolism, angiogenesis, and intercellular signaling pathways in both LD and IM samples. Gene expression data were analyzed using a general linear model that included the fixed effect of tissue. Pearson correlation coefficients were also computed between gene expression in LD and IM tissue samples that were at the same stage of development. Fatty acid binding protein 4 and *PPARγ* expression were greater (P<0.05) in more mature IM while *PREF-1* expression was less (P<0.01) indicating successful separation into different maturity categories. Genes associated with metabolism and angiogenesis in LD tissue showed no differences among stages of development. Myostatin expression did not change in LD tissue, but mysotatin receptor and follistatin expression decreased (P<0.01) as IM matured. Angiogenic growth factors in MM IM tissue had a strong positive correlation (r>0.88) with angiogenic growth factors in LD associated with MM IM; however, no correlation was observed in ME or MA IM. Also, *IFG1* in LD was positively correlated (r=0.56) with *IGF1* receptor in MM IM but not ME or MA. These data indicate a coordinated effort between LD and IM in early stages of IM development.

Key Words: gene expression, intercellular signaling, intramuscular fat

O213 **Effect of timing of mixing during the grow-finish period on the growth performance and carcass characteristics of barrows and gilts under commercial conditions.** L. Ochoa[1,*], M. Ellis[1], B. Isaacson[2], B. A. Peterson[2], [1]*Animal Sciences, University of Illinois, Urbana,* [2]*The Maschhoffs, Carlyle.*

This study was carried out to evaluate the effect of timing of mixing during the grow-finish period on the growth performance and carcass characteristics of barrows and gilts. The study was carried out in a commercial wean-to-finish facility as a RCBD (blocking factor was BW) with a 2 × 6 factorial arrangement of treatments: 1) Gender (Barrows vs. Gilts), and 2) Timing of mixing [Control (Not-mixed) vs. Mixed at wk 9, 11, 13, 15 or 17 post-weaning, respectively]. The study involved 1,440 commercial crossbred pigs housed in 48 single-gender pens of 30 (4 pens per Gender × Timing of mixing subclass). Mixing of pigs was carried out by exchanging 50% of pigs between 2 pens of the same Mixing treatment combination (experimental unit = 2 pens). The study was carried out from wk 9 post-weaning (33.4 ± 1.27 kg BW) to a pen mean BW of 130.0 ± 2.15 kg BW (~wk 23 post-weaning). Pigs were sent to a commercial plant for harvest and carcass measurements were collected. There were no treatment interactions ($P > 0.05$) for any measurement. Morbidity and mortality levels were not affected ($P > 0.05$) by any of the treatments. Gender had no effect ($P > 0.05$) on overall ADG. Barrows had higher ($P < 0.05$) overall ADFI (2.53 vs. 2.36 kg; SEM 0.072), lower ($P < 0.05$) overall G:F (0.369 vs. 0.385; SEM 0.0039), lower ($P < 0.05$) carcass yield (73.7 vs. 74.5%; SEM 0.15), lower *Longissimus* muscle depth (5.4 vs. 5.5 cm; SEM 0.03), and lower predicted carcass lean content (52.2 vs. 53.7%; SEM 0.29) than gilts. Mixing of pigs had no effect ($P > 0.05$) on overall growth performance or on carcass measures, regardless of the timing of mixing. These results confirm previously observed gender differences and suggest that under the commercial conditions of this study, pigs can be mixed as late as 17 weeks post-weaning (~6 weeks before harvest) without affecting morbidity and mortality levels, growth performance, or carcass characteristics.

Key Words: growth, mixing, pigs

O214 **Prenatal and postnatal nutritional effects on postnatal growth and carcass characteristics of steers.** K. J. McLean*, B. H. Boehmer, C. L. Maxwell, G. W. Horn, R. P. Wettemann, *Oklahoma Agricultural Experiment Station, Oklahoma State University, Stillwater.*

Fall calving cows grazing native grass pasture were used to evaluate effects of nutritional supplementation during breeding and the first trimester of gestation on postnatal growth and carcass characteristics of calves. Cows calved in Sept-Oct and were individually fed control (C, 1.82 kg/d of 38% CP supplement) or low (L, 0.2 kg/d of 8% CP supplement) from Nov. 17 to March 20. Cows were in one pasture and exposed to bulls for 60 d commencing Dec. 1. During lactation the subsequent year, half of the cows on C and L prenatal treatments was assigned to C and the other half was assigned to L. Prenatal L (n = 14) and prenatal C (n = 21) steers were fed a concentrate diet commencing at 19 mo. of age and were harvested on the same day. GLM (SAS) was used to analyze weaning weight, yearling weight, harvest BW, HCW, ADG, and carcass characteristics, as a 2 x 2 factorial. Prenatal x postnatal treatments did not influence BW (P > 0.25). Calves on postnatal C cows had greater ADG from birth to 3 mo. compared with L calves ($P = 0.05$). Weaning weight (205 d) was greater for calves on postnatal C compared with L (200 ± 5 and 184 ± 5 kg, respectively, $P = 0.02$). Postnatal C calves had greater 365 d weight compared with L calves (P = 0.01). Postnatal C calves compared with L calves had greater BW at harvest (647 ± 12 and 610 ± 9 kg, respectively) and HCW (393 ± 8 and 370 ± 6 kg, respectively). There was a tendency (P = 0.06) for a prenatal x postnatal effect on ADG during finishing. Steers on L prenatal and C postnatal had greater gain during finishing compared with C prenatal and C postnatal steers. Marbling and ribeye area were not influenced (P > 0.15) by prenatal or postnatal treatment. Protein supplementation of cows during the first trimester of gestation, that resulted in less BW loss and greater plasma IGF-I concentration (J. Anim. Sci. 90(E-Suppl. 3): 325) did not influence HCW or carcass characteristics of calves.

Key Words: beef cattle, nutrition, postnatal growth

HARLAN RITCHIE BEEF SYMPOSIUM

O117 **The future of genomic selection in animal agriculture.** J. Taylor*, *University of Missouri, Columbia.*

The efficiency of genomic selection (GS) is maximized when the population used to train molecular breeding value (MBV) prediction models is dynamic and is recurrently updated to include the candidates selected at each previous selection cycle who have then gone on to produce progeny with records. This strategy optimizes the two factors which determine the accuracy of predicted MBVs: it minimizes the genetic distance (or maximizes the relatedness) between individuals in the training population and each generation of new selection candidates, and it increases the information available upon which to train the MBV prediction models, increasing the accuracy of MBVs for the training population individuals. This design best fits industries in which phenotyping is widespread and inexpensive and where the cost of genotyping is low relative to the value of the increased selection response achieved by the use of MBVs relative to mid-parent predictions produced by BLUP. In practice, this has meant that the greatest utility of GS has been to the dairy industry where all bulls are progeny tested, the cost of progeny testing is high and reproductive rates per bull are also high, enabling the cost of genotyping selection candidates to be recovered from the superiority of the progeny of selected bulls. On the other hand, the greatest initial hope for GS was for traits such as disease resistance and feed efficiency which are not routinely measured due to difficulty and cost in many industries. However, MBV prediction models trained in static populations generated to facilitate GS for such traits have no predictive capability when applied to selection candidates from breeds that were not represented in the training population and will decline in their accuracy of prediction when sequentially applied to future generations of selection candidates from the same breeds as those in the training population. The periodic recreation of training populations appears inevitable to enable GS to be successfully applied to these traits—but will the cost of recurrent phenotyping outweigh the value of response? The low reproductive rates per sire in populations and species for which artificial insemination is not cost effective also limits the utility of GS when the cost of genotyping is species agnostic. The future success of GS for most traits and species will rely on the development of very inexpensive, high-throughput genotyping technologies and/or the identification of the causal mutations which underlie variation in economically important traits. The companies which currently control the delivery of genotyping technologies have no interest in developing ultra-low cost genotyping technologies and neither does

the human medical research community. Consequently, agricultural research scientists appear to be most highly motivated and to have access to the appropriate populations of phenotyped individuals to tackle both of these dilemmas.

Key Words: genomic selection, genomics, MBV, QTL

O118 **Industry issue or opportunity—Increasing carcass weights?** J. Stika*, C. Walenciak, *Certified Angus Beef LLC, Wooster.*

One of the consistent linear trends in the beef industry, over the last 30 years, has been a progressive increase in carcass weight. Since 1980, there has been a 74.1 kg increase in carcass weight, with the average steer carcass weight exceeding 390 kg in 2012 (USDA data). The NCBA National Quality Audit, conducted in 2011, reported 3.7% of the carcasses exceeded 454 kg. Numerous factors have contributed to this change, but superior growth genetics, along with new and more extensive use of growth technologies, have been key factors. This has resulted in positive and negative economic consequences for the beef industry. The positive is certainly, in spite of a dwindling cow herd size, we produce more beef from fewer cattle creating a constant to growing supply of U.S. produced beef. The negative economic consequence has been the challenge heavier carcasses present to our marketing partners—foodservice and retail—caused primarily by the increase in middle meat primal size. The ideal carcass weight to these marketing sectors is a 318 to 363 kg carcass. Data from the foodservice "cut shops" has been collected by Certified Angus Beef LLC and will be shared illustrating unintended economic issues created by this industry trend. We will also share data on how the retail and foodservice industry has adjusted cutting practices to cope with this industry issue.

Key Words: carcass weight, foodservice, retail

O119 **Creating customer-centric beef production systems**. N. Speer*, *Western Kentucky University, Bowling Green.*

The U.S. beef industry has witnessed significant transformation during the past ten to fifteen years. Evolution stems from several important convergent factors. Especially important has been the rapid expansion of branded programs. Consumers have greater ability to purchase beef products with added value across a variety of attributes. The branded beef market now comprises 10-15% of all beef sales. The beef industry has also witnessed tremendous shifts and square-footage expansion in the grocery retailing business. That dictates special considerations with respect to volume assurance; an especially difficult challenge given ever-shrinking supply of available cattle to source from. In response, stakeholders are increasingly relying on contractual arrangements and out-front beef sales (now comprising nearly two-thirds of wholesale beef transactions) to ensure product availability, avoidance of stock-outs and increasing price stability. Lastly, the 2011 National Beef Quality Audit clearly documented consumers desire more transparency about where food comes from; knowledge that extends beyond the product itself, with particular emphasis upon the production processes from which those products are derived. That reality highlights the growing importance of documenting, verifying and maintaining integrity of information throughout the value chain. Like any industry, the beef complex must produce and deliver consistent, high-quality products in an efficient manner to maintain competitiveness in the marketplace. Shifting consumer demands and marketing-channel influences mandate more responsive and efficient business models going forward. Future innovation and competitiveness will be increasingly comprehensive, derived around emphasis upon risk management, knowledge sharing, and information transfer throughout the supply chain. The outcome being greater prevalence of coordinated networks that leverage genetic inputs, supply development, management schemes and marketing programs to ensure a more consumer-oriented value chain that delivers beef products with greater value and better precision in the marketplace.

Key Words: beef, consumers, systems

O120 **Economic rewards of hitting consumer targets for beef.** S. Brown*, *Department of Agricultural and Applied Economics, University of Missouri, Columbia.*

The premiums available for cattle that grade upper choice or prime have grown over the past several years. The prime premium has exceeded $450 per metric ton for the past 16 months and the select discount to choice beef although variable has exceeded $400 per metric ton over much of this period. The growth in sales of higher quality beef and associated value has added a significant additional revenue source for the industry. The investment in higher-quality beef made by retailers like Walmart provides antidotal evidence of the available returns from pursuing the high-quality target. This paper shows the growth in revenue that has been generated by hitting this higher-valued consumer targets over the past decade but more importantly explores the possible future growth in revenue from pursuing additional supplies of high-quality beef. The United States beef industry has endured many financial challenges over the past several years as feed costs have hit record highs and the general economic activity entered a downturn not experienced in decades. The volatility resulting from these events has been difficult to balance. The higher-quality targets have provided some buffer from this volatility as more consistent growth in high-quality beef demand despite these large events has helped reduce volatility for those focused on these high-quality targets. In focusing on the prime beef market, demand for prime beef grew by 20 percent in 2010 and another 24 percent in 2011. Even more impressive is the demand shifts that occurred in the economic downturn of 2009. Prime beef demand did dip by 2 percent in 2009 yet that remains small in comparison to the near 20 percent decline in select beef. The result of hitting the target of beef that consumers demand today will result in a much larger industry in this country than will result from a strategy of producing commodity beef for the lowest cost possible.

Key Words: beef cattle, price premiums, quality

NONRUMINANT NUTRITION: FEED INGREDIENTS AND ADDITIVES

O121 **Effect of β-mannanase and β-glucanase on pig performance, active glucose absorption, and intestinal microbial population in the early nursery period.** Z. Rambo [1], M. Rostagno [2], J. Radcliffe [1], J. Ferrel [3], A. Jones [1], D. Kelly [1], B. Richert [1,*], *[1]Animal Sciences, Purdue University, [2]USDA-ARS, Livestock Behavior Research Unit, West Lafayette, [3]ChemGen Corp, Gaithersburg, MD.*

Individual barrows (BW=8.45±0.38kg; 29d age) were used to evaluate the effect of adding β-mannanase (M) or in combination with β-glucanase (MG) in a corn-soybean meal-dried distillers grains with solubles diet on pig performance, active nutrient absorption, and intestinal microbial population in the early nursery period.

Pigs (9 or 10/diet) were blocked by BW, and allotted to diets: T1, Control (C; 3298 Kcal/kg ME); T2, C+M (0.06 MU/kg); and T3, C+MG (0.08 MU/kg glucanase, 0.10 MU/kg mannanase) for 16d. At d16 pigs were euthanized and a jejunum section was used in modified Ussing chambers. Ileal and cecal samples were collected for bacteriological enumeration. For d 0-7 ADG tended (P<0.10) to increase for T3 over C with T2 being intermediate (419, 464, 488 g/d, T1-T3, respectively) and G:F numerically improved for T2 and T3 over C (0.811, 0.851, 0.831, T1-T3, respectively). D 7-16 ADFI was greater (P<0.05) for T3 compared to C, T2 was intermediate and G:F tended to improve (P<0.10) for T2 compared to T3 while C was intermediate (0.675, 0.702, 0.643, T1-T3, respectively). Overall, T2 and T3 ADG was numerically higher compared to C (509, 535, 555 g/d, T1-T3, respectively) and T3 ADFI was greater (P<0.05) compared to C while T2 was intermediate. Final BW was 16.56, 16.85, 17.47 kg, T1-T3, respectively. Active glucose absorption, estimated based on changes in short circuit current, was 8.2, 16.6, and 2.3 µA/cm2,T1-T3, respectively (*P*=0.13, SEM=4.7). No difference among treatments was detected in analyzed cecal microbial populations (*P*>0.05). Ileal *E. coli* was reduced in T3 while T2 was intermediate, Aerobes increased in T2 while T3 was intermediate, and Bifidobacteria increased in T3 with T2 being intermediate compared to C (*P*<0.05). Supplementation of diets with enzymes β-mannanase and in combination with β-glucanase can improve pig performance and positively impact the intestinal microbial ecosystem of young pigs.

Key Words: swine, β-glucanase, β-mannanase

O122 **The effects of cereal type and xylanase supplementation on growing pig growth performance and nutrient and energy digestibility.** A. J. Myers[*], J. Patience, *Animal Science, Iowa State University, Ames.*

Two studies were conducted to determine the effects of cereal type and xylanase supplementation on growing pig performance and nutrient and energy digestibility. In both experiments, treatments were arranged as a 2 × 2 factorial with the main effects of cereal type (corn v. wheat) and xylanase supplementation (0 v 16,000 U/kg; Econase XT®, AB Vista, Marlborough, UK). In Exp. 1, 440 pigs (initial BW 7.8 ± 2.4 kg) were used in a 28-d growth study. Pigs were randomly allotted to 1 of 4 treatments with 10 replications per treatment and 11 pigs per pen. There were no significant cereal x enzyme interactions or main effects of cereal and enzyme observed for any of the growth criteria evaluated (*P* > 0.84). However, from d 13 to 28, there was a tendency (*P* =0.07) for pigs fed diets supplemented with xylanase to have improved ADG compared to pigs fed unsupplemented diets. Pigs fed the xylanase- supplemented diets showed a tendency (*P*=0.11) for increased feed intake compared to pigs fed diets without xylanase over the 28 d study. In Exp. 2, 72 pigs from the previous study were used in a metabolism study. This study was carried out over two collection periods, with 9 pigs (initial BW 17.9 ± 0.55 kg) per collection period, that were randomly selected from each treatment in Exp. 1 and moved to individual pens for 14 d. Pigs remained on the same cereal type and xylanase treatment as in Exp. 1. Feces were collected, and apparent total tract digestibility (ATTD) of dry matter (DM) and gross energy (GE) were determined. A cereal × xylanase interaction was observed (*P* < 0.0001) for ATTD of DM and GE, which was primarily due to xylanase supplementation improving both ATTD of DM and GE in corn-based diets (85.6 v 87.6 % and 85.4 v 87.4 %, respectively), but decreasing ATTD of DM and GE in wheat-based diets (89.3 v 86.3 % and 89.7 v 86.6 %, respectively). Thus, the efficacy of xylanase supplementation on DM and GE digestibility may be dependent on cereal type and the addition of xylanase to corn-based diets may increase ATTD of DM and GE.

Key Words: corn, wheat, xylanase

O123 **Effects of phytase and xylanase supplementation on energy and nutrient digestibilities in growing pigs fed wheat and wheat co-products-based diets.** A. K. Agyekum[1,*], A. Owusu-Asiedu[2], J. M. Heo[1], M. Nyachoti[1], *[1]Department of Animal Science, University of Manitoba, Winnipeg, Canada, [2]DuPont Industrial Biosciences-Danisco Animal Nutrition, Marlborough, Wiltshire, United Kingdom.*

The effect of combining a newly derived microbial phytase from *Buttiauxella spp*. produced in *Trichoderma reesei* (BP) and xylanase from *T. reesei* (XYL) in a high fiber-based diet low in standardized ileal digestible (SID) AA contents has not been adequately studied. Therefore, an experiment was conducted to determine the effects of BP with or without XYL on apparent ileal (AID) and total tract (ATTD) digestibility of nutrients and energy in growing pigs fed wheat and wheat co-products based diet low in SID AA contents. The experimental diets were: 1) a control, formulated to meet NRC (2012) requirements (except AA, which were 10% lower; CON), 2) CON plus BP (PHY), and 3) CON plus BP and xylanase (PHY+XYL). The target enzyme activities in the enzyme-supplemented diets were 500 FTU/kg and 2,000 U/kg for BP and XYL, respectively, and all the diets contained titanium dioxide as an indigestible marker. Six ileal cannulated barrows (~ 35 kg BW) were fed the 3 diets in a randomized crossover design to obtain 6 replicates per diet. Each experimental period lasted 9 d; d 1 to 5 for adaptation, d 6 and 7 for fecal sampling, and d 8 and 9 for ileal digesta sampling. Compared with CON, addition of PHY+XYL combination increased AID of energy (*P* < 0.10) and Lys (*P* < 0.10) from 40.2 to 48.0% and 73.1 to 80.9%, respectively. Also, adding PHY+XYL increased (*P* = 0.069) ATTD of DM, energy, and CP by 4.0, 5.0, and 4.8%, respectively. The ATTD of crude fiber improved (*P* < 0.05) from 27.1 to 41.4% in PXP+XYL-fed pigs compared with CON. Overall, the results indicate that a combination of a newly derived microbial phytase from *Buttiauxella spp*. produced in *Trichoderma reesei* and xylanase increased nutrient utilization in pigs fed a high fiber-based diet low in SID AA contents.

Key Words: digestibility, pigs, wheat and wheat co-products

O124 **Growth performance and gastrointestinal responses in growing pigs fed either corn and corn DDGS or wheat and wheat co-products based diets without or with supplemental xylanase.** E. G. Kiarie[1,*], L. Romero[1], S. Baidoo[2], *[1]Research, Dupont Industrial Biosciences-Danisco Animal Science, Marlborough, United Kingdom, [2]Animal Science, University of Minnesota, Waseca.*

The high content of anti-nutritive arabinoxylans in cereal co-products can negatively impact nutrients availability, gastrointestinal (GIT) physiology and hence growth performance in swine. Although xylanase can mitigate these negative effects, such xylanase should be able to hydrolyze large array of arabinoxylans that exists in feedstuffs. In the present study we evaluated the efficacy of a xylanase (2000U/kg of feed) on growth performance and GIT measurements in growing pigs fed either corn/corn DDGS or wheat/wheat bran and wheat middlings based diets. All the dietscontained supplemental microbial phytase (500 FTU/kg) and were formulated

to meet nutrient requirements of growing pigs (20-50 kg BW, NRC 1998). Enzymes were provided by Danisco UK Ltd, Marlborough, UK. Thirty-two pigs (initial BW, 33 kg) were assigned to pens (n = 2 pigs/pen) containing one barrow and one gilt and based on a 2 x 2 factorial arrangement allotted to the 4 diets in a completely randomized design to give 4 pens/diet. Experimental diets were fed for 6 weeks. Feed and BW were taken weekly and at the end of the experiment one pig per pen was sacrificed to measure empty GIT sections weight and digesta pH and viscosity. There was no interaction ($P > 0.10$) between the diet type and xylanase on measured parameters. Xylanase fed pigs had higher final BW (71.9 vs. 67.3, SEM = 1.4 kg; $P = 0.05$) and ADG (930 vs. 827, SEM = 29 g/d; $P = 0.04$), tendency for lower FCR (2.37 vs. 2.64, SEM = 0.1; $P = 0.08$) and a lighter cecum (2.2 vs. 3.1,SEM = 0.2 g/kg empty BW; $P < 0.01$) than pigs fed diets without xylanase. Diet type had no effect on growth performance, however, pigs fed corn diets showed heavier ($P < 0.01$) stomach than those fed wheat diets; whilst pigs fed wheat diets showed heavier ($P \leq 0.05$) cecum and colon than corn fed pigs. There was no treatment effect ($P > 0.10$) on digesta pH and viscosity. The present data indicate that independent of diet type, xylanase improved growth performance and feed utilization in growing pigs and potentially reduced GIT expenditure as suggested by lighter cecum.

Key Words: xylanase, pigs, growth performance

O125 **Effect of supplementing of protease, phytase, and carbohydrase enzymes on nutrient digestibility of canola meal in growing pigs.** Z. Nasir [1,*], J. Broz [2], R. T. Zijlstra [1], *[1]Dept. of Agriculture, Food and Nutritional Science, University of Alberta, Edmonton, Canada, [2]DSM Nutritional Products, Basel, Switzerland.*

Solvent-extracted canola meal (CM) is an important feedstuff in Canada; however, its nutrient digestibility is limited by anti-nutritional factors such as phytate, non-starch polysaccharides (NSP). Supplementation of enzymes may increase nutrient digestibility of CM. Effects of supplementation of protease, phytase, and carbohydrase on nutrient digestibility of CM based diets was evaluated in a 6 × 6 Latin square using 6 ileal-cannulated barrows. Six corn starch-based diets that each contained 50% CM were prepared: 1. Control, without enzyme; 2. Protease (Ronozyme ProAct (RPA), 200 mg/kg); 3. High protease (RPA, 2,000 mg/kg); 4. Phytase (Ronozyme HiPhos (RHP), 100 mg/kg (min 1000 U/kg); 5. Protease and phytase (RPA, 200 mg/kg; RHP, 100 mg/kg); and 6. Protease, phytase and carbohydrase (RPA, 200 mg/kg; RHP, 100 mg/kg; Ronozyme VP, 800 mg/kg). Barrows were fed test diets in six 9-d periods. Feces and ileal digesta were collected for 2 d each. Protease supplementation (200 or 2,000 mg/kg) increased ($P < 0.05$) apparent total tract digestibility (ATTD) of CP by 2.7 % units, but did not affect apparent ileal digestibility (AID) of CP; 2,000 mg/kg did not increase ATTD of CP more than 200 mg/kg. Supplementation of phytase to diets 4, 5, and 6 increased ($P < 0.001$) the ATTD of P and Ca. Compared with control, the ATTD of P and Ca was increased by 17 and 25 % units, respectively. Combining protease and phytase did not increase AID of energy, Met, and Thr compared to control, but increased ($P < 0.05$) these AID compared to solely phytase. The combination of protease, phytase, and carbohydrase did not increase AID or ATTD of energy. In conclusion, nutrient digestibility of CM can be increased by supplementation of enzymes. Protease supplementation increased CP digestibility, while phytase supplementation increased Ca and P digestibility.

Key Words: canola meal, phytase, protease

O126 **Protease and carbohydrase supplementation increased carcass weight and yield in finishing pigs eating an alternative diet.** J. Escobar*, Y. Ma, N. Odetallah, M. Vazquez-Añón, *Novus International, St. Charles.*

Including high levels of alternative ingredients and byproducts containing high fiber levels can reduce diet cost but may decrease growth performance despite adequacy of nutrients in the formulation. The objective of this study was to improve growth performance, and carcass weight and yield of finishing pigs eating a wheat and corn-derived DDGS based diet supplemented with a mixture of dietary protease and carbohydrases (Cibenza® DP100 and Cibenza® CSM, respectively, NZ). Fifty-four TR-4×C-22 (PIC®, Hendersonville, TN) barrows were individually housed, and had free access to feed and water at all times. After a 7-d acclimation period, pigs were weighed (81.8±4.4 kg BW) and randomly assigned to 3 treatments: typical corn-soybean meal based diet (CON), alternative diet (wheat and 30% corn-derived DDGS, ALT), or ALT+NZ. All diets were formulated to contain equal nutrient profiles. A complete randomized block design with 18 replicate pens per treatment was used and data were analyzed using the mixed procedure (SAS® Institute, Gary, NC). Inclusion of alternatives ingredients and byproducts reduced diet costs by 8.4% for ALT and 6.7% for ALT+NZ compared to CON. Pigs were fed in 2 phases for 21 and 19 d, respectively, and then transported 4.5 h to a commercial harvesting facility. During the 40-d trial, ALT reduced (P<0.02) ADG, ADFI, hot carcass weight (HCW) and yield, HCW-ADG, and HCW-GF, and tended to reduce (P=0.08) GF compared to CON. Inclusion of NZ increased (P<0.05) HCW (+5.6%) and yield (+1.7%), loin depth (+9.4%), and HCW-ADG (+10.9%) in ALT+NZ compared to ALT. Jowl iodine value (IV) was higher (P<0.005) in ALT+NZ compared to CON, but was not different (P=0.64) between ATL and ALT+NZ. Growth performance and carcass traits (except jowl IV) were not different (P=0.15 to 0.94) between CON and ALT+NZ. Total feed cost per pig was lower (P<0.03) for ALT (-13.5%) and ALT+NZ (−8.7%) compared to CON. Carcass income over feed cost during the 40-d trial was ALT+NZ (114%) > CON (100%) > ALT (60%). Dietary enzyme supplementation may be a viable solution to increase the inclusion levels of alternative ingredients and byproducts while maintaining growth performance, and carcass weight and yield in finishing pigs.

Key Words: enzyme, carcass, alternative ingredients

O127 **Oral hen egg antibodies for the control of hyperphosphatemia during chronic kidney disease.** E. A. Bobeck [1, 2,*], M. E. Cook [2], *[1]Animal Science, Iowa State University, Ames, [2]Animal Science, University of Wisconsin, Madison,*

Patient survival during chronic kidney disease (CKD) depends on control of hyperphosphatemia to prevent vascular calcification. Standard care of CKD patients involves active vitamin D supplementation (control hypocalcemia), low phosphate (P) diets, and P binders (sevelamer hydrochloride, sev) to reduce dietary P absorption. High cost and adverse side effects of P binders cause <30% patient compliance, hence an opportunity to improve the management of dietary P during CKD exists. A novel method for reduction of dietary P uptake was developed through production of hen egg yolk antibodies (Ab) against two mechanisms involving P: 1) digestion (intestinal alkaline phosphatase, IAP), and 2) transport (sodium-dependent phosphate co-transporter 2b, NaPi2b). Seventeen egg yolk Ab against IAP were screened for inhibition of IAP activity in vitro and in vivo. In all in vivo studies, chicks or mice were

housed in cages (n≥3/ cage, ≥3 replicates/diet) and were randomly assigned a diet that contained a minimum 0.1% specific egg yolk Ab fed for ≥14d. Weight, blood P, and bone (ash %) were collected weekly and data were analyzed using ANOVA and student's t-test, where p≤0.05 denoted a significant difference. Antibody to IAP peptide MFPMGTPD inhibited enzyme activity 33% in Caco-2 cells and reduced chick plasma P by 27% v. control Ab (P<0.05). Compared to sev, MFPMGTPD (0.2% of diet) fed for 21d was as effective in preventing active vitamin D-induced increase in chick plasma P (P>0.05) but ineffective in preventing an increase in body weight gain or bone ash % (P<0.05). Eight hen egg antibodies were produced against NaPi2b. Antibodies against TSPSLCWT and YPLTLGSN reduced Caco-2 P transport 73 and 39%, respectively, P<0.05. In chicks fed a diet containing 1% anti-NaPi2b Ab yolk powder (TSPSLCWT or YPLTLGSN), 21d growth was reduced by 21 and 10%, respectively, P<0.05. When fed to mice (1% of diet) for 14d, anti-TSPSLCWT significantly reduced serum P 18% v. control Ab (P<0.05). These data demonstrate the usefulness of oral egg Ab for the reduction of intestinal transport of dietary P and potential usefulness in the management of hyperphosphatemia during CKD.

Key Words: chronic kidney disease, oral hen egg antibody, phosphate

O128 **Effect of glycan infusion on net fluid absorption in piglet jejunal segments challenged with enterotoxigenic Escherichia coli.** A. D. Woodward*, X. Chen, M. G. Ganzle, R. T. Zijlstra, *Agricultural, Food, and Nutritional Science, University of Alberta, Edmonton, Canada.*

Enterotoxigenic *Escherichia coli* (ETEC) adhere to the intestinal mucosa in the small intestine and produce toxins that cause fluid loss and diarrhea. Production of the exopolysaccharides reuteran and levan by *Lactobacillus reuteri* may be a cost effective tool to reduce the occurrence of ETEC-associated diarrhea in swine; however, benefits of glycans used to prevent pathogen adhesion have not been demonstrated in vivo. We hypothesized that customized functional glycans obtained from lactic acid bacteria production reduces the incidence of ETEC derived fluid loss in piglets. Weanling gilts (5 – 6 wks old; 10.2 ± 1.8 kg BW; n = 4) were surgically prepared with 10 jejunal segments using the small intestinal segment perfusion method. Five segments were infected with ETEC K88 (5×10^9 CFU/mL); remaining segments were treated with saline. Five pairs of segments, one ETEC and one non-ETEC infected each, were infused with 70 mL of 10 g/L dextran, inulin, reuteran, levan or saline as control over an 8-hr period. After infusion, segments were removed and net fluid absorption per surface area was determined. Student's t-test was used to determine differences between treatments in ETEC and non-ETEC infected segments. ETEC-infection decreased (198.2 vs. 52.1 ± 31.6 mL cm^{-2}; P < 0.01) net fluid absorption in control (saline) segments, proving the model effective. Compared to non-ETEC infected segments, ETEC increased net fluid loss in the presence of dextran (246.5 vs. 156.2 ± 25.7; P < 0.01) or inulin (252.9 vs. 168.4 ± 25.7; P < 0.01). Net fluid loss tended to increase with reuteran (221.4 vs. 156.8 ± 25.7; P = 0.06), but was not different with levan (203.8 vs. 170.1 ± 25.7; P > 0.1). In conclusion, ETEC infection decreased net fluid absorption. Levan and reuteran specifically eliminated the increased net fluid loss caused by ETEC infection. Additional research will indicate whether these compounds also prevent ETEC-associated diarrhea in piglets.

Key Words: enterotoxigenic Escherichia coli, fluid loss, pigs

O129 **Effects of grow-finish diets supplemented with CALSPORIN® (*Bacillus subtilis* C-3102 spores) or Stafac® on pig performance.** T. A. Meyer [1], S. Crowder [1,*], T. Weeden [1], N. Otomo [2], T. Lohrmann [3], *[1]Purina Animal Nutrition LLC, Shoreview, MN, [2]Calpis USA, Inc., Mt. Prospect, IL, [3]Quality Technology International (QTI), Inc., Elgin, IL.*

A 119-d grow-finish experiment was conducted at a commercial wean-to-finish facility in Iowa from February to June to evaluate the effects of supplementing diets with CALSPORIN® (Calpis Co. Ltd, Tokyo, Japan; *Bacillus subtilis* C-3102 spores at 3 x 10^5 cfu/g feed) or Stafac® (Pfizer Animal Health, virginiamycin 11 ppm) on pig performance. Pigs were fed the standard 6-phase corn-SBM-DDGS feed program as the control (CON) or the CON diets supplemented with either CALSPORIN® or Stafac®. Pen was the experimental unit with 11 replicates/treatment. A total of 632 pigs (initial BW 24.7 ± 0.18 kg) were sorted and randomly allocated in a CRD to minimize gender and weight differences among treatments. Data were analyzed with Statistix® 8.0 using One-Way ANOVA and mean separation by LSD (P≤0.05). Percent mortalities were 3.76, 3.85 and 6.16 for the CON, CALSPORIN® and Stafac® treatments, respectively. Final BW (118.8, 121.4 and 120.3 kg), overall gains (94.2, 96.7 and 95.9 kg), ADG (0.999, 1.020 and 1.011 kg/d) and ADFI (2.198, 2.206 and 2.244 kg/d) did not differ (P>0.10) by CON, CALSPORIN® or Stafac® treatments, respectively. The overall G:F was less (P =0.006) for the CON (0.454) and Stafac® (0.451) treatments versus the CALSPORIN® (0.463) treatment. From 0 to 14 d, ADG was greater (P=0.01) for Stafac® (0.729 kg/d) versus CON (0.654 kg/d) but were similar for CALSPORIN® (0.687 kg/d). From 0 to 35 d, ADG was greater (P=0.03) for Stafac® (0.809 kg/d) versus CON (0.760 kg/d) but were similar for CALSPORIN® (0.779 kg/d). From 0 to 77 d G:F was greater (P=0.05) for the CALSPORIN® (0.433) treatment versus the CON (0.426) and Stafac® (0.426) treatments. Stafac® diets improved ADG from d 0 to 35, and CALSPORIN® diets improved overall G:F compared to CON and Stafac® diets.

Key Words: *Bacillus subtilis* C-3102, Calsporin, pigs, virginiamycin

O130 **The effects of feeding narasin or virginiamycin on the performance of grow-finish pigs.** R. A. Arentson [1,*], D. Mowrey [1], E. McMillan[2], *[1]Elanco, Greenfield, [2]Nutreco, Burford, Canada.*

The purpose of this study was to determine the effects of narasin (NAR; Skycis®, Elanco Animal Health, Greenfield, IN) or virginiamycin (VIR; Stafac®, Phibro Animal Health, Teaneck, NJ) on the growth and harvest performance of grower-finisher pigs. On day -7, sixty pens of gilts and sixty pens of barrows each containing 6 pigs and weighing 25.0 kg were blocked by weight within gender and then treatment. Control (CON), NAR 15 ppm, or VIR 11 ppm) were randomly assigned to pens within gender of each block. Diet treatments consisted of a sequence of 4 corn-soybean meal basal diets that were divided into thirds and then the appropriate amount of antimicrobial premix was added to each, and then each diet was pelleted. Pigs were weighed on d 0, 28, 56, 77, 91, and harvest to determine start weight, phase weights, harvest weight, and ADG. Feed issuance and weigh backs were recorded in order to determine ADFI and G:F. When pigs reached a bodyweight of 132 kg, they were transported to a Canadian food company for harvest. Hot carcass weight (HCW), fat depth, and loin depth were measured for each carcass. No gender x treatment interactions were detected (P>0.1) for any of the parameters measured. No NAR or VIR ADG effects were detected (P>0.1) in any time period. Pigs fed diets containing NAR had a higher G:F than those fed CON diets during d 0 to 77

(*P*=0.016), d 0 to 91(*P*=0.002), and d 56 to 91(*P*=0.006). Pigs fed diets containing NAR had a higher G:F than those fed diets containing VIR during d 0 to 77 (*P*=0.037) and d 0 to 91(*P*=0.042). Pigs fed NAR had a higher (*P*=0.027) ADFI than those fed diets containing VIR during periods d 0 to 28 and lower (*P*=0.035) ADFI than pigs fed VIR during d 56 to 77. Pigs fed diets containing VIR had less fat depth (*P*=0.034) than those fed CON. HCW and backfat depth were not different (*P*>0.1) across diet treatments. Overall, pigs fed diets containing NAR had a higher G:F than those fed VIR or CON diets.

Item	CON	VIR	NAR	SE	VIR vs CON, P<	NAR vs CON, P<	NAR vs VIR, P<
ADG, 0 to 91	0.980	0.976	0.985	0.088	0.650	0.554	0.297
G:F, 0 to 91	0.391	0.393	0.399	0.004	0.302	0.002	0.042
ADFI, 0 to 91	2.505	2.476	2.464	0.025	0.250	0.103	0.628

Key Words: narasin, pig, virginiamycin

O026 **Increasing dietary levels of extruded and expeller-pressed canola juncea meal on pig growth performance and carcass traits.** X. Zhou [1,*], M. Young [2], V. Zamora [2], R. T. Zijlstra[1], E. Beltranena [3], *[1]Department of Agricultural, Food & Nutritional Science, University of Alberta, Edmonton, [2]Gowans Feed Consulting Ltd, Wainwright, [3]Alberta Agriculture and Rural Development, Edmonton, Canada.*

The dietary energy value of conventional dark-seeded canola meal (*Brassica napus*) is considered low because of its relatively high fiber and low oil content. *B. juncea* is a novel yellow-seeded canola species with thinner seed coat and therefore lower fiber content. If seeds are expeller-pressed rather than solvent-extracted, residual oil remains in the meal (12 – 17%) and higher dietary energy value can be expected. Extrusion prior to expeller-pressing could reduce effects of glucosinolates by inactivating the seed enzyme myrosinase and increase both fat and AA digestibility. To evaluate effects of feeding increasing (0, 5, 10, 15, 20%) inclusions of extruded + pressed (EP) *B. juncea* meal on pig growth performance and carcass traits, 1,056 pigs (27 kg) housed in 48 pens by sex were fed 5 dietary regimens with 0, 5, 10, 15, 20% *B. juncea* meal over 5 growth phases. Diets were formulated to equal g SID Lys:Mcal NE by phase (4.10, d 0-21; 3.70, d 22-42; 3.30, d 43-63; 3.00, d 64-74; 2.75, d 77- 120 kg market weight). For the entire trial, each 5% increase in dietary EP *B. juncea* meal inclusion linearly reduced (*P*<0.01) ADFI by 54 g and ADG by 14g, but did not affect (*P*>0.10) G:F. Each 5% increase in dietary EP *B. juncea* meal inclusion linearly reduced (*P*<0.01) carcass weight by 52 g and loin depth by 0.65 mm, but did not affect (*P*>0.10) backfat thickness, pork yield, or index. Pigs fed 20% EP *B. juncea* meal reached slaughter weight 2.5 d later and were 4 kg lighter (*P*<0.01) than controls not fed canola meal. In conclusion, increasing dietary inclusions of EP *B. juncea* meal up to 20% linearly reduced growth performance and carcass traits. The reduction in performance could be attributed to high 3-butenyl (10 µmol/g) content in EP *B. juncea* meal, a bitter glucosinolate than others found in dark-seeded *B. napus* canola meal.

Key Words: *B. juncea* canola meal, carcass, extrusion and expeller-pressing, performance, pig

NONRUMINANT NUTRITION: SOW NUTRITION AND MANAGEMENT

O131 **Variability in daily urinary nitrogen excretion in gestating gilts at 2 levels of energy intake**. E. G. Miller[*], D. Wey, C. de Lange, C. Levesque, *Animal and Poultry Science, University of Guelph, Canada.*

In nitrogen (N) balance studies, urine samples are pooled across days to estimate mean daily urinary nitrogen excretion (UN), without considering daily variation in UN. In a gestating gilt N balance study, daily UN was quantified to determine the coefficient of variation (CV) within and across N-balance periods. Nine gilts were placed on high or low daily energy intake (8.9 and 6.4 Mcal DE/d) from the same diet (containing 3.5Mcal DE/kg and 2.8g N/kg of feed) during gestation. In each gilt, total daily urine was collected using urinary catheters during 4.5 d periods starting at 35, 49, 63, 85, and 106 d of gestation, whereby the last 0.5 collection day (minimum duration 5.5h) was adjusted to a 24h period based on duration of collection. Due to technical difficulties, 10% of daily UN collections were incomplete and UN was again adjusted to a 24 h period (UN_{adj}). Within pig and across stage of gestation, the CV for UN_{adj} ranged from 2 to 49% and when daily collections of <20h were removed the CV was not improved (1 to 57%). The UN_{adj} CV ranged from 3 to 29% and 2 to 42% for the high and low energy intakes, respectively. When based on at least 3 daily UN_{adj} values within pig and stage of gestation, a CV of < 15% could be obtained in 88% of the collection periods. There was an effect of diet (P<0.001) and stage of gestation (*P*<0.04), but no diet x stage of gestation interaction. The UN_{adj} was greater (*P*<0.001) for high than low dietary energy intake (31 and 23g/d, respectively) but UN_{adj} as a percent of N intake was lower (*P*<0.01) for high than low dietary energy intake (41 and 46%, respectively). The UN_{adj} was 26, 27, 29, 28, and 23 g/d (SEM=2.0) at 35, 49, 63, 85, and 106 d, respectively. The UN_{adj} was lowest (*P*<0.05) at 106 d of gestation. The data indicates that urine collections between 5.5 and 24h may be used to calculate daily UN, but should be adjusted to 24h. Despite the large variation within pig and N-balance periods, differences between dietary treatments and collection periods were identified. Daily variation in UN excretion within collection periods should be considered when conducting N-balance studies in gestating gilts.

Key Words: gestating gilts , urinary nitrogen, variation

O132 **The effects of added vitamin D3 in maternal diets on sow and pig performance.** J. Flohr[1,*], M. D. Tokach[1], J. L. Nelssen[1], S. S. Dritz[1], J. M. DeRouchey[1], R. D. Goodband[1], J. R. Bergstrom[2], *[1]Kansas State University, Manhattan, [2]DSM Nutritional Products Inc., Parsippany.*

A total of 84 sows (PIC 1050) were used to determine the effects of feeding increasing dietary vitamin D_3 on maternal performance, sow and piglet serum 25(OH)D_3 and Ca, suckling pig performance, and neonatal bone mineralization. Sows (n=28/treatment) were allotted at breeding to 1 of 3 dietary treatments (1,500, 3,000, or 6,000 IU/kg vitamin D_3; 0.88% Ca and 0.50% available P in gestation, and 0.88% Ca and 0.48% available P in lactation) in a RCBD with parity as a blocking factor. Serum 25(OH)D_3 was collected from sows on d 0 and 100 of gestation, at farrowing, and at weaning (d 21). Pigs were weighed at birth and weaning to determine weight gain, and a subsample of the population were bled at birth, on d 10, and at weaning to determine serum 25(OH)D_3 and Ca. Fifty-

O132 Table

Maternal Vit. D_3, IU/kg	Sow 25(OH)D_3, ng/mL		Sow Ca, mg/dL		Pig 25(OH)D_3,ng/mL		Pig Ca, mg/dL		Pig BW, kg		bone	ash, %
	F[1]	W	F	W	F	W	F	W	F	W	rib	femur
1,500	30.1	39.3	8.9	9.3	4.5	5.6	10.3	10.1	1.31	5.32	43.6	44.9
3,000	35.4	52.5	9.3	9.5	5.9	8.0	10.7	10.0	1.36	5.56	43.6	44.5
6,000	56.9	66.3	9.3	9.4	9.4	14.0	10.3	9.8	1.35	5.54	43.5	44.8
SEM	4.65	4.65	0.34	0.34	0.75	0.81	0.62	0.66	0.042	0.165	0.80	0.55

[1]F=farrowing, W=weaning

four pigs were euthanized at birth (18/treatment) to collect femurs and ribs for bone ash determination. Overall, increasing maternal vitamin D_3 increased (linear, $P < 0.01$) sow serum 25(OH)D_3 on d 100 of gestation, farrowing, and weaning. Additionally, suckling pig serum 25(OH)D_3 was increased (quadratic, $P < 0.03$) at birth, d 10, and weaning with increased maternal vitamin D_3. However, no differences were observed in maternal performance criteria ($P > 0.32$), pig birth or weaning weights ($P > 0.43$). Bone ash content of femurs and ribs were not different ($P > 0.66$) and serum Ca for sows or pigs was not influenced ($P > 0.14$) by maternal vitamin D_3 treatment. In conclusion, increasing dietary vitamin D_3 in sows increased serum 25(OH)D_3, and suckling pig serum 25(OH)D_3, but increasing vitamin D_3 in maternal diets did not influence serum Ca, performance parameters for sows, or growth and bone mineralization of their offspring. (See table above.)

Key Words: 25(OH)D_3, sow performance, vitamin D

O133 **Development of a prediction equation to estimate post-partum sow body weight from pre-partum weight.** D. Rosero [1,*], C. Arellano [2], E. van Heugten [1], M. E. Johnston [3], R. D. Boyd [4], *[1]Department of Animal Sciences, [2]Department of Statistics, North Carolina State University, Raleigh, [3]JBS United , Sheridan, IN, [4]Hanor Company, Inc., Franklin, KY.*

The objective of this study was to derive a prediction equation to estimate the sow BW after farrowing from pre-farrow BW and total litter size at birth. Data were collected from 748 first through sixth litter PIC sows from a commercial research farm. Sows were weighed individually at placement (112 to 114 d of gestation) and again after farrowing. Pre-farrow BW was adjusted to estimate immediate pre-farrow weight assuming 0.7 kg daily gain from placement to day of farrowing based on a daily ME intake of 8 Mcal (Close et al., 1984). Post-partum sow weight was determined within 20 h of farrow. Information collected included total alive and stillborn pigs, but not placenta weight. A total of 10 sows were removed from the analysis because BW change (post-farrow minus pre-farrow BW) was greater than 3 standard deviations. Body weight of the remaining 738 sows ranged from 147.3 to 361.3 kg and averaged 247.8±37.8 kg. Total pigs born (alive plus stillborn) averaged 10.9±2.3 pigs and ranged from 2 to 18 pigs born. Post-farrow sow BW prediction equation is described by: BW (kg) = -19.75 + 0.973 x pre-farrow BW – 1.09 x pigs born (R^2=0.962, P<0.001; relative error of predicted values ranged from -7.55 to 7.22%). Post-farrow BW was alternatively estimated using equations suggested by Noblet et al., 1985 for comparison. Estimated weight of fetus (logeW = 8.729 - 4.077 x exp (-0.033 x (t - 45))+ 0.0002 f t + 0.068 n), placenta (logeW = 7.027 – 0.952 exp (-0.069 (t – 45)) + 0.0001 f t + 0.093 n) and fluids (loge W = -0.264 + 0.188 t – 0.001 t2 + 0.132 n; where W is weight (g), t is the stage of gestation (d), n is total pigs born and f is the level of energy intake (MJ ME/d)) were subtracted from pre-farrow BW to estimate weight after farrowing. The Pearson correlation coefficient between the measured post-farrow weights and estimated weights using Noblet equations was 0.978, P<0.0001; which indicates a strong linear relationship between these two variables. In conclusion, use of the proposed equation or Noblet equations resulted in similar and accurate estimated weights for sows post-farrow when compared to actual weight**.**

Key Words: body weight, farrowing, prediction equations

O134 **Effects of commercial diets with or without CALSPORIN® (*Bacillus subtilis* C-3102 spores) on fresh fecal microbial profiles of sows from breeding through lactation.** B. K. Knudson[1,*], N. Otomo [2], T. Hamaoka [2], B. Lee [2], S. C. Johnson [3], *[1]Nutrition Services – Livestock Management Company (LiManCo), Waverly, IA, [2]Calpis USA, Inc., Mt. Prospect, IL, [3]Quality Technology International (QTI), Inc., Elgin, IL.*

Three groups each having 10 sows, initially at different stages of reproduction (breeding, early gestation, or advanced gestation), were used in an 18-week feeding trial at a commercial facility in Iowa from May-September to evaluate the effects of CALSPORIN® (0 or 3x10^5 cfu/g feed) on fresh fecal microbial profiles. The initial 30 sows were reduced to 19 from movement within the facility, recycling, and death loss. This sow herd had previously been on a regimen of high (~240 g/ton, top dressed) BMD® in feed for 2 weeks prior to farrowing for control of clostridial enteritis caused by *C. perfringens* in suckling piglets (history of clostridial scours on the premises). Fresh fecal sampling was done on 6 dates, at initiation of the trial and prior to feeding CALSPORIN® (breeding stage or during gestation) or during CALSPORIN® feeding (pre-farrowing, farrowing, and lactation), in the 3 groups of sows. Samples were submitted to Calpis USA, Inc. Laboratory in Mt. Prospect, IL for immediate microbial profiling on culture media. By combining data for like stages of production (breeding or gestation pre-trial with 10 sows/group; or pre-farrowing, farrowing, or lactation during CALSPORIN® feeding with 7, 6, and 6 sows/group) from the 3 groups of sows, selected species of fecal bacteria were evaluated (1-Way ANOVA, 4 treatments, Statistix® 9).

Table 1. Sow fresh fecal bacteria counts, log10 cfu/g (in positive cultures), by stage

	Pre-trial feeding	During CALSPORIN®	P value
Enterobacteriaceae	7.47 (19/19)	7.15-7.62 (19/19)	0.170
Salmonella	4.91 (12/19)	4.82-5.32 (12-14/19)	0.349
Lactobacilli	7.55 (15/19)	7.58-7.82 (15-18/19)	0.643
Bifidobacteria	5.59 (8/19)	5.59-6.14 (11-14/19)	0.339
Total anaerobic count	8.55 (19/19)	8.38-8.61 (19/19)	0.376
Lactobacilli/Anaerobes	16.0 (15/19)	20.0-28.9 (15-18/19)	0.336
Total aerobic count	4.46 (19/19)	5.38-5.86 (19/19)	<0.001
Clostridium perfringens	5.79 (18/19)	4.47-5.36 (7-18/19)	<0.001
Bacillus subtilis C-3102	2.83 (17/19)	5.36-5.84 (19/19)	<0.001

Clostridium perfringens decreased 77.1% in farrowing and 95.2% in lactation vs. pre-trial count. Dietary CALSPORIN® increased total aerobic counts and decreased *Clostridium perfringens* vs. pre-trial counts in fresh fecal samples from these sows.

Key Words: *Bacillus subtilis* C-3102, CALSPORIN®, *Clostridium perfringens*, fecal bacteria, sow

O135 **Sow and nursery pig performance are improved when diets are supplemented with a *Saccharomyces cerevisiae* fermentation product.** J. W. Frank*, K. L. Dorton, *Diamond V, Cedar Rapids.*

A total of 259 sows and 2724 piglets were utilized in a 2 x 2 factorial study to evaluate the effects of feeding *Saccharomyces cerevisiae* fermentation product (XPC; Diamond V XPC™$_{LS}$, Diamond V, Cedar Rapids, IA) to sows and weaned pigs on sow and nursery performance. Sows were allotted to either no XPC (CON-S; n = 129) or XPC (XPC-S; n = 130) from d 28 of gestation (5 g/d XPC) through lactation (15 g/d XPC). At weaning (29 d of age), pigs from these sows were allotted to either no XPC (CON-P; n = 26) or XPC at 2 g/kg (XPC-P; n = 26) in the diet. Nursery pigs were housed in groups of approximately 26 pigs/pen with 2 pens sharing a common feeder. Number of pigs born alive was 11.09 and 10.90 for XPC-S and CON-S sows, respectively ($P = 0.21$). At 21 d of lactation, XPC-S had 10.83 pigs/litter and CON-S had 10.57 pigs/litter ($P = 0.12$). Litter weights at 21 d of lactation were 68.96 kg and 65.90 kg for XPC-S and CON-S, respectively ($P = 0.17$). Number of pigs weaned on d 29 ($P = 0.17$) and litter weaning weights ($P = 0.11$) for XPC-S vs. CON-S were 10.82 pigs and 91.33 kg vs. 10.62 pigs and 87.72 kg; respectively. There were no main effect differences of nursery treatment on pig performance. Final BW (d 36) in the nursery was significantly greater in pigs from XPC-S compared to CON-S (24.92 vs. 23.60 kg; $P = 0.04$) indicating that the weaning weight advantage increased throughout the nursery period. Interestingly, there was an additive effect of feeding XPC to the sow and pig on overall ADG and d 36 BW in the nursery ($P < 0.05$; Table 1). Results from this study indicate that feeding XPC to both the sow and weaned pig has an additive effect on improving growth rate and BW in the nursery.

Table 1. Nursery pig performance

	Control Sow		XPC Sow		
	Control Pig	XPC Pig	Control Pig	XPC Pig	SE
number of pens	13	13	13	13	
d 0 BW, kg	8.20	8.29	8.52	8.65	0.14
d 36 BW, kg	23.48^{a}	23.71^{ab}	24.40^{ab}	25.45^{b}	0.33
ADG, g	426^{a}	431^{ab}	443^{ab}	469^{b}	7
ADFI, g	660	631	655	687	10
F:G	1.55	1.47	1.49	1.47	0.02

^{ab}Means in the same row with different superscripts differ $P < 0.05$.

Key Words: nursery pig, *Saccharomyces cerevisiae* fermentation product, sow

PHYSIOLOGY

O136 **Bovine females with thecal cell androgen excess result in altered oocyte maternal effect gene abundance.** A. F. Summers[1,*], W. E. Pohlmeier[1], V. M. Brauer[1], K. M. Sargent[1], R. M. McFee[1], R. A. Cushman[2], J. R. Wood[1], A. S. Cupp[1], *[1]Animal Science, University of Nebraska, Lincoln, [2]USDA-ARS U.S. Meat Animal Research Center, Clay Center.*

In Nebraska, 1.9 million cows are calved/yr; however, 550,000 more (30%) are bred but fail to calve. If markers to identify females with reduced fertility identified even 5% of sub-fertile females this would reduce costs associated with their development and breeding. Within the UNL physiology herd, we have identified two sub-populations of cows, one that inefficiently converts androgens (A4) to estrogen (E2; low granulosa efficient, LGE) and a population that efficiently converts E2 to A4 (HGE; which serves as our high fertility group). These classifications are 87% repeatable over multiple estrous cycles/yr suggesting intrinsic differences in steroidogenic capability. Therefore, our hypothesis was that androgen excess is a result of altered theca cell gene expression and impacts abundance of mRNAs affecting oocyte competence. The objective of this study was to identify differences in mRNA abundance of theca steroidogenic enzymes and oocyte maternal effect genes in tissues collected from these two cow sub-populations. Beef cows (4.7 ± 0.3 yr) were synchronized (modified Co-Synch + CIDR protocol) and ovariectomies performed 36 h after PGF2α injection and CIDR removal. Follicular fluid, theca cells, granulosa cells and cumulus-oocyte complexes (**COC**) from dominant follicles were collected. Androstenedione production was 19-fold greater ($P = 0.0004$) for LGE (n = 53) compared to HGE (n = 28) cows. In LGE cows, expression of *CYP11A1* was 3.3-fold greater ($P = 0.02$) and *CYP17A1* 15.5-fold greater ($P = 0.03$). Abundance of *ZAR1* was decreased ($P = 0.05$) while conversely, *NLPR5* had a tendency ($P = 0.12$) to be increased 13.5-fold in COCs from LGE cows. Interestingly, LGE cows display characteristics similar to androgen excess disorders in women. Taken together, increased androgen production in LGE cows alters gene expression and/or mRNA stability during oocyte growth and maturation which may reduce fertility success. USDA is an equal opportunity provider and employer.

Key Words: androgen excess, steroidogenesis, theca

O137 **Inflammation in the transition dairy cow: Hormesis to homeorhesis.** J. Farney*, B. Bradford, *Animal Science, Kansas State University, Manhattan.*

The transition into lactation is a period of primary concern to dairy producers because of the tremendous incidence of health disorders observed at time. Two common disorders that lead to decreases in production and retention within the herd are fatty liver and ketosis. These disorders have been commonly associated with negative energy balance, yet recently it has been hypothesized that inflammation is an etiologic contributor. Two experiments were completed to determine the effects of inflammation on transition dairy cows. In an inflammation induction model, cows receiving the pro-inflammatory cytokine TNFα for 7 d after parturition had reductions in dry matter intake, water intake, milk production, and milk component yields. In contrast, the role of endogenous inflammation was determined by administration of the anti-inflammatory drug, sodium salicylate (SS), to cows for 7 d after parturition. Rather than improve markers of metabolic health, SS induced hypoglycemia and increased

triglyceride accumulation in the liver (while administered) and increased lipid mobilization and ketone concentrations (2 weeks after administration ended), but also increased whole lactation milk production in older cows. However, in primiparous cows whole lactation milk production was marginally decreased and the relative risk of being removed from the herd tended to increase following SS treatment. Overall, it appears that inflammatory pathways are involved in the normal biological adaptations of the transition dairy cow and disruption can lead to interesting negative effects on metabolism and differences in production measures. However, when inflammation is elevated beyond these low levels during the transition period, it can lead to negative production effects. These findings call to mind the concept of hormesis, referring to beneficial responses to a very low dose of an agent which is toxic at higher levels. Furthermore, the alterations in metabolism following SS treatment suggest that inflammatory pathways may play a role in homeorhesis. Better understanding these concepts in relation to inflammation in the transition cow may provide opportunities to improve health and productivity of dairy cows.

Key Words: inflammation, sodium salicylate, transition dairy cow

O138 **The effects of porcine reproductive syndrome virus (PRRSV) on immune biomarkers.** G. Mastromano [1], T. Burkey [1,*], A. Rakhshandeh [2], G. Gourley [3], T. Weber [2], M. Fitzsimmons [3], K. Schwartz [2], J. Dekkers [2], C. Sparks [4], J. Odle [5], N. Gabler [2], *[1]University of Nebraska, Lincoln, [2]Iowa State University, Ames, [3]Swine Graphics Enterprises, Webster City, IA, [4]Newsham Choice Genetics, Des Moines, IA, [5]North Carolina State University, Raleigh.*

Pigs infected with PRRSv can lead to reduced weight gain, poor feed efficiency, reproductive problems, and secondary infections. The objective of this study was to determine whether immune biomarkers are related to growth performance of pigs challenged with a live field strain of PRRSv. Blood samples were obtained from intramuscularly-PRRSv-challenged gilts (n = 74; BW 16 ±4.4 kg) at 0, 7, 14, 28, and 56 d post-inoculation in a commercial setting. A hierarchical cluster analysis using Ward's method on standardized adjusted BW (adjusted for the effects of age and BW at infection and pen) was used to identify 4 subgroups of pigs with varying growth patterns following infection. Immune biomarker analyses were conducted on blood samples (n = 6 pigs/group) according to d 56 ADG as follows: Group 1 (0.67 kg/d), Group 2 (0.73 kg/d), Group 3 (0.78 kg/d), and Group 4 (0.82 kg/d). Tumor necrosis factor-α (TNF-α), haptoglobin (Hp), and C-reactive protein (CRP) were quantified via porcine specific ELISA. Data were analyzed using the PROC MIXED procedures of SAS. No time (d) x group interaction was observed for TNF-α or CRP. However, main effects of time and Group were observed for both TNF-α and CRP. Irrespective of Group, TNF-α was greater ($P < 0.01$) on d 14, 28, and 56, and CRP concentrations were greater on d 14 and 28 compared to all other time points. Group 1 pigs tended ($P < 0.06$) to have greater CRP compared to both Group 3 and 4 pigs across all time points. Significant effects of time, group, and their interaction were observed for Hp ($P < 0.05$). On d 28, Group 1 pigs had greater Hp concentrations compared to both Groups 3 and 4 ($P < 0.01$), Groups 2 pigs had greater Hp concentrations compared to Group 3 ($P < 0.01$), and Group 4 pigs had greater Hp concentrations compared to Group 3 ($P < 0.02$). On d 56, Group 1 ($P < 0.02$) and 2 ($P < 0.04$) pigs had greater Hp concentrations compared to Group 4. Results indicate that acute phase proteins (CRP and Hp) may be increased in low ADG, PRRSV-challenged pigs. Supported by the Iowa Pork Producers Association 12-113.

Key Words: biomarker, pigs, PRRSv

O139 **Measures of immune function as biomarkers in serum of pigs infected with porcine reproductive and respiratory syndrome virus.** A. Rakhshandeh [1,*], T. E. Burkey [2], T. E. Weber [1], M. Fitzsimmons [3], K. Schwartz [1], J. C. Dekkers [1], C. Sparks [4], J. Odle [5], N. K. Gabler [1], G. Gourley [3], *[1]Iowa State University, Ames, [2]University of Nebraska, Lincoln, [3]Swine Graphics Enterprises, Webster City, [4]Newsham Choice Genetics, Des Moines, [5]North Carolina State University, Raleigh.*

The cost of porcine reproductive and respiratory syndrome virus (PRRSV) represents a loss of $640 million per year for the US swine industry. In order to characterize the impact of PRRSV on pig metabolism and growth, it is important to find biomarkers that relate health status to growth performance. The current study was conducted to determine whether immunological parameters measured in serum are quantitatively related to growth performance of pigs challenged with PRRSV. ADG, serum viral load, antibody titer, and complete blood cell count (CBC) of 74-intramuscularly-PRRSV-challenged gilts (BW 16 ±4.4 kg) were determined at 0, 7, 14, 28 and 56 days post-inoculation (dpi) in a commercial production setting. Serological and qPCR data indicated that all pigs became PRRSV-positive within 7-14 dpi. Serum viral load was highest at 7 dpi and then declined within 14-28 dpi. Relative to day 0, PRRSV challenge altered measures of CBC (lymphocytes - 13, platelets + 6, MPV + 10 and hemoglobin - 6%; $P < 0.01$). A decrease in ADG was observed at 7 and 14, and to a lesser degree at 28 dpi ($P < 0.01$). No significant relationship between ADG, serum antibody titer and viral load, and measures of CBC were observed ($P > 0.10$), except for white blood cell and platelet count, which were negatively correlated with ADG at 12 dpi (r = 0.29 and 0.30, respectively; $P < 0.02$). Collectively, these results suggest that a challenge with PRRSV alters measures of immune function and may be used to study the impact of disease on pig metabolism. However, serum viral load and antibody titer, and measures of CBC as biomarkers that relate health status to ADG deserve further investigation. Supported by National Pork Board grant no. 12-113.

Key Words: biomarker, pig, PRRSV

O140 **Effects of zinc amino acid complex on gut integrity and metabolism in acutely heat-stressed pigs.** S. C. Pearce [1,*], M. V. Sanz-Fernandez [1], J. Torrison [2], M. E. Wilson [2], N. K. Gabler [1], L. H. Baumgard [1], *[1]Animal Science, Iowa State University, Ames, [2]Zinpro Corporation, Eden Prairie.*

Heat stress (HS) negatively affects intestinal integrity and livestock function. Therefore, our objective was to determine whether Zinc-amino acid complex (ZnAA) supplementation would mitigate acute HS-induced changes in intestinal integrity. Crossbred gilts (n=32; 64±3 kg BW) were individually penned and fed ad libitum 1 of 2 diets for 17d: 1) 120 ppm of Zn from $ZnSO_4$ (CON); or 2) 60 ppm from $ZnSO_4$ + 60 ppm from ZnAA (ZnAA). After 17d, CON pigs were exposed to either TN conditions (21°C; 70% humidity) with ad libitum intake (TN-CON, n=8), HS conditions (37°C; 40% humidity) with ad libitum intake (HS-CON, n=8,), or pair-fed in thermal-neutral conditions (PFTN; n=8); while ZnAA pigs were only exposed to HS conditions (HS-ZnAA, n=8). Pigs were sacrificed after 12h of environmental exposure and blood markers of stress, and ileum and colon permeability were assessed by Ussing chamber transepithelial resistance (TER) and FITC-dextran permeability (PaPP). As expected, HS-CON and HS-ZnAA pigs had markedly increased ($P<0.01$) rectal temperature (Tr). Interestingly, HS-ZnAA pigs had lower Tr compared to HS-CON pigs starting at 4 h (0.32°C

average; $P<0.05$). HS increased (>3 fold, $P<0.05$) respiration rates compared to both TN-CON and PFTN pigs. Overall, 12h feed intake and body weight was reduced due to HS compared to TN pigs ($P<0.05$). Interestingly, both HS and PFTN pigs experienced >3 fold increase in ileal PaPP compared to TN pigs ($P<0.01$). However, HS-ZnAA ileum PaPP did not differ from either TN or HS pigs. HS and PFTN ileal TER decreased by 31% compared to TN pigs ($P<0.01$). However, compared to HS-CON, HS-ZnAA pigs had an increased TER (30.2%; $P=0.05$). Under this short duration of HS, colon permeability and TER was not altered. Blood glucose did not differ between treatments, however blood urea nitrogen (BUN) was increased in HS-CON and HS-ZnAA pigs by 3.3 and 2.3 fold compared to TN-CON and PFTN controls ($P<0.01$). HS-ZnAA pigs had reduced (13.3 vs. 9.4 mg/dL; $P=0.04$) BUN compared to HS pigs. These data indicate supplementing ZnAA improves key aspects of small intestinal integrity, body temperature, and blood markers of muscle catabolism during acute heat stress.

Key Words: heat stress, pig, zinc

O141 **The effect of post-thaw motility of frozen-thawed boar sperm on pregnancy rate and litter size in mature gilts.** K. Mcnamara*, R. V. Knox, *Animal Sciences, University of Illinois, Urbana.*

Frozen-thawed sperm (FTS) allows dissemination of superior genetics to females across great distances for precision AI. However, FTS has been shown to have decreased fertility compared to cooled semen.This experiment tested the effect of 5-min post-thaw motility (poor (P), 20.2 ± 3.4%; moderate (M), 31.3 ± 4.2%; or good (G), 43.5 ± 3.2%) on pregnancy rate and litter size. Ejaculates from 43 boars were frozen individually in 0.5 mL straws at 1.4×10^9 total sperm/mL. Mature synchronized gilts were checked for estrus at 12 h intervals and randomly assigned at onset of estrus (n = 207) to first and second AI with semen from unique boars: 1) first AI with P and second AI with M (P-M); 2) first AI with M and second AI with P (M-P); 3) first AI with G and second AI with M (G-M); and 4) first AI with M and second AI with G (M-G). Insemination occurred at 24 and 36 h after onset of estrus, and each sire was represented across both inseminations. Number of motile sperm in each dose was $0.8 \times 10^9 \pm 0.2$ for P, $1.2 \times 10^9 \pm 0.2$ for M, and $1.7 \times 10^9 \pm 0.1$ for G in 80 mL of extender. Ovulation was determined by ultrasound at 12 h intervals. Pregnancy and litter size were assessed at d 33. Data were analyzed for the main effects of treatment and replicate. Treatment did not affect ($P > 0.10$) pregnancy rate (MG, 74%; GM, 72%; MP, 67%; and PM, 50%; ± 0.1%, pooled SEM) or number of normal fetuses (MG, 9.1; GM, 8.9; MP, 8.5; and PM, 8.5, ± 0.7 pooled SEM). Predicted fertility index, although not statistically tested, indicated a 10 to 13% stepwise reduction in potential number of normal pigs produced by treatment (MG, 730; GM, 660; MP, 590; and PM, 512). The results of this study indicate that our classification method for FTS motility had no effect on early pregnancy rate or number of normal fetuses. This approach may not be sensitive enough to detect fertility effects and suggests that P and M FTS from superior sires can be used to produce high indexing offspring. However, based on the calculated fertility index, classification of FTS based on motility indicated that insemination order was important for pig production.

Key Words: artificial insemination, boar, frozen sperm

O142 **Timed insemination following OvuGel administration in weaned sows.** M. E. Johnston*, M. E. Swanson, S. K. Webel, *R&D, JBS United, Inc., Sheridan.*

The objective was to determine the effect of a single fixed-time insemination following OvuGel® (OG) administration on farrowing efficiency (number of sows farrowed of number of sows in service eligible breeding group) and litter size. OvuGel® is a 2 ml proprietary formulation containing 200 µg of the GnRH agonist, triptorelin acetate, which is administered intravaginally. Weaned Newsham sows (205) were blocked by parity (1 through 8; average 4.2), previous lactation length (15 to 26 d; average 21 d), and body condition score (2 to 4; average 3.1) and allocated to one of two treatments: Control (105) and OG (100). All sows were observed for behavioral estrus for 7 d after weaning. Control sows were inseminated the first day in estrus and every 24 h for the duration of estrus. OG sows were treated with OvuGel® on d 4 after weaning and were inseminated once 24 ± 3.5 h post-OvuGel® treatment, regardless of whether or not they were in standing estrus. Of the 105 Control sows, 94.3% (99) expressed estrus and were bred by 7 d post-weaning. All 100 OG sows were bred even though only 92 expressed estrus. Control sows averaged 2.2 inseminations per sow while all OG sows had 1 insemination per sow ($P<0.01$). There was no difference ($P<0.57$) in farrowing efficiency between Control and OG sows (89.6% and 92.0%, respectively). Total pigs born per litter was 13.5 and 13.4 for Control and OG sows, respectively ($P<0.82$). Piglet index (number pigs born alive/100 sows in service eligible breeding group) was 1130 for OG sows compared to 1094 for Control sows. Pigs born per semen dose was 5.9 *vs.* 12.4 ($P<0.01$) for Control and OG sows, respectively. These data indicate that treating sows with OvuGel® followed by one insemination approximately 24 h later results in farrowing efficiency, litter sizes, and piglet index comparable to sows receiving multiple inseminations during behavioral estrus.

Key Words: OvuGel, reproduction, sow

O143 **Effects of metabolizable protein during gestation on vasoreactivity in response to angiotensin II and mRNA expression of angiotensin receptors in cotyledonary arteries.** L. A. Lekatz[1,*], A. Reyaz [1], M. S. Sane [2], F. Yao [2], S. T. O'Rourke [2], C. Schwartz[1], M. L. Van Emon [3], C. S. Schauer [3], K. R. Maddock-Carlin [1], C. O. Lemley [1], J. S. Haring [4], K. A. Vonnahme [1], *[1]Center for Nutrition and Pregnancy, Animal Sciences, North Dakota State University, [2]Pharmaceutical Sciences, North Dakota State University , Fargo, [3]Hettinger Research Extension Center, North Dakota State University, Hettinger, [4]Animal and Dairy Sciences, Mississippi State University.*

To examine the effects of metabolizable protein (MP) intake during late gestation on the vasoreactivity of placental arteries in response to angiotensin II (ANG II) and the mRNA expression of angiotensin receptors 1 (AT1) and 2 (AT2), 18 singleton pregnant ewes received diets containing 60% (MP60), 100% (MP100), or 140% (MP140) of MP requirement from d 100 to 130 of gestation. On d 130, several cotyledonary (COT) arteries from placentomes of similar size and in close proximity to the umbilicus were selected for vasoreactivity studies and qPCR. Arterial rings were suspended in organ chambers filled with 25 mL of physiological salt solution aerated with a mixture of 95% O_2 and 5% CO_2 and kept at 38.6°C. Optimal tension was found by progressively stretching the rings until the contractile response to KCl (20 mM) was maximal. The presence or absence of endothelium was verified by testing the ability of bradykinin

(BK; 10^{-7} M) to produce endothelium-dependent relaxation during contraction evoked by U46619 (10^{-6} M). One endothelium-intact (E+) and one endothelium-removed (E-) ring for each animal underwent a dose response curve to ANG II (10^{-10} M to 10^{-6} M). Quantitative PCR was used to determine COT artery expression of AT1 and AT2 relative to 18S. There was no difference ($P = 0.13$) in the response to increasing doses of ANG II among the 3 dietary treatments. There was an endothelium by dose interaction ($P = 0.03$) where E+ and E- rings responded to ANG II similarly to the first 7 doses of ANG II, but E- rings had a greater ($P = 0.03$) contraction to the last 3 doses (3 x 10^{-7}, 1 x 10^{-6}, and 3 x 10^{-6} M) of ANG II compared with E+ rings. Maternal MP intake did not result in significant differences for AT1 ($P = 0.92$) or AT2 ($P = 0.81$) mRNA expression in the COT arteries. Angiotensin-induced constriction in fetal placental arteries was potentiated when the endothelium was removed from the arteries. While ANG II induces constriction by binding to its receptors on vascular smooth muscle, the endothelium appears to be important for modulating this effect at pharmacological doses.

Key Words: angiotensin, placental vasoreactivity , sheep

O144 **Novel mechanisms involved with lipid metabolism in adipose tissue of dairy cows.** D. Koltes*, D. Spurlock, *Animal Science, Iowa State University, Ames.*

Adipose tissue is mobilized during early lactation to compensate for energy deficiencies associated with milk production and depressed feed intake. Although prolonged and severe negative energy balance (NEB) are associated with a decline in fitness, mechanisms involved in lipid metabolism of adipose tissue remain unclear. Therefore, the objective of this research was to explore novel mechanisms of lipid metabolism in adipose tissue of dairy cattle. Lipid droplet associated protein and adipokine transcript abundances were measured in adipose tissue from 26 multiparous Holstein cows 21 d prior to expected calving date, 5, 21, and 150 d in milk (DIM). Energy balance and serum non-esterifed fatty acid (NEFA) concentrations were measured. During early lactation, cows were in NEB and serum NEFA concentrations were elevated compared to prepartum and 150 DIM. The increased lipolytic activity was accompanied by increased phosphorylation of hormone sensitive lipase (HSL; P=0.02) and perilipin (P=0.07), but not total protein abundance (P>0.4). In contrast, adipose triglyceride lipase (ATGL) protein abundance decreased during NEB (P<0.01). Transcript abundance of leptin tended to decline with NEB (P=0.08), while angiopoietin-like protein 4 (ANGPTL4) increased (P<0.01). To better characterize the role of ATGL in lipolysis, primary adipocytes were treated with leptin. Adipocytes from 8 mid lactation (230-395DIM) primiparous Holstein cows were exposed to 0, 10, 100, or 200ng/mL of bovine leptin. Glycerol concentration in the media increased with 100ng/mL of leptin (P=0.02), but NEFA concentrations remained similar (P>0.8). Phosphorylation and total protein abundance of HSL and perilipin were similar between control and treated adipocytes (P>0.05). However, ATGL protein abundance increased with 100 and 200ng/mL of leptin (P<0.05). In conclusion, lipid metabolism in dairy cattle may be regulated during early lactation 1) through the regulation of lipolysis via phosphorylation of HSL and perilipin, and 2) through reduced lipid uptake by adipose tissue via increased production of ANGPLT4. In contrast, basal lipolysis may be regulated by ATGL abundance in dairy cows.

Key Words: adipose triglyceride lipase, leptin

O145 **Reduction in the risk of peripartum transmission of *Mycobacterium avium* subsp. *paratuberculosis* in holstein calves born in individual calving pens.** P. Pithua [1,*], L. Espejo [2], S. M. Godden [3], S. J. Wells [2], *[1]University of Missouri, Columbia, [2]University of Minnesota, [3]University of Minnesota, St. Paul.*

The objective of this study was to quantify the efficacy of individual calving pens (ICP) cleaned between uses compared with multiple calving pens (MCP) for preventing transmission of *Mycobacterium avium* subsp *paratuberculosis* (MAP) in Holstein calves. The hypothesis that calves born in ICP were at no greater risk of MAP infection than calves born in MCP was tested in a systematic non-randomized study design framework. Every other pregnant cow or heifer in three Minnesota MAP endemic herds was assigned to calve in either the ICP within 48 h to 72 h prior to expected calving. Calves born in the ICP were assigned to the intervention group (n =238) while calves born in the MCP were considered controls (n = 211). Calves were separated from their dams within 1 h of birth. The intervention within the ICP was the higher levels of hygiene relative to that in the MCP, achieved by removing fecal material in the ICP immediately after each birth. Upon enrollment in 2005, calves were monitored into adulthood. Of the original number enrolled, 173 cows born in ICP and 141 cows born in the MCP completed the trial and were tested for MAP in 2007, 2009, and 2010 using a commercial ELISA and bacterial fecal culture tests. Cox regression analysis was performed to evaluate the time to MAP positivity. Cows born in the ICP had hazard ratios of 0.297 (95% CI =0.21 to 0.422) and 0.571(95% CI = 0.377 to 0.864), respectively for testing MAP fecal culture and serum ELISA positive, compared with cows born in MCP. These findings indicate that using ICP for calving is protective against MAP transmission and provides an effective strategy for reducing peripartum MAP transmission risks in herds attempting to limit the impact of paratuberculosis.

Key Words: individual-cow calving pen, multiple-cows calving pen, paratuberculosis

RUMINANT NUTRITION: CO-PRODUCTS

O146 **Supplementing modified distillers grains plus solubles mixed with low quality forage to replace grazed intake of cow-calf pairs.** J. M. Warner*, A. J. Doerr, C. J. Schneider, G. E. Erickson, R. J. Rasby, T. J. Klopfenstein, *Animal Science, University of Nebraska, Lincoln.*

Multiparous, nonpregnant, crossbred (Simmental x Angus), lactating beef cows (n = 32) with spring-born calves at side were used over 2 yr to evaluate supplementing modified distillers grains plus solubles (MDGS) with low quality forage on 1) grazed forage intake and 2) cow and calf performance. In a randomized complete design, cow-calf pairs were stratified annually by pair BW and randomly assigned to one of 2 treatments within strata. Treatments were 1) the recommended stocking rate of 9.46 AUM/ha with no supplementation (CON) or 2) double the recommended stocking rate (18.9 AUM/ha) and supplemented with a 30:70 MDGS:cornstalks (DM) mixture (SUPP). To replace 50% of grazed forage DM intake, SUPP pairs were fed an average of 1.13% of BW (DM) over the grazing season. SUPP and CON pairs grazed adjacent smooth bromegrass pastures for 132 d during the summer growing period. Pasture (4 per year) was considered the experimental unit. By design,

cow and calf initial BW was similar ($P \geq 0.32$) between treatments. Gain was similar ($P = 0.22$) between SUPP and CON cows (0.31 vs. 0.22 kg/d, respectively). Final cow BW was not impacted ($P = 0.48$) by treatment. Similarly, calf gain was not influenced ($P = 0.38$) by supplementation. Likewise, final BW was similar for SUPP and CON calves (231 vs. 214 kg, respectively). In studies where confined cow-calf pairs were fed average quality (IVDMD = 52.9%) forage, DMI was 2.26% of pair BW. Based on these data, CON and SUPP pairs consumed 16.3 and 17.0 kg DM, respectively, of total forage/pair/d. SUPP pairs consumed 6.8 kg/pair/d DM of the supplement, replacing 40% of grazed forage intake. Data suggest mixtures of ethanol co-products and a low quality forage can be supplemented to replace grazed forage intake of cattle, allowing for increased stocking rate without impacting animal performance.

Key Words: cow-calf pairs, distillers grains, forage replacement

O147 **Influence of corn processing and distiller's grains inclusion for finishing cattle on feeding behavior, gain efficiency, and carcass quality.** A. Islas*, T. C. Gilbery, M. L. Bauer, K. Swanson, *Animal Science, North Dakota State University, Fargo.*

Sixty-four steer calves (352 ± 8.4 kg of BW), predominantly of Angus, Simmental, and Shorthorn breeding, were used to study the effects of dry-rolled corn processing and corn dry distiller's grains plus solubles (DDGS) inclusion on feeding behavior, gain efficiency, and carcass quality of finishing steers fed a 90% concentrated diet. Animals were blocked by BW into three pens (n = 21 or 22) equipped with Insentec feeders. Within each pen steers were assigned randomly to one of four treatments (n = 5 or 6 per treatment): 1) fine-rolled corn and 20% DDGS; 2) fine-rolled corn and 40% DDGS; 3) coarse-rolled corn and 20% DDGS; and 4) coarse-rolled corn and 40% DDGS. Intake and feeding behavior traits were calculated from data generated by the Insectec System. Steers were fed to a finishing BW of approximately 600 kg. Steer were slaughtered and carcass traits were collected. Final BW and ADG were not affected ($P > 0.05$) by corn processing or DDGS. However, DMI (kg/d and % of BW) and G:F (kg/kg) were affected ($P < 0.001$) by DDGS with least DMI and greatest G:F observed at 40% DDGS. Steers consuming fine-rolled corn spent more time at the feeder ($P = 0.02$) regardless of whether they were fed 20 or 40% DDGS. Corn processing and DDGS inclusion affected ($P < 0.05$) the number of meals daily. Meal numbers were greater when coarse-rolled corn was fed regardless of whether DDGS was fed at 20 or 40%. Also, the number of meals consumed daily by steers fed 40% DDGS was greater than those observed for steers fed 20%. Steers fed fine-rolled corn or 40% DDGS consumed smaller ($P < 0.001$) meals (kg/meal) when compared to those fed coarse corn and 20% DDGS. Dry-rolled corn processing (coarse vs. fine) or inclusion of DDGS (20 vs. 40%) had no effect ($P > 0.05$) on carcass traits (HCW, fat thickness, LM area, and marbling). Fine or coarse dry-rolled corn fed in combination with 40% DDGS decreased intake, improved efficiency, and altered feeding behaviors of finishing steers consuming a 90% concentrate diet without affecting performance and carcass quality.

Key Words: cattle, distillers dried grains with solubles

O148 **Effect of feeding increasing levels of wet distillers grains plus solubles with and without oil extraction on finishing performance.** M. L. Jolly*, B. L. Nuttelman, D. B. Burken, C. J. Schneider, G. E. Erickson, T. J. Klopfenstein, *Animal Science, University of Nebraska, Lincoln.*

A finishing trial was conducted to evaluate feeding increasing levels of wet distillers grains plus solubles (WDGS) with and without oil extraction. Seven treatments were evaluated in a 2x3+1 factorial arrangement as a randomized block design utilizing 336 yearling steers (352 ± 19 kg). Factors were fat content (de-oiled or normal), inclusion level (35%, 50%, 65%, DM basis), and a corn based control (CON). All diets contained a 1:1 blend of high-moisture and dry-rolled corn, 12% corn silage, and 5% supplement. The fat concentration was 8.4% for de-oiled and 13.3% for normal WDGS. Therefore, dietary fat was 5.6% for de-oiled 35%, 7.2% for normal 35%, 6.2% for de-oiled 50%, 8.5% for normal 50%, 6.7 for de-oiled 65%, and 9.8% for normal 65% WDGS compared to 4.3% for CON. An inclusion x content interaction was observed for DMI ($P < 0.04$). Dry matter intake was greater for normal 35%, de-oiled 35%, and de-oiled 50%, intermediate for normal 50% and de-oiled 65%, and lowest for normal 65% ($P < 0.01$). Fat content had no effect on final BW, ADG, and G:F ($P < 0.20$). Level of WDGS had no effect on FBW or ADG ($P > 0.88$) but was significant for G:F ($P < 0.01$). Feed efficiency increased linearly for both de-oiled ($P = 0.01$) and normal fat ($P < 0.01$). Feed efficiency was the most improved at the 65% inclusion with de-oiled at 0.172 and normal at 0.179. No differences ($P \geq 0.29$) were observed in carcass characteristics due to fat content or level of WDGS. Regardless of level, fat content of WDGS had no significant effect on cattle performance but was numerically about 5% lower in feeding value, suggesting removal of oil with this new centrifugation process will have minimal impact on performance.

Key Words: cattle, centrifugation, de-oiled distillers grains

O149 **Effect of varying doses of vitamin C growth and carcass characteristics of cattle consuming a high sulfur diet.** D. Pogge*, S. Hansen, *Animal Science, Iowa State University, Ames.*

The objective of this study was to examine the effects of supplemental vitamin C (VC) on live and carcass-based performance and blood metabolites of cattle receiving a 40% distillers grains diet (0.55% S). Yearling Angus-cross steers (n = 140) were blocked by initial BW (432 ± 0.41 kg) and stratified within blocks by ultrasound-measured initial intramuscular fat (3.6% ± 0.06) and assigned to treatments (5 steers per pen, 7 pens per treatment), including: 1) no VC control (CON), 2) 5 g $VC \cdot h^{-1} \cdot d^{-1}$ (5VC), 3) 10 g $VC \cdot h^{-1} \cdot d^{-1}$ (10VC), and 4) 20 g $VC \cdot h^{-1} \cdot d^{-1}$ (20VC). Jugular blood was collected prior to feeding at the beginning and end of the 100 d study, and cattle were harvested by block when greater than 60% had 1.27 cm of backfat (by visual appraisal). The CON cattle had greater ($P < 0.01$) DMI than the VC supplemented cattle. Inclusion of VC did not influence ADG or final BW, resulting in a tendency for a linear increase ($P < 0.10$) in G:F as VC inclusion increased (0.150, 0.152, 0.158, 0.160 ± 0.004, for CON, 5VC, 10VC, and 20VC, respectively). Ending plasma VC exhibited a quadratic effect ($P < 0.05$) due to the lower concentrations exhibited by 5VC cattle (1186 µg/L) compared with the CON (1454 µg/L), 10VC (1304 µg/L), and 20VC (1436 µg/L; SEM ± 64.8) cattle. Ending plasma insulin concentrations of CON cattle tended ($P < 0.10$) to be lesser than the VC supplemented cattle. Plasma glucose and NEFA concentrations were not affected by VC inclusion. Hot carcass weight, 12th rib backfat, marbling, and quality grade were not affected by VC inclusion. Increasing VC inclusion linearly increased ($P < 0.01$) ribeye area (84.9, 86.5, 88.7, 89.1cm^2 ± 1.17, for CON, 5VC, 10VC, and 20VC, respectively), corresponding to a linear decrease ($P < 0.05$) in yield grade with increasing inclusions of VC. A tendency ($P < 0.10$) for a quadratic effect on kidney pelvic and heart fat was observed, in which values increased across CON

(2.27%), 5VC (2.37%), and 10VC (2.39%), then decreased in 20VC (2.20%; SEM ± 0.07). In conclusion, VC supplemented to a high S diet for 100 d had limited effects on blood metabolites, but increased feed efficiency and ribeye area.

Key Words: cattle, vitamin C

O150 **Effects of feeding condensed distillers solubles with and without oil extraction on growing cattle performance.** M. L. Jolly*, C. J. Schneider, D. B. Burken, B. L. Nuttelman, G. E. Erickson, T. J. Klopfenstein, *Animal Science, University of Nebraska, Lincoln.*

An 84 d growing study utilized 60 individually fed steers (241 ± 14.1 kg) to evaluate the effects of feeding condensed distillers solubles (CDS) with and without oil extraction at varying inclusions and in two different forage quality diets. Based on initial BW, steers were stratified and assigned randomly to one of seven treatments. Of the seven treatments, five were designed as a 2x2+1 factorial consisting of 20% or 40% de-oiled or normal CDS and a control (CON) without CDS. Diets contained an 80:20 blend of brome hay and sorghum silage (GRASS). The last two treatments were designed as a 2x2 factorial comparing fat (de-oiled or normal) and forage type [GRASS (previous diets) or wheat straw (WS)] at 40% inclusion of CDS (DM basis). Dietary fat was 2.4% for 20% de-oiled CDS, 3.2% for 20% normal CDS, 5.2% for 40% de-oiled CDS, 8.8% for 40% normal CDS, 2.9% for 40% de-oiled WS, 8.4% for 40% normal WS, and 1.5% for CON. Ending BW, DMI, and ADG increased linearly with increasing levels of CDS ($P < 0.01$), but fat content of CDS had no effect ($P > 0.21$). There was a tendency for an interaction for G:F ($P = 0.14$). At 20% inclusion, G:F improved 13.4% for normal CDS compared to de-oiled, but at 40% inclusion, G:F differed only 1%. This suggests oil may have hindered fiber digestion. An interaction was observed between diets varying in forage quality and CDS fat content for DMI ($P = 0.06$) and a tendency for ADG ($P = 0.13$. Compared to normal CDS, de-oiled CDS reduced DMI and ADG on GRASS diets and increased DMI and ADG on WS diets. Feed efficiency was greater for GRASS diets compared to WS ($P < 0.01$), regardless of fat content ($P = 0.53$). At low levels of CDS, normal fat improves feed efficiency while higher inclusions resulted in little effect on performance.

Key Words: condensed distillers solubles, de-oiled, growing

O151 **Effect of feeding distillers dried grains with solubles during lactation on feedlot performance and carcass characteristics of steer progeny.** C. N. Shee*, R. P. Lemenager, M. C. Claeys, J. P. Schoonmaker, *Animal Science, Purdue University, West Lafayette.*

Feeding dried distillers grains with solubles (DDGS), a feed high in fat and protein, to lactating cows can alter milk production and composition. This alteration in milk profile may consequently alter the growth and carcass composition of the offspring. Therefore, Angus x Simmental steers (n = 48) whose dams were fed one of two forage based diets supplemented with either DDGS or soybean meal (SBM) from calving to mid lactation (d 129) were placed in a feedlot to determine the effects of maternal nutrition during lactation on progeny development and carcass composition. Cow-calf pairs were allotted to treatments at birth by cow and calf BW, breed and age. Maternal diets were isocaloric (0.95 Mcal/kg NEg) and consisted of rye hay supplemented with DDGS as 1% of BW (19.4% CP) or corn silage and hay based diet supplemented with SBM (11.7% CP). At termination of maternal treatments at 129 d post partum (dpp), cow calf pairs were managed as one group until weaning at 219 dpp. Steers were then transitioned to a common diet composed of 60% DDGS, 34% corn silage and 6% vitamin/mineral supplement until 256 dpp, when steers were placed indoors in individual pens with slatted floors. Steers were slaughtered at a target BW of approximately 591 kg. Categorical and continuous data were analyzed using the GLIMMIX and MIXED procedures of SAS, respectively. Initial BW was 287.7 and 296.1 kg ($p = 0.18$) for SBM and DDGS steers, respectively. Days on feed ($p = 0.42$), ADG ($p = 0.80$), daily DMI ($p = 0.76$) and feed efficiency ($p = 0.90$) did not differ between treatments. Hot carcass weight ($p = 0.54$), dressing percent ($p = 0.50$), fat thickness ($p = 0.71$), ribeye area ($p = 0.17$), percent kidney pelvic heart fat ($p = 0.31$) and yield grade ($p = 0.19$) were not different between treatments. Marbling score was decreased ($p = 0.04$) in steers whose dams were fed DDGS (293 vs. 343). Percentage of carcasses grading choice or greater, however, did not differ between treatments ($p = 0.39$). In summary, feeding DDGS to lactating cows did not affect growth of steer progeny; however, marbling was decreased in steers whose dams were fed DDGS.

Key Words: developmental programming, distillers grains

O152 **Replacement of grazed forage and animal performance when distillers grains are fed in a bunk or on the ground.** K. Gillespie*, T. Klopfenstein, J. Volesky, L. Stalker, J. Musgrave, B. Nuttelman, C. Schneider, G. Erickson, *Animal Science, University of Nebraska, Lincoln.*

The second year of a completely randomized grazing experiment estimating forage savings and ground feeding efficiency when supplementing spayed yearling heifers with modified distillers grains (MDGS) on native range was completed, under drought conditions. Heifers (n=24, BW=306 ± 5 kg) grazed Sandhills range 120 d beginning May 23, 2012. Treatments were no supplementation (CON), ground-fed MDGS at 0.6% BW (GRD), or bunk fed MDGS at 0.6% BW (BNK). There were four heifers per replication with two replications per treatment. Each treatment group rotated through six one-hectare paddocks. Rotation length was longer for grazing cycle two due to forage growth stage. A 17% forage savings from MDGS supplementation at 0.6% BW was assumed based on smooth bromegrass research, thus supplemented groups grazed their paddocks 17% longer than CON each rotation. In cycle two, all early, middle, and late rotationally grazed paddocks were hand-clipped to determine residual forage. Diet samples were collected via esophageally fistulated cows at mid-point of the grazing period to estimate forage quality over the grazing season. Supplemented cattle gained more per day ($P <0.01$) and had greater final weights ($P <0.01$) than CON. There was no difference in daily gain ($P = 0.28$) or ending weight ($P = 0.91$) between GRD and BNK. Daily gains were 0.33, 0.99, and 1.05 kg/d for CON, GRD and BNK respectively, with final BW's of 325, 368, and 373 kg, respectively. A retrospective analysis determined 9.5% of offered MDGS was lost when ground fed. Residual forage indicated control cattle consumed more forage than supplemented cattle ($P =0.01$), indicating forage savings when supplementing MDGS at 0.6% BW was greater than the hypothesized 17%. MDGS at 0.6% BW can be fed to decrease forage consumption and increase summer grazing gains. Compared to year one data, cattle performance was consistent, MDGS ground feeding loss was five percentage units greater, and forage savings was greater under drought.

Key Words: beef cattle, bunk, supplementation

O153 **Effect of calcium oxide inclusion in beef feedlot diets containing 60% dried distillers grains with solubles on performance and carcass characteristics.** A. J. C. Nunez [2], T. L. Felix[1], S. C. Loerch [3], R. P. Lemenager [4], J. P. Schoonmaker [4,*], *[1]Animal Sciences, University of Illinois, Champaign, [2]Animal Sciences, University of São Paulo, Pirassununga, Brazil, [3]Animal Sciences, Ohio State University, Wooster, [4]Animal Sciences, Purdue University, West Lafayette.*

The acidic nature of dried distillers grains with solubles (DDGS) is a key determinant in depressing fiber and protein digestibility and plays a primary role in decreased feed intake and growth rate when DDGS concentrations go above 30% of the diet DM. The ability of alkali treatments, including calcium oxide (CaO) to increase rumen pH and enhance fiber digestibility of low quality roughages has been recognized for decades. Thus, we hypothesized that CaO would mitigate rumen acidity caused by DDGS and increase nutrient utilization in diets containing elevated concentrations of DDGS. To determine the effect of dietary CaO on performance and carcass characteristics, 120 Angus x Simmental steers were allotted by weight (354.6 ± 7.93 kg) to one of four treatments containing 60% DDGS. Steers were housed indoors in group pens and fed a total mixed ration at 0800, which included 60% DDGS, 20% corn silage, 13.5 to 14.4% ground corn, 4% supplement, and 0 to 2.5% limestone on DM basis. Treatments consisted of 0, 0.8, 1.6, or 2.4% CaO inclusion in the diet on a DM basis, with CaO replacing limestone. Steers were slaughtered at a target weight of approximately 641 kg. Statistical analyses were conducted using the MIXED procedure of SAS. There was a quadratic response (P = 0.03) of ADG to CaO inclusion. Inclusion of CaO at 0.8% and 1.6% increased overall ADG by 5.1 and 4.1%, respectively, compared to the 0% CaO diet, whereas inclusion of CaO at 2.4% of the diet DM did not increase gain relative to the 0% CaO diet. DMI was linearly decreased (P = 0.04) by CaO inclusion. Feed efficiency increased linearly (P = 0.02) by inclusion of CaO at 0.8 and 1.6% of the diet DM. Dressing % and %KPH responded quadratically to inclusion of CaO. Dressing % increased (P < 0.01) and % KPH decreased (P = 0.05) from 0 to 1.6% dietary inclusion of CaO, whereas dressing % decreased and % KPH increased from 1.6 to 2.4% dietary inclusion of CaO. No other carcass measurements were affected (P > 0.20) by dietary inclusion of CaO. In conclusion, inclusion of CaO up to 1.6% was effective in improving performance of feedlot cattle.

Key Words: calcium oxide, distillers grains, feedlot cattle

O154 **Effects of corn processing method and dietary inclusion of corn wet distillers grains with solubles (WDGS) on nutrient metabolism and enteric gas production in finishing steers.** J. Jaderborg [1,*], G. I. Crawford [1], A. DiCostanzo [1], M. J. Spiehs [2], K. E. Hales [3], *[1]Animal Science, University of Minnesota, Saint Paul, [2]Environmental Management Unit, USDA-ARS U.S. Meat Animal Research Center, [3]Nutrition Research Unit, USDA-ARS Meat Animal Research Center, Clay Center, NE.*

Dry rolled (DRC) and high moisture (HMC) corn are common corn processing methods used by feedlots in the Upper Midwest. Research is limited on higher inclusion rates of wet distillers grains with soluble (WDGS). Therefore, the effects of increasing the concentrations of WDGS in dry rolled and high moisture corn-based diets on energy metabolism and enteric methane (CH_4) production were evaluated in eight MARC III (initial BW = 394 kg) steers using respiration calorimetry head boxes. A 4 x 4 replicated Latin square with 2 x 2 factorial arrangement of treatments was used with the following dietary treatments: 1) DRC-based diet with 25% WDGS (DRC-25); 2) DRC-based diet with 45% WDGS (DRC-45); 3) HMC-based diet with 25% WDGS (HMC-25); 4) HMC-based diet with 45% WDGS (HMC-45). Dry matter intake tended to decrease (P = 0.10) and CH_4production was reduced (P < 0.01) as WDGS concentration increased in the diet. The CO_2 to CH_4 ratio increased (P = 0.02) and RQ decreased (P < 0.01) when WDGS increased in the diet. Retained energy tended to be greater (P = 0.07) for DRC vs HMC. Urinary and fecal N excretion as proportion of N intake was not affected (P = 0.62) by corn processing method. However, as a proportion of N intake, urinary N excretion was increased (P < 0.01), whereas, fecal N excretion was decreased (P < 0.01) when WDGS concentration increased in the diet. As a percent of intake, ether extract apparent digestibility was greater (P < 0.01) for WDGS at 45 than 25% of DM. Diets containing 25% WDGS or HMC had a lower (P < 0.01) NDF digestibility. Starch apparent digestibility as percent of intake was increased (P < 0.01) for diets containing DRC, while it was not affected (P = 0.29) for WDGS concentrations in diet. Using 45 vs 25% WDGS in diets increased retained energy as a percentage of GE and retained N as a percentage of N intake.

Key Words: cattle, distillers grains, methane

O155 **Distillers grains supplementation in a forage system with spayed heifers.** K. Gillespie*, T. Klopfenstein, B. Nuttelman, J. Volesky, G. Erickson, C. Schneider, *Animal Science, University of Nebraska, Lincoln.*

A two-year beef systems study was conducted to determine optimal time within a forage system to supplement distillers grains. A completely randomized design with a 2 x 2 factorial arrangement was used. Each year, 230 spayed heifer calves (BW = 215 ± 26 kg) grazed corn residue 144 d and bromegrass 32 d (WTR), and native Sandhills range 120 d (SMR). Factorial treatments were 0.91-kg DM wet distillers grains with solubles (WDGS) (LO) or 2.3-kg DM WDGS (HI) supplement on corn residue, and modified distillers grains with solubles (MDGS) fed at 0.6% BW daily (SUP) or no MDGS (NO) during SMR. A 17% forage savings from MDGS supplementation at 0.6% BW was assumed based on past research, thus available SMR grazing acres for SUP were 17% less than NO. Forage residual height was measured in each of 3 pastures at the end of each SMR grazing period to validate forage savings. Winter ADG was greater for HI cattle at 0.62 kg than LO at 0.38 kg (P<0.01). Summer SUP ADG at 0.74 kg was greater than NO at 0.52 kg (P<0.01). System gains included total WTR and SMR gains and there was a system gain interaction between WTR and SMR treatments (P<0.01). System gain was greatest among treatments for HI, SUP at 0.63 kg (P<0.01), second for HI, NO at 0.58 kg (P<0.01), followed by LO, SUP at 0.56 kg (P=0.03), and least for LO, NO at 0.47 kg (P<0.01). There was no difference in residual forage height (P=0.5), indicating equal grazing pressure by supplemented and unsupplemented heifers and verifies forage savings hypothesis when supplementing yearlings with MDGS at 0.6% BW. Gains increased with higher WTR WDGS supplementation level and SMR MDGS supplementation, due to additional energy or undegradable intake protein supplied. System gains were highest for HI, SUP, intermediate for HI, NO and LO, SUP, and lowest for LO, NO.

Key Words: beef cattle , distillers grains, supplementation

O156 **Effects of abruptly transitioning cattle from RAMP to a finishing diet on feedlot performance and carcass traits.** C. J. Schneider [1,*], B. L. Nuttelman [1], D. B. Burken [1], T. J. Klopfenstein [1], G. E. Erickson [1], R. A. Stock [2], [1]*Animal Science, University of Nebraska, Lincoln,* [2]*Cargill Inc., Blair, NE.*

Individually fed yearling crossbred steers (n=60; BW=383 ± 15 kg) were used in a CRD study to evaluate transitioning cattle from RAMP, a complete feed provided by Cargill containing Sweet Bran and minimal forage, to a finishing diet with or without an adaptation period and a traditional grain adaptation program using alfalfa hay. Steers were consecutively weighed over 3 d and assigned randomly to 1 of 3 adaptation treatments. RAMP adaptation treatments involved a 4-step system (4-STEP) which gradually decreased RAMP inclusion (100 to 0%) while increasing finishing ration (0 to 100%) equally over 4 periods (4, 6, 6, and 6 d) by mixing RAMP with finishing ration 1 (F1, 47.5% Sweet Bran, 40% high-moisture corn (HMC), 7.5% alfalfa hay and 5% supplement, DM basis) and fed as a single diet or a 1 step adaptation system (1-STEP) which involved feeding RAMP for 10 d and switching directly to F1 on d 11. The traditional adaptation program (TRD) decreased alfalfa hay inclusion (45 to 7.5%) while corn grain inclusion increased (25 to 62.5%) over 4 periods (4, 6, 6, and 6 d). On day 28 all cattle were switched to a common finishing diet (F2), which contained (DM basis) 42.5% HMC, 25% Sweet Bran, 22.5% modified distillers grains with solubles, 5% wheat straw and 5% supplement, and remained on a common diet for the remainder of the finishing period for a total of 138 DOF. During grain adaptation 1-STEP cattle had greater ADG (P=0.02) compared to TRD and tended to have greater ADG compared to 4-STEP (P=0.10) with ADG of 1.63, 1.70, and 1.85 for TRD, 4-STEP, and 1-STEP, respectively. Feed intake variance among d for animals was greater for TRD compared to 4-STEP and 1-STEP, but DMI and G:F were not different during the adaptation period. Feedlot performance over the entire finishing period and carcass traits were not affected (P>0.15) by adaptation treatment. Cattle started on RAMP for 10d can be transitioned directly to a finishing diet containing 47.5% Sweet Bran without negatively affecting feedlot performance or carcass traits.

Key Words: beef cattle, by-products, grain adaptation

O157 **Comparing condensed distillers soluble concentration in steam-flaked corn finishing diets on cattle performance and carcass characteristics.** M. E. Harris[1,*], G. E. Erickson[1], K. H. Jenkins[2], M. K. Luebbe [2], [1]*Animal Science, University of Nebraska, Lincoln,* [2]*Animal Science, University of Nebraska, Lincoln, Scottsbluff.*

Performance and carcass characteristics were evaluated using five concentrations of condensed corn distillers solubles (CCDS) replacing steam-flaked corn (SFC) in finishing diets of cross-bred steers (BW=399 ± 27 kg). Concentrations of CCDS were: 0, 9, 18, 27, or 36% CCDS on a DM basis. Urea and soybean meal were included in all diets to meet or exceed NRC requirements for MP. All diets contained 16% corn silage and 4% pelleted supplement. Steers were utilized in a randomized block design, blocked by BW, stratified by BW within block, and assigned randomly to pens. Pens were assigned randomly to treatments within blocks with 8 pens/treatment and 11 steers/pen. Steers were fed for an average of 97d. Dry matter intake decreased quadratically (P<0.01) as the concentration of CCDS increased in the diet. Average daily gain increased quadratically (P<0.01) with greatest gains observed at 27% and slightly decreased at 36%. Similar to ADG, G:F increased quadratically (P<0.01), with greatest G:F observed at 27% before decreasing at 36% CCDS. Hot carcass weight increased quadratically (P<0.01), also peaking at 27% CCDS. Calculated YG and marbling score increased quadratically (P=0.06 and 0.08, respectively). Fat thickness and LM area also tended to be quadratically increased (P=0.13 and 0.07, respectively). An increasing linear response (P=0.01) was observed for dressing percentage as CCDS increased in the diet. These results suggest feeding condensed distillers solubles can effectively be used to replace SFC in feedlot finishing diets and increase ADG and G:F.

Table 1. Effects of condensed distillers solubles level in steam-flaked corn diets.

	CCDS, % Diet DM					*P*-value	
Item	0	9	18	27	36	Linear	Quadratic
DMI, kg/d	11.8	11.8	11.5	11.4	10.8	<0.01	0.02
ADG, kg	1.90	2.05	2.03	2.08	1.90	0.83	<0.01
G:F	0.161	0.173	0.176	0.182	0.175	<0.01	<0.01

Key Words: by-products, distillers solubles, steam-flaked corn

O158 **Effects of increasing soybean hulls in finishing diets with distillers grains on performance and carcass characteristics.** C. J. Bittner[1,*], B. L. Nuttelman[1], C. J. Schneider [1], D. B. Burken[1], L. Johnson [2], T. L. Mader [2], T. J. Klopfenstein [1], G. E. Erickson [1], [1]*Animal Science, University of Nebraska, Lincoln,* [2]*Animal Science, University of Nebraska, Concord.*

Two experiments evaluated the effects of soybean hulls (SBH) on animal performance and carcass characteristics in finishing diets containing distillers grains plus solubles. Dietary inclusion levels of SBH used were 0, 12.5, 25, and 37.5% of diet DM. In Exp. 1, 167 (395 ± 22 kg of BW) crossbred yearling steers were used in a randomized block design replacing dry-rolled corn (DRC) with pelleted SBH and fed for 117 d. The remainder of the diet consisted of 25% modified distillers grains plus solubles (MDGS), 15% corn silage, and 5% liquid supplement. As SBH level increased, DMI increased linearly (P > 0.03). Gains decreased linearly (P < 0.01) along with G:F (P < 0.01) in response to increasing levels of SBH. Hot carcass weight linearly decreased (P < 0.01) by 24 kg as SBH increased. The feeding value of SBH was 69.6 to 59.5% of corn and decreased when SBH increased from 12.5 to 37.5% of DM. In Exp. 2, a randomized block design utilized 160 (BW = 363 ± 16 kg) backgrounded steer calves in a 138 d finishing study. Dietary treatments of SBH were similar to Exp. 1; however, the meal form of SBH was used. Basal ingredients consisted of a 1:1 ratio of high-moisture corn (HMC) and DRC, 40% wet distillers grains plus solubles (WDGS), 8% sorghum silage, and 4% dry meal supplement. A tendency (P = 0.09) for a linear increase in ADG as dietary SBH increased was observed, but gain was greatest at the 12.5% inclusion level. Feed efficiency tended (P > 0.12) to respond quadratically as SBH level increased; with steers fed 12.5% SBH being 2.3% more efficient than 0% SBH fed cattle. The feeding value of SBH was greater than that of corn when SBH was included in the diet at 12.5 and 25%. Results were variable between experiments and may be related to inclusion of distillers or cattle type. Feeding SBH at 12.5% of the diet with 40% WDGS; improved animal performance when replacing HMC and DRC in the diet.

Key Words: distillers grains, finishing cattle, soybean hulls

O159 **Effect of calcium oxide inclusion in beef feedlot diets containing 60% dried distillers grains with solubles on rumen pH, volatile fatty acids, and nutrient digestibility.** A. J. C. Nunez[1], T. L. Felix[2], S. C. Loerch[3], R. P. Lemenager[4], J. P. Schoonmaker[4,*], *[1]Animal Sciences, University of São Paulo, Pirassununga, Brazil, [2]Animal Sciences, University of Illinois, Champaign, [3]Animal Sciences, Ohio State University, Wooster, [4]Animal Sciences, Purdue University, West Lafayette.*

Four Angus x Simmental steers (initial BW = 288 ± 3 kg) were randomly allocated to a 4x4 Latin Square design (14-d periods) to determine the effect of calcium oxide (CaO) on ruminal pH, VFA concentration, and digestibility in feedlot steers fed 60% dried distillers grains with solubles (DDGS). Animals were housed in individual pens and fed a total mixed ration, which included 60% DDGS, 20% corn silage, 13.5 to 14.4% corn, 4% supplement, and 0 to 2.5% limestone on a DM basis. Treatments consisted of 0, 0.8, 1.6, or 2.4% CaO inclusion in the diet DM, replacing limestone. Ruminal pH was obtained on d 12 and 13 via wireless rumen sensors located in the dorsal sac of the rumen. Ruminal fluid samples were collected via stomach tube at 0, 3, 6, 12, and 18 h post-feeding on d 14 for determination of VFA concentrations by gas chromatography. Total urine and feces collections were performed during a 24-h period on d 13. Nutrient digestibility was determined using AIA as an internal marker. Statistical analyses were conducted using the MIXED procedure of SAS. A diet x time interaction occurred for ruminal pH ($P \leq 0.01$). Steers fed 0% CaO had the greatest pre-feeding ruminal pH and steers fed 0 and 0.8% CaO exhibited the most rapid post-feeding decline in ruminal pH. Ruminal pH of steers fed 2.4% CaO remained relatively stable throughout the 24 h period. Acetate, butyrate, and total VFA concentrations increased linearly ($P \leq 0.05$) at 0, 3, 6, and 12 h post-feeding with increasing CaO. No differences were observed for propionate concentrations ($P > 0.10$). Urine pH increased linearly ($P \leq 0.01$) while urine output decreased linearly ($P \leq 0.05$) as CaO inclusion increased. CaO had no effect on DMI ($P > 0.59$), however, apparent DM ($P = 0.03$), NDF ($P = 0.03$), ADF ($P = 0.01$), and protein ($P = 0.10$) digestibilities of the diets increased linearly with increasing concentrations of CaO. In conclusion, increased ruminal pH, increased concentrations of acetate and butyrate, and increased apparent DM, fiber, and protein digestibility indicated that CaO improved ruminal fermentation in cattle fed 60% DDGS diets.

Key Words: calcium oxide, digestibility, distillers grains

RUMINANT NUTRITION: GENERAL RUMINANT NUTRITION I

O160 **Effects of crude glycerin on ruminal fermentation parameters of Nellore steers.** E. H. C. B. Van Cleef[1,*], J. M. B. Ezequiel[2], F. B. D. O. Scarpino[2], D. A. V. Silva[3], A. P. D` Aurea[2], J. B. D. Sancanari[2], *[1]Animal Science and Industry, Kansas State University, Manhattan, [2]Animal Science, [3]Veterinary Medicine, São Paulo State University, Jaboticabal, Brazil.*

Five rumen-cannulated Nellore steers (402 ± 44 kg BW) were used to evaluate the effects of increasing levels of crude glycerin on fibrous fraction degradation and ruminal parameters, such as pH, ammonia, and volatile fatty acids. Cattle were assigned to five treatments in a 5 × 5 Latin square design. Each period consisted of 14 d adaptation and 16 d sampling. Diets consisted of 30% corn silage and 70% concentrate with or without crude glycerin, which replaced mainly corn grain. The inclusion levels of crude glycerin were 0; 7.5; 15; 22.5; and 30%, respectively for treatments 1 to 5. Samples of ruminal contents were taken manually 1 h before feeding, 0, 1, 2, 4, 6, and 8 h post feeding. The pH and ammonia were measured immediately after ruminal fluid extraction, and samples were stored with a 25% (v/v) m-phosphoric acid solution for VFA analysis. Samples of soybean hulls, sunflower meal, and corn silage were dried, ground and incubated in the rumen using 14 x 7 nylon porous bags for 72, 120, and 120 h, respectively to ingredients. Data were analyzed using the MIXED procedure of SAS and contrasts were used to determine the linear and quadratic effects of glycerin and 0% glycerin × glycerin treatment. Feeding crude glycerin to the animals linearly decreased ($P \leq 0.01$) insoluble but potentially fermentable fraction of NDF of soybean hulls (51.25, 49.62, 49.43, 42.24, and 42.64%, respectively to treatments 1 to 5), sunflower meal (42.36, 41.78, 37.09, 32.22, and 31.22%), and corn silage (42.72, 42.37, 41.98, 39.11, and 35.93%), and increased linearly the insoluble fraction up to 11.24%. There was no effect of glycerin treatments on rumen NH_3-N concentrations ($P > 0.05$), however, between 2 and 4 h post feeding, pH values tended ($P = 0.06$) to be greater on high glycerin treatments. Adding glycerin to diets increased propionate, butyrate, and valerate ($P \leq 0.05$), and decreased acetate, and acetate:propionate ratio ($P \leq 0.05$), without changing isobutyrate, isovalerate, and total VFA. Including glycerin in byproduct-based diets depresses dietary fiber degradation and increases propionate production of Nellore steers. This research was funded by FAPESP, São Paulo, Brazil.

Key Words: degradation, glycerin, propionate

O161 **Methods to study the contribution of rumen microorganisms to metabolizable protein.** E. Castillo Lopez*, T. Klopfenstein, S. Fernando, P. Kononoff, *Animal Science Department, University of Nebraska, Lincoln.*

A series of experiments were conducted to study the contribution of rumen microorganisms to metabolizable protein (MP) when cattle are fed high concentrations of corn distillers grains (CDG). We tested the use of diaminopumelic acid (DAPA), purines and DNA as microbial markers to measure intestinal supply of microbial crude protein (MCP). To evaluate the impact of diet and better understand the bacterial community structure in the rumen we employed the 16S rDNA bacterial tag-encoded FLX amplicon pyrosequencing (bTEFAP) technology. The resulting microbial sequences were analyzed using the Quantitative Insights Into the Microbial Ecology (QIIME) pipeline. In a study designed to evaluate the supply and nature of RUP in CDG fed to steers, CDG was include at 0, 10 and 20% of the diet DM replacing corn bran and urea. We estimated that the concentration of RUP in CDG was 63 ± 0.64%, and that CDG reduced the flow of MCP, where 0.6 ± 0.10% of MP was contributed from yeast contained in CDG. We observed that Bacteroidetes and Firmicutes were the most abundant phyla, and that Prevotellaceae and Lachnospiraceae are the largest families of bacteria found within the rumen. In an additional study designed to evaluate the flow of MCP when feeding reduced fat CDG to dairy cows, diets were formulated to include 0, 10, 20 and 30% CDG (DM basis) replacing a portion of alfalfa hay, cottonseed, ground corn and soybean meal. We observed a decrease in rumen pH and a decrease in the ratio of acetate to propionate in the rumen. Intestinal flow of MCP was maintained, while yeast from CDG contributed 0.41 ± 0.04% of MP, milk yield was unaffected and averaged 34.1 ± 1.29 kg/d. Results of this research indicates that the effect of CDG on rumen MCP depends on ingredient and chemical composition of the diet, and MCP could supply 38 to 58% of MP in cattle fed CDG. Diaminopumelic acid and DNA yielded similar estimates of MCP; however, purines yielded higher MCP than DNA markers. In addition,

when reduced fat CDG are fed to dairy cattle no negative effects on rumen fermentation and lactation was observed.

Key Words: corn milling co-products, metabolizable protein, microbial crude protein, DNA pyrosequencing, QIIME

O162 **Feeding Next Enhance® 300 improved growth performance and carcass measurements of beef steers.** M. Westerhold[1,*], M. S. Kerley[1], W. J. Sexten[1], B. R. Wiegand[1], T. J. Wistuba[2], *[1]Division of Animal Sciences, University of Missouri, Columbia, [2]Novus International, Inc., St. Charles.*

Next Enhance® 300 (NE 300, Novus Intl.) consists of essential oils that have been shown to modify rumen fermentation. We hypothesized NE 300 would improve growth and carcass characteristics of feedlot steers. Crossbred steers (n=98; BW=413±37.7 kg) were used in a randomized, complete block design and fed increasing levels of NE 300. Steers were blocked by initial BW, randomly assigned to treatment (TRT), and allotted to 5 pens per TRT. TRTs consisted of 0 (CON, n=25), 150 (n=24), 300 (n=25), and **600** (n=24) $mg \cdot hd^{-1} \cdot d^{-1}$ of NE 300. Steers were fed a corn based diet that was 15.4% CP and 3.06 Mcal/kg NEg. NE 300 inclusion linearly decreased DMI at d 28 (P=0.04), 56 (P<0.01), and 84 (P=0.01). Overall DMI did not differ (P=0.19). Steers fed the 150 diet had the greatest ADG at d 28 (P=0.05) and 56 (P=0.10). However, there was a linear decrease in ADG at d 28 (P=0.04), 84 (P=0.03), and overall (P=0.01) due to decreased performance of steers fed 300 and 600 diets. On d 28, G:F of steers fed the 150 diet did not differ from CON but was increased (P<0.05) when compared to 300 and 600 steers. However, there was a linear decrease (P<0.01) in overall G:F due to decreased efficiency of steers fed the 600 diet, which differed from CON steers. Inclusion of NE 300 caused a quadratic (P=0.01) increase in dressing percent (DP) and a quadratic decrease in 12th rib backfat (BF) (P=0.05) with CON steers having the lowest DP and the most BF. There tended to be a quadratic increase in LM area (P=0.10) and LM area/45.4 kg (P=0.10). There was a quadratic decrease (P=0.04) in USDA yield grade in response to NE 300 inclusion. Steers fed the 150 diet had increased performance early in the feeding period resulting in decreased performance and efficiency at the end. When performance was adjusted to a common DP (62%), NE 300 inclusion caused a quadratic increase (P=0.02) in overall ADG and tended to cause a quadratic decrease (P=0.11) in G:F, suggesting cattle should have been harvested at a similar carcass endpoint rather than days of feed. Based on harvest at similar days on feed, we concluded that NE 300 improved ADG, DP, BF, LMA, and YG when included at 150 $mg \cdot hd^{-1} \cdot d^{-1}$.

Key Words: essential oil, feedlot cattle

O164 **Effects of a terminal sorting system with Zilpaterol hydrochloride on feedlot performance and carcass characteristics of yearling steers.** F. Hilscher[1,*], B. Nuttelman[1], D. Burken[1], G. Erickson[1], K. Vander Pol[2], *[1]Animal Science, University of Nebraska, Lincoln, [2]Technical Services Specialist, Merck Animal Health, Lincoln.*

Crossbred yearling steers (n=1400, 376 ± 29 kg) were used to evaluate the effects of Zilpaterol hydrochloride (ZH) and terminal sorting 50 d prior to harvest on feedlot performance and carcass characteristics. Steers were blocked by arrival group (25 steers/pen, 56 pens) and assigned randomly to pen to receive 1 of 4 treatments: 1) unsorted non-ZH negative control (-CON); 2) unsorted ZH fed positive control (+CON); 3) early weight sort fed ZH (1-sort) with heaviest 20% identified at d 1 and sorted 50 d from harvest and marketed 14 d prior to -CON and +CON, with the remaining 80% of the pen fed 7 d longer than -CON and +CON; and 4) four-way sort 50 d from harvest fed ZH (4-sort) with steers sorted into a heavy, mid-heavy, mid-light, and light group, marketed -14 d, 0 d, +7 d, and +21 d from the -CON and +CON, respectively. All steers fed ZH were fed 8.3 mg/kg of DM for 20 d followed by 3 d withdrawal. The +CON had 6.4 kg heavier (P=0.02) final BW than -CON. Daily gain and G:F were greater (P<0.02) for cattle receiving ZH when compared to -CON, but were not different (P>0.21) among treatments fed ZH. Carcass weight for +CON was 15 kg heavier (P<0.01) than -CON, and HCW for 4-sort was greater (P<0.02) than +CON. Carcass weight SD was not different (P>0.10) between +CON and -CON, while carcass weight SD of 4-sort was reduced (P<0.01) compared to +CON. Steers fed ZH had a greater percentage of carcasses over 454 kg than -CON (P<0.01). Although not statistically different, % of carcasses over 454 kg were reduced by 28% for 4-sort compared to +CON. Longissimus muscle area was greater in +CON and sorted treatments (P<0.01) than -CON, and 1-sort and 4-sort had increased (P<0.05) LM area vs. +CON. Fat depth was lower (P<0.05) in +CON than -CON, but did not differ in ZH treatments. Marbling was lower (P<0.04) for treatments; 1-sort, 4-sort, and +CON when compared to -CON. Feeding ZH increases carcass weight, but sorting reduces variation allowing increases in carcass weight while minimizing overweight carcasses.

Key Words: feedlot, sorting, Zilpaterol

O163 **Effect of source and concentration of copper on cattle growth and copper status.** M. Drewnoski[1,*], S. Hansen[2], *[1]Animal and Vet Sci, University of Idaho, Moscow, [2]Animal Science, Iowa State University, Ames.*

Sources of dietary Cu differ in their ability to be metabolized and used by cattle. The objective of this experiment was to examine the effect of differing Cu sources and concentration in mineral premixes on cattle growth, efficiency, and repletion of Cu status following a period of Cu depletion. Thirty Angus-cross steers (420 kg ± 12.1 BW) were group-fed a corn silage-based diet with no supplemental Cu which included sodium molybdate (3-5 mg Mo/kg DM) for a period of 95 d to induce Cu deficiency. Liver Cu concentrations at the end of depletion indicated a severe Cu deficiency was achieved (30.7 mg Cu/kg liver DM). Plasma ceruloplasmin concentrations supported this assessment, averaging 11.9 mg/dL. Steers were then moved into pens of 6 head, blocked by liver Cu concentrations to a repletion diet, and individual steer intakes were recorded through a 114 d repletion period (60 d on growing diet and 54 d on finishing diet). During the repletion period dietary treatments included supplementation with mineral premixes containing: 1) no Cu (CON; n = 6 steers), 2) 2000 mg Cu/kg DM (as $CuSO_4$; SULF; n = 12 steers), and 3) 2000 mg Cu/kg DM (as tribasic Cu chloride; TBCC; n = 12 steers). Mineral premixes were added to total mixed rations to achieve average daily intakes of approximately 113 g of premix per d. Based on repeated measures analysis, DMI across the repletion period of CON cattle was greater (P = 0.04) than TBCC cattle and tended (P = 0.09) to be greater than SULF cattle. Average daily gain across the repletion period did not differ (P = 0.9) due to treatment, nor did G:F (P = 0.28; 0.152, 0.156, and 0.166 ± 0.006 for CON, SULF, and TBCC, respectively). Liver Cu concentrations at the end of the growing repletion phase were greater (P < 0.001) in steers supplemented with Cu, regardless of source (16, 205, and 208 ± 14.6

mg Cu/kg DM for CON, SULF, and TBCC, respectively). Similar differences ($P < 0.001$) in liver Cu across treatments remained at the end of the finishing repletion period (25, 275, and 285 ± 16 mg Cu/kg DM for CON, SULF, and TBCC, respectively). In non-stressed cattle, copper deficiency did not affect performance of feedlot cattle.

Key Words: copper, feedlot cattle

O165 **Changes in steer performance throughout the feeding period**. J. C. MacDonald*, C. J. Schneider, K. M. Rolfe, G. Erickson, T. J. Klopfenstein, *Animal Science, University of Nebraska, Lincoln.*

Seven research experiments representing five years, 298 pens, and 2380 steers were compiled to determine changes in BW, ADG, DMI, and G:F through the feeding period on a shrunk BW and carcass weight basis. Steers were weighed at approximately 30-d intervals, were fed from 117 to 159 days from May to October, and were marketed at an average of 1.3 cm backfat. Interim carcass weights were calculated using dressing percentages determined from the equation y = 0.097x + 53.4 where x is days on feed expressed as a percent of total. This equation was derived from two published serial slaughter feeding trials. All data were expressed as a percentage of total days on feed. Linear and quadratic regression were calculated for each pen and the mixed procedures of SAS was used to determine if the linear and quadratic terms were significant for each variable ($P < 0.05$). Both BW and carcass weight increased quadratically through the feeding period ($P < 0.01$). DMI increased quadratically through the feeding period ($P < 0.01$). Body weight ADG decreased linearly through the feeding period ($P < 0.01$), while carcass weight ADG increased quadratically ($P < 0.01$), resulting in a linear increase in the percent of BW gain that is transferred to the carcass ($P < 0.01$). Feed efficiency decreased linearly on a BW basis ($P < 0.01$), and declined quadratically on a carcass weight basis ($P < 0.01$). While gain and efficiency decreases through the feeding period, the decline is more dramatic when calculated on a live BW basis vs. a carcass basis.

Table 1. Changes in performance variables through the feeding period[1].

Item	Intercept	SE	Linear	SE	Quadratic	SE
Live BW, kg	349	1	2.71	0.02	-0.0023	0.0002
Carcass weight, kg	186	1	1.80	0.01	0.0011	0.0001
DMI, kg/d	10.4	0.1	0.0075	0.0031	0.00010	0.00002
Live BW ADG, kg	1.92	0.02	-0.00299	0.00027	NS	NS
Carcass ADG, kg	1.22	0.05	0.00504	0.00173	-0.00004	0.00001
Weight Transfer, %	61.9	1.2	0.276	0.017	NS	NS
Live BW G:F, g/kg	189	2	-0.5593	0.0230	NS	NS
Carcass G:F, g/kg	118	5	0.3446	0.1459	-0.0042	0.0011

[1]Expressed as a percent of total time on feed. NS = Not significant ($P < 0.05$).

Key Words: carcass, feedlot, performance

O166 **Effects of dietary change on viral-bacterial interactions in the rumen of cattle.** C. Anderson*, M. Jolly, G. Erickson, T. Klopfenstein, S. Fernando, *Animal Science, University of Nebraska, Lincoln.*

Viruses are the most numerous biological entities on the planet, yet little is known about their impact on community structuring due to their size, rapid evolution, and the fact that the majority cannot be cultured. Our knowledge on viral diversity within the rumen and how they help structure microbial communities is in its infancy. However, with contemporary metagenomic approaches the study of viral properties is now a possibility, which has helped in determining the influence of viral populations on complex environments such as the gut microbiome. To better understand the role and functional relationships of viruses, in particular how prophages influence rumen bacterial communities, we have investigated viral and microbial relationships in four different diets using a metagenomics approach. In addition to the bacterial 16S gene, the viral and bacterial metagenomes were sequenced using 454-pyrosequencing to identify species composition, interactions between viruses and bacteria, and metabolic profiles based on diet. Our preliminary analysis demonstrates unclassified single stranded DNA viruses dominating the rumen virome (49%). Of those single stranded DNA viruses, Sclerotinia sclerotiorum hypovirulence associated DNA virus 1 had the highest relative abundance (44.3%). Viral families present in the rumen included *Germiniviridae* (32%), *Microviridae* (12%), *Circoviridae* (5%), *Nanoviridae* (0.8%) and *Inoviridae* (0.09%). This is one of the few studies analyzing the influence of diet on the structure of the rumen microbiome and virome and will help to improve the understanding of dynamics between viral and bacteria populations to improve cattle health, productivity, and feed efficiency.

Key Words: rumen microbes, virome

O167 **Small intestinal digestion of raw cornstarch in cattle is rapidly increased by duodenal infusion of casein.** D. Brake[1,*], E. Titgemeyer[1], D. E. Anderson[2], *[1]Animal Sciences and Industry, [2]Department of Clinical Sciences, Kansas State University, Manhattan.*

Many cattle feeding strategies are designed to maximize ruminal fermentation of starch, because small intestinal (SI) starch digestion is limited. SI digestion of starch, however, is more energetically efficient than ruminal fermentation. SI starch digestion is limited because dietary starch per se reduces pancreatic α-amylase secretion in cattle. Previous data with cattle suggest that intact cornstarch is better digested with greater postruminal protein flows, perhaps due to greater pancreatic α-amylase secretion. Yet, some research failed to demonstrate responses to post-ruminal casein. We used 6 duodenally and ileally cannulated steers to measure basal nutrient flows from a soybean hull-based diet. Cattle consumed 3.7 kg/d DM, 68 g/d dietary N, and 70 g/d dietary starch. Duodenal starch flow was small (38 g/d), and N flow was 91 g/d. SI digestibility of duodenal N was 57%, and SI digestion of duodenal starch flows was 92%. When raw cornstarch (1.5 kg/d) was continuously infused into the duodenum along with CrEDTA as a flow marker, SI starch digestibility was only 34%. Subsequently, cattle receiving 1.5 kg/d raw cornstarch were used in replicated 3×3 Latin squares to measure effects of duodenal casein infusion (200 or 400 g/d) on SI starch digestion and the length of adaptation time required. Casein linearly increased ($P < 0.01$) SI starch digestibility, and SI starch digestion adapted to infusion of casein in 6 d. Ethanol-soluble starch and unpolymerized glucose flowing to the ileum increased linearly ($P \leq 0.01$) with increasing infusion of casein. Plasma cholecystokinin was not affected by casein. Subsequently, we evaluated effects of duodenal amino acids on SI starch digestion. Effects of casein on SI starch digestion could be mimicked by provision of amino acids. Duodenal supply of non-essential amino acids had a greater effect on starch digestibility than did the essential amino acids, but essential amino acids increased ileal flow of ethanol-soluble starch.

Key Words: casein, cattle, starch

O168 **Peripartal immunometabolic indices and hepatic transcriptomics in transition dairy cows in response to methionine supplementation.** J. S. Osorio [1,*], E. Trevisi [2], P. Ji [3], D. Luchini [4], S. Rodriguez-Zas [1], R. E. Everts [1], H. A. Lewin [1], J. K. Drackley [1], G. Bertoni [2], J. J. Loor [1], *[1]University of Illinois, Urbana, IL, United States, [2]Institute of Zootechnic, Università Cattolica del Sacro Cuore, Piacenza, Italy, [3]The William H. Miner Agricultural Research Institute, Chazy, NY, [4]ADISSEO, Alpharetta, GA.*

There is a growing concern about the protein and essential amino acid (AA) balance in transition dairy cows. Our hypothesis was that methionine supplementation with either MetaSmart® (MS) or Smartamine M® (SM) would alleviate inflammation and enhance liver function partly via alterations of transcriptional mechanisms in liver and immunometabolic indices in blood. Thirty-eight Holstein cows were fed the same diet (1.24 Mcal NE_L/kg DM, 14.3% CP) from -50 to -22 d before expected calving. From -21 d to calving cows received a close-up diet (1.54 Mcal/kg DM, 15.1 % CP) with no Met supplementation (CO, n = 14), CO + MS (n = 12), or CO + SM (n = 12). From calving through 30 DIM cows received the same postpartum diet (1.75 Mcal/kg DM, 17.5% CP) (CO), or the CO + MS or CO + SM. The Met supplements were top-dressed over the total mixed ration during the experiment at a rate of 0.19% or 0.07% of feed (DM basis) for MS or SM, respectively. A subgroup of cows (n = 8/diet) was used for analysis of metabolites related to immune function and hepatic transcriptomics. Blood samples were collected to assess immunometabolic indices. Biopsies of liver tissue (-10, +7, and +21) were collected to measure mRNA profiles using a 13,257 bovine oligonucleotide microarray. After calving there was an increase in DMI (P = 0.06) and milk yield (P = 0.08) in Met-supplemented cows. Albumin remained unchanged in Met-supplemented cows, while CO decreased (P = 0.03) after calving. In contrast, there was greater ceruloplasmin (P = 0.01) and serum amyloid A (P = 0.06) in CO cows than Met-supplemented cows. There were 2,663 differentially expressed genes (DEG) affected in liver tissue due to a diet × time interaction. Among the main biological processes enriched within the DEG were AA (cyanoamino acid, cysteine, and methionine), lipoic acid, and glutathione metabolism, in response to supplemented Met. Overall, results indicate that supplementing Met throughout the transition period may diminish inflammatory conditions, enhance liver function, and considerably impact the hepatic transcriptome, all of which may help the cow cope with negative AA balance early after calving.

Key Words: dairy cows, inflammation, transcriptomics

O169 **Effects of two dietary concentrations of Levucell SC in growing or finishing feedlot diets.** G. Huber*, A. DiCostanzo, G. I. Crawford, *Animal Sciences, University of Minnesota, Saint Paul.*

Two experiments were conducted to determine the effect of *Saccharomyces cerevisiae* (SC; Levucell SC 20) on growing or finishing steers. Forty-seven Angus and Simmental steers were allocated in a randomized complete block design during a growing (Exp. 1; Initial BW = 341 ± 6.8 kg) or finishing (Exp. 2; Initial BW = 430 ± 7.7 kg) experiment to one of three treatments: 0, 500, and 1,000 mg of SC/hd daily (SC0, SC500, and SC1000, respectively). Basal diets for Exp. 1 (1.14 Mcal NEg/kg, 15.6% CP) and Exp. 2 (1.39 Mcal NEg/kg, 16.7% CP) consisted primarily of corn earlage and modified distillers grains (MDG; Exp. 1) or dry-rolled corn and MDG (Exp. 2). Steers were fed in a Calan gate individual feeding system, and were weighed every 28 d throughout each experiment. Experiment 1 and Exp. 2 lasted 56 d and 115 d, respectively. For Exp.1, final BW (432 kg) and ADG (1.61 kg) were not affected (P ≥ 0.64) by SC. Overall Exp. 1 DMI measured 9.02, 9.02, and 9.84 kg/d (linear P = 0.12), and G:F measured 0.178, 0.182, and 0.166 (linear P = 0.12, quadratic P = 0.17) for SC0, SC500, and SC1000, respectively. At the end of the step-up feeding period in Exp. 2 (0-28 d), ADG measured 1.64, 1.98, and 1.88 kg (linear P = 0.16, quadratic P = 0.15) andG:F measured 0.158, 0.187, and 0.182 (linear P = 0.11, quadratic P = 0.19) for SC0, SC500, and SC1000, respectively. Final Exp. 2 DMI measured 12.05, 11.34, and 11.09 kg/d (linear P = 0.13) for SC0, SC500, and SC1000, respectively. Final Exp. 2 ADG averaged 1.77 kg and G:F averaged 0.156 and were not affected (P≥ 0.30) by SC inclusion. Inclusion of SC did not affect (P ≥ 0.16) HCW, 12th rib fat thickness, LM area, marbling score, or frequency of individual USDA quality or yield grades. Though no significant differences were present, numeric differences in DMI in growing and finishing experiments warrant further research to determine effects on feedlot cattle performance.

Key Words: cattle, distillers grains, *Saccharomyces cerevisiae*

TEACHING

O170 **Factors impacting undergraduate student success in genetics.** J. M. Bormann*, D. Moser, K. Bates, *Animal Sciences and Industry, Kansas State University, Manhattan.*

The objective of this study was to determine the factors that affected student success in an undergraduate genetics course in the Department of Animal Sciences and Industry at Kansas State University. Data collected from 1,516 students over 11 years included year and semester of the course, student age, gender, state of residence, population of hometown, Kansas City metro resident or not, instructor of course, American College Testing Program (ACT) scores, number of transfer credits, major, college, pre-veterinary student or not, freshman, sophomore, junior, and senior grade point average (GPA), semester credits when taking genetics, class standing when enrolled in genetics, cumulative GPA before and after taking genetics, semester GPA in semester taking genetics, number of semesters between the biology prerequisite and genetics, grade in biology, location of biology course, and final percentage in genetics. Final percentage in genetics did not differ due to instructor, gender, state of residence, major, or college (P > 0.16). Transfer students tended to perform better than non-transfer students (P = 0.09), and students from the Kansas City metro outscored students from other areas (P = 0.03). Pre-veterinary option students scored higher in genetics than non-pre-veterinary students (P < 0.01). Seniors scored higher than juniors and sophomores, who scored higher than freshmen (P < 0.02). We observed a tendency for students with higher grades in biology to perform better in genetics (P = 0.06). Students who took biology at Kansas State University performed better in genetics than students who transferred the credit (P < 0.01). There was a negative regression of hometown population on score in genetics (P < 0.01), and positive regressions of ACT score, all measures of GPA, course load, and cumulative credits on final percentage in the course (P < 0.02). To maximize chances for success in genetics, students should take biology from Kansas State, perform well in biology, and wait until at least sophomore standing to enroll in genetics.

Key Words: genetics, student performance, teaching

O171 **Teaching the fundamentals of swine nutrition using guided discovery.** B. D. Whitaker*, *Animal Science, University of Findlay.*

Students often have little knowledge of or experience in swine nutrition. To introduce students to the principles of swine nutrition and basic feedstuff identification, guided discovery during class was implemented in the swine production and management course. This strategy incorporated lecture, four self-guided assignments, and a small ration project. The course goals were to: 1) explain key concepts in today's industry; 2) demonstrate comprehension by solving issues associated with the industry, and 3) analyze different production systems and management principles currently used in the industry. The activities were designed to provide a mechanism for students to integrate classroom discussion and previous knowledge into experiential situations and self-discovery. Students (n = 27) were evaluated through pre- and post-activity assessments to determine if the guided discovery structure increased their understanding and application of knowledge, based on a scale where 1 = not at all and 10 = expert level. Criteria for increasing knowledge was a positive change in individual assessment score, successfully applying knowledge was defined as 90% of the students receiving a grade of > 80% on the nutrition ration assignment, and a successful educational experience was defined as the students rating the experience > 7. All students significantly increased ($P < 0.05$) their knowledge of swine production and management based on post-assessment compared to pre-assessment scores and self-reported understanding. The ration project assessment indicated significant numbers ($P < 0.05$) of students were successful in applying knowledge. Students enjoyed the method of learning (8.38) and believed it increased their comprehension of the material (7.33). Students believe that the course objectives were met (8.09) and that the guided discovery method was an appropriate learning strategy to use for various principles in swine production (8.96) because it provided opportunities for practical experiences (8.89), which are continuously requested by students (9.25). Based on these results, guided discovery will continue to be used in classes in order to cultivate students' interest in swine production.

Key Words: guided discovery, swine production, hands-on learning

O173 **Development and use of an extensive swine production system in interdisciplinary education.** D. Rozeboom*, L. Thorp, J. Biernbaum, J. Moghtader, D. Fillius, A. Snedegar, K. Turner, L. Goralnik, *Michigan State University, East Lansing.*

The "Pig Project" at the Michigan State University (MSU) Student Organic Farm (SOF) began in September of 2009, with an objective to develop an organic farming system that integrates pork production with vegetable production. The 10 acre SOF is home to the MSU Organic Farming Training Program (OFTP), whose goal is to prepare students for successful careers in organic farming. Students in the OFTP and other majors participate in the daily care and husbandry of the animals including following the animals to slaughter and processing. To-date, 4 years of pork production has been completed: a 43-d finishing project with 5 hogs; feeder-to-finish with 12 pigs; and single batch farrow-to-finish of 2 and 3 litters (18 and 26 pigs' total, respectively). Growing pigs in years 1 and 2, and bred sows in years 3 and 4, were obtained from the MSU Swine Farm. Organic certification was achieved in years 3 and 4. Pork has been sold locally through a Community Supported Agriculture program (CSA), at the MSU Meats Lab, and directly to MSU Culinary Services. In addition to educating future organic farmers in extensive swine production methods, this project has created new experiential learning opportunities for 9 classes (over 300 students) in Natural Science, Philosophy, Integrative Studies in Arts and Humanities, Animal Science, Lyman Briggs, and Community, Agriculture, Recreation and Resource Studies departments. Multiple graduate and undergraduate research projects have utilized these animals, and have led to abstract or paper presentations at 3 professional meetings. The Ph.D. dissertations of 2 graduate students utilized aspects of the project. In the past two years, the biosecurity requirements at the MSU Swine Farm, with its intensive production approach, have been relaxed to allow tours for students to experience and consider extensive and intensive approaches to pork production simultaneously. In-depth key informant interviews were conducted with faculty and staff involved in the project. Preliminary qualitative data analysis reveals that extensive pork production at MSU has enhanced learning about food and sustainability through meaningful interdisciplinary collaborations.

Key Words: experiential learning, pigs, sustainability

O172 **Student leadership skills development after experiences in both intensive and extensive swine production systems.** L. Thorp*, L. Goralnik, K. Powys Whyte, D. Rozeboom, *Michigan State University, East Lansing.*

For students to participate in the world as engaged citizens they not only need to learn about food animal production and sustainability, but also develop the character traits and deliberative skills that enable them to work with others with different values. Instructors in Animal Science, Horticulture, Sociology, Fisheries and Wildlife and Philosophy have collaborated to raise pigs at the Michigan State University (MSU) Student Organic Farm and concurrently assess intensive pig production at the MSU Swine Farm. The farms embed students in elements of what might be considered wicked sustainability issues. Disagreements in animal agriculture and in institutions of higher education are laden with divergent values. There are few educational approaches that are framed in ways that can guide the various perspectives toward mutually beneficial improvement. The wicked problems framework adds dimension to our teaching and provides students opportunities to practice and understand the importance of virtues that are important for collaborative problem-solving. Data were collected pre/post in the form of a reflective worksheet. Analysis reveals the students are united in their care for the animals and each other, expressing almost a unanimous desire to learn more about each other's production system, and to learn more about the animals themselves. The students also shared a sentiment of being tired of dualisms such as organic/conventional, environment/agriculture, large-scale/small-scale, expressing an interest in moving beyond these polarizing divisions recognizing that these categories did not fit who they were or how they thought about food and farming. Students spoke of the need for leadership skills or character traits such as: patience, openness, humility, empathy and willingness to learn from each other across different scales and differing backgrounds. These findings underscore our proposition that moving students out of their disciplinary silos into interdisciplinary experiential learning settings, such as the campus farms, provides a practice field for the development of the participatory skills needed for the global challenges we face.

Key Words: undergraduate education, sustainable pork production, deliberative skills

O174 **Development of a teamwork/leadership activity across two animal science courses.** K. J. Stalder*, T. J. Baas, J. A. Sterle, *Animal Science, Iowa State University, Ames.*

The two swine oriented courses within the Department of Animal Science at Iowa State University are Swine Science (AnS 225) and Swine Systems Management (AnS 425). Faculty involved in teaching these two undergraduate courses had their course content evaluated by an external advisory committee. The advisory committee's evaluation indicated that while very technically sound, our graduates need additional soft skills experience, particularly in communication and team building. In order to further develop interpersonal and communication skills, a teamwork/leadership project was designed involving students from the two swine courses (AnS 225 and AnS 425). Prior to assigning teams, students from both courses were provided leadership training. Additionally, students from AnS 425 were provided personality assessment training. The leadership and personality assessment trainings were designed to help students work more effectively in a team environment. The team mentoring assignment involved an AnS 425 student acting as team leader who was randomly paired with 2 to 3 students from AnS 225. All students were provided team member names and e-mail information, but the AnS 425 students were responsible for making initial team member contacts. The course instructors identified 8 different critical swine industry issues from which the teams identified their top 3 choices or chose an alternative that was approved by the instructors. The project was designed for the AnS 425 students to mentor AnS 225 students as they searched for critical material, identified support data, and as they developed their response to the critical swine issue. The team leader was responsible for giving the presentation, but all members were required to attend their individual team's presentation for assessment purposes. Presentations occurred during non-contact class times and hence the AnS 425 students were responsible for scheduling their team presentation and ensuring that their team met all project deadlines. Students from both courses indicated that additional teamwork/leadership skills development is needed in the Animal Science curriculum at ISU.

Key Words: communication, leadership, teamwork

O175 **Student evaluations of a teamwork/leadership activity across two swine courses in animal science at Iowa State University**. T. J. Baas*, K. Stalder, J. Sterle, *Animal Science, Iowa State University, Ames.*

A new teamwork/leadership exercise was coordinated across two swine-specific courses in the Department of Animal Science at Iowa State University to increase student awareness of the importance of interpersonal and communication skills. Teams were formed by pairing each student in the senior level course (AnS 425) with 2-3 students in the sophomore/junior level course (AnS 225). The exercise/assignment included development of a PowerPoint presentation that would address a current industry critical issue. Each team was required to schedule a 30 minute meeting with two swine faculty to present their material and supporting information. The activity was worth 50 points to each student or about 10% of the total points within each course. A project evaluation form was developed to provide feedback from students regarding the benefits of this teamwork exercise. Students were asked to respond to five questions on a scale of 1 to 10 with 1 being no benefit and 10 being great benefit. They were asked to rate the project in helping them understand their leadership style and the process of working in a team setting, along with how this project might benefit them in other courses at ISU and in their future career. When asked to rate the exercise on a scale of 1 to 10 on how it will benefit them in their future career, over half of the students in each class gave a rating of 8 or higher. Average scores for how the exercise benefitted them in understanding the process of working in a team setting were 7.5 for AnS 225 students and 7.3 for AnS 425 students. As expected, the biggest challenge with the project identified by students was finding time for the team to meet outside of regular class meetings. An additional challenge was the coordination of schedules and the time required by the instructors in meeting with and evaluating each team's presentation. Students recommended that the activity be continued and their evaluations indicated that they see great value in the addition of more teamwork/leadership exercises in Animal Science courses at ISU.

Key Words: teamwork, leadership

O176 **Swine-specific career night for animal science students tt Iowa State University.** B. McNeil*, K. Stalder, J. Sterle, T. Baas, *Animal Science, Iowa State University, Ames.*

Career Day for the College of Agriculture and Life Science at Iowa State University is an opportunity for students to meet with over 200 prospective employers about jobs and internships. The size of the event and the number of students attending can be overwhelming, particularly for freshman and sophomore students seeking their first job experience in their field of interest. With this in mind, a "Swine Industry Night" was held the night before Career Day. Block and Bridle Swine Interest Group officers were responsible for organizing the event. This event had three main objectives: 1) expose underclassmen to swine companies in a very personal, intimate setting; 2) encourage students to be more involved with the larger College of Agriculture and Life Science Career Day; and 3) further develop leadership skills of the Swine Interest Group officers. All swine production companies slated to participate in the larger Career Day were invited to join students for a less formal Swine Industry Night to discuss career and internship opportunities. Nine companies accepted the invitation to attend. Recruiters set up booths in a style similar to what students would see the next day. Students were encouraged to attend by offering them personal time with companies in their area of interest and by providing pizza and soft drinks at the event. Approximately 75 students, including Block and Bridle Club members and several nonmembers, participated in the event. Both students and prospective employers indicated that this was a venue where more was accomplished in a shorter period of time when compared to most other recruiting events. Reviews from both employers and students came back positive and encouraged us to continue the event next year. An event will be planned again next year to continue the development of underclassmen seeking employment in the swine industry and leadership skills of Swine Interest Group officers.

Key Words: career search, swine industry, undergraduate

BREEDING & GENETICS

O181 **Accurate prediction of genomic breeding values across families combining linkage disequilibrium and co-segregation.** X. Sun*, R. L. Fernando, D. J. Garrick, J. C. M. Dekkers, *Animal Science, Iowa State University, Ames.*

Traditional genomic prediction methods relying only on linkage disequilibrium (LD) between marker and QTL can have low accuracy because LD is not likely to be consistent in phase or strength across different families. A linear mixed model fitting both genome-wide co-segregation (CS) and LD (LD-CS model) is developed to improve prediction accuracy across families. CS is modeled as the effects of all 1-centimorgan haplotypes that one individual inherits from pedigree founders through identity-by-descent, while LD is modeled as allele substitution effects for all marker genotypes of that individual. Prediction accuracy of LD-CS model was compared to three LD methods—GBLUP, BayesA and BayesB, using simulated datasets of paternal half sib families varying in number of sires. Within each sire family, 10 half sibs were used for training and to predict breeding values for another 10 half sibs. All individuals had phenotypes for a quantitative trait with heritability 0.5 and genotypes for 2,000 SNPs. Results showed that LD-CS model had significantly higher accuracy than any LD methods except for the dataset of one sire family. With the increase in the number of families, the accuracies of LD-CS model persisted while those of LD methods dropped. In conclusion, by fitting CS explicitly the LD-CS model potentially have higher and more consistent prediction accuracy across families than LD methods.

Table 1. Prediction accuracy of LD-CS model and LD model using GBLUP, BayesA and BayesB for simulated datasets with different number of sires (No. Sires). Results are the average of 32 replicates for each number of sires.

No. Sires	LD-CS	GBLUP	BayesA	BayesB
1	0.345	0.337	0.350	0.347
2	0.535	0.524	0.523	0.526
10	0.503	0.464	0.464	0.463
100	0.546	0.480	0.433	0.327

Key Words: genomic prediction, identity by descent, linkage disequilibrium

O182 **Accuracy of genomic prediction when accounting for population structure and polygenic effects.** N. Piyasatian*, J. C. M. Dekkers, *Animal Science, Iowa State University, Ames.*

Linkage disequilibrium (LD) between QTL and SNPs is an important source of information in genomic prediction, besides co-segregation (CS) of QTL and SNP alleles and additive-genetic relationships (RS). QTL mapping studies have shown that methods such as the transmission disequilibrium test (TDT) that account for population structure reduce spurious LD and thereby decrease the number of false positive QTLs, which may result in higher accuracy when such methods are used for genomic prediction. The accuracy of genomic breeding values from four models were compared in this study, which were 1) the standard SNP effects model, 2) the same model with polygenic effects, 3) a genomic TDT (GTDT) model that fits for each SNP a parent average effect and a mendelian sampling effect, and 4) the GTDT model with polygenic effects. Stochastic simulations were conducted varying the number of QTL, SNP density, training data size, and extent of LD, while simulating an unbalanced population structure with influential sires. Accuracies were obtained for individuals in seven generations after training, such that accuracy of the last generation was mostly due to LD. Previous studies only focused on the accuracy for the offspring of training individuals, which also includes CS and RS. Fitting polygenic effects increased accuracies for all seven validation generations, all scenarios, and for both the standard and the GTDT models. Accuracies from models with polygenic effects tended to be higher in early generations after training, because polygenic effects not only enhance the LD signal but also capture the remaining relationship information that is not exploited by SNPs. The GTDT models always resulted in lower accuracy than the standard models and did not better account for population structure as they showed a similar increase in accuracy with polygenic effects and a lower accuracy due to LD. In conclusion the standard SNP effects models with polygenic effects improved the utilization of LD information when predicting genomic breeding values. Supported by USDA NIFA Grant No. 2010-65205-20341.

Key Words: accuracy, linkage disequilibrium, transmission disequilibrium test

O183 **Improving the accuracy of genomic prediction of milk traits in the New Zealand Holstein Friesian population.** M. Hayr[1,*], M. Saatchi [1], D. Johnson [2], D. Garrick [1], [1]*Animal Science, Iowa State University, Ames,* [2]*LIC, Hamilton, New Zealand.*

Accurate Genomic Estimated Breeding Values (GEBV) are crucial for preventing the accumulation of inaccuracies when unproven parents are selected. This study investigated the effect of including the DGAT1 mutation, a major gene for milk traits, in calculating GEBV. Data on 5,661 Holstein Friesian cows were provided by LIC, a dairy cattle breeding company in New Zealand, and included Illumina SNP50 (50k) genotypes and Deregressed Estimated Breeding Values (DEBV) for fat yield. DGAT1 genotypes were provided for 1,133 cows and DGAT1 genotypes were imputed for the remaining 4,528 cows using BEAGLE. Three models were run in GenSel using the Bayes C method and 5-fold cross-validation with 2.5% of SNPs assumed to have an effect on the trait: 1) a model relying on linked 50k markers to pick up the effect of DGAT1; 2) a model with 50k markers and DGAT1 fit as random effects; and 3) a model with 50k markers as random effects and DGAT1 genotype as a fixed effect. These models were run on all cows then repeated using only cows where DGAT1 had been directly genotyped. The GEBV accuracy was defined as the simple correlation between DEBV and GEBV, whereas the genetic correlation between GEBV and BV would be approximately twice this magnitude after dividing by root heritability to account for residual variation in GEBV. The regression of GEBV on DEBV was obtained to quantify bias in the GEBVs. Accuracy was lowest when only 50k markers were included in the model and increased when DGAT1 was included in the model, with the highest accuracy when DGAT1 was fit as a fixed effect. Regression coefficients were close to one to indicating little to no bias in GEBV, however the least bias was when DGAT1 was fit as a fixed effect. These results suggest that including DGAT1 genotype as a fixed effect when calculating GEBV both increases accuracy of the GEBV and reduces bias.

Table 1. Regression coefficients (b) and correlations (r) between DEBV and GEBV

Model	Direct Genotypes		Direct and Imputed Genotypes	
	b	r	b	r
50k	1.104	0.402	0.908	0.377
50k + DGAT1 (Random)	1.102	0.406	0.911	0.381
50k + DGAT1 (Fixed)	1.014	0.425	0.917	0.389

Key Words: Dairy Cattle, DGAT1, Genomic Prediction

O184 **Comparison of actual 50K and imputed 770K genotypes for QTL mapping in Hereford cattle using 1Mb SNP windows and Bayesian inference.** V. K. Katneni[1], M. Saatch[2,*], D. Berry[3], D. J. Garrick[2], *[1]Central Institute of Brackishwater Aquaculture, Chennai, India, [2]Animal Science, Iowa State University, Ames, [3]Animal & Grassland Research & Innovation Center, Teagasc, Moorepark, Fermoy, Co. Cork, Ireland.*

Using high-density marker panels may help fine mapping of quantitative trait loci (QTL). This study compared two different marker panels with respect to quantifying QTL regions for ten commercially important traits in Hereford cattle. Some 1,081 animals were genotyped with Illumina BovineSNP50 BeadChips (50K). For these animals, genotypes for about 770,000 markers were imputed using genotype information of 364 Irish Hereford cattle genotyped with Illumina BovineHD BeadChip (770K) and BEAGLE software. Actual 50K and imputed 770K genotypes were separately analyzed using deregressed breeding values and a BayesB approach in GenSel software with 1Mb SNP windows (UMD3.1 assembly) to estimate percentage of genetic variance explained by each window. A window explaining more than 1% of genetic variance was considered to be a QTL. Marbling is the only trait where imputed 770K genotypes identified a QTL region not found using 50k genotypes, at 3Mb on BTA4 (4_3). Both 50K and 770K genotypes identified the same QTL windows for weaning weight (20_4 & 7_93), yearling weight (20_4 & 7_93) and fat depth (20_4). Two of the three identified QTL for birth weight (20_4 & 7_93) were in the same window for 50K and 770K genotypes. However, the third QTL was located at 6_38 using 50K but at 6_41 using 770K genotypes. One QTL was identified for calving ease direct using 50K genotypes (6_38) whereas 2 QTL were identified using 770K genotypes (6_37 & 6_41). A QTL for rib eye area was located at 7_93 using 50K and at 7_91 using 770K genotypes. No QTL were identified for calving ease maternal, weaning weight maternal, and scrotal circumference traits. Though the actual and imputed genotypes differ in terms of identified QTL, nevertheless identified QTL are on the same chromosome within 1–3 Mb. In general, QTL identified using 770K genotypes explained more genetic variance compared to 50K genotypes (cumulative genetic variance of identified QTL increased from 19% to 29% for birth weight and from 19% to 25% for calving ease). Results indicate that there are more and stronger signals for existence of QTL using 770K genotypes in comparison with 50K genotypes.

Key Words: GWAS, High density SNP panel, QTL mapping

O185 **A genome-wide association study identified CYP2J2 as a major gene controlling serum vitamin D status in beef cattle.** E. Casas[1,*], R. J. Leach[2], T. A. Reinhardt[1], R. M. Thallman[2], J. D. Lippolis[1], G. L. Bennett[2], L. A. Kuehn[2], *[1]National Animal Disease Center, ARS, USDA, Ames, IA, [2]U. S. Meat Animal Research Center, ARS, USDA, Clay Center, NE.*

Vitamin D is an important modulator of calcium homeostasis and has several effects on the immune system. The objective of the study was to estimate its heritability, and to identify genomic regions associated with concentration of circulating 25-hydroxyvitamin D (25OHD) in beef cattle. Status of vitamin D was measured in crossbred animals from the Cycle VII of the USMARC Germplasm Evaluation Project. Progeny were born from March through May in 2008 and in 2010. Heritability was estimated and a genome-wide association study (GWAS) was conducted on the concentration of 25OHD measured in 1,432 animals at pre-conditioning and 1,333 animals at weaning. Genotyping of the population was done by imputing from the parental generation genotyped with a high density array (777,000 SNP) to a target population genotyped with a medium density SNP array (50,000 SNP). After imputation, 675,018 SNP were used in the GWAS analysis. Heritability of concentration of circulating 25OHD in cattle at pre-conditioning and at weaning was 0.41± 0.08 and 0.32 ± 0.11, respectively. A region on BTA3 was associated with circulating 25OHD. The region on BTA3 had 7 SNP significantly ($P< 7.4 \times 10^{-8}$) associated at the genome-wide level with serum concentrations of serum 25OHD. Genome-wide significant SNP spanned the region between 84.93 megabases (MB) and 86.65 MB; however, 6 SNP reside between 86.64 and 86.65 MB. The gene *CYP2J2* was identified as a candidate gene associated with concentrations of serum 25OHD in cattle. This is one of 6 enzymes involved in metabolizing vitamin D to 25OHD. Results from the present study suggest that *CYP2J2* is a major gene controlling serum 25OHD levels in cattle. *CYP2J2* should be considered a prime candidate for understanding both genetic and physiological factors affecting serum 25OHD concentrations in cattle, therefore, vitamin D status.

Key Words: cattle, CYP2J2, genome-wide association study

O186 **Estimation of genetic marker effects for CAPN1, CAST, and GHR on carcass quality traits in angus cattle selected to increase minor marker frequencies.** R. G. Tait, Jr.[1,*], S. D. Shackelford[1], T. L. Wheeler[1], D. A. King[1], E. Casas[2], R. M. Thallman[1], T. P. L. Smith[1], G. L. Bennett[1], *[1]U.S. Meat Animal Research Center, USDA, Agricultural Research Service, Clay Center, NE, [2]National Animal Disease Center, USDA, Agricultural Research Service, Ames, IA.*

Genetic marker effects and interactions cannot be accurately estimated when minor marker allele frequencies (MAF) are low. To increase the accuracy of estimation for three marker systems in commercial use, an Angus population at USMARC was subjected to marker assisted-selection for multiple years to increase MAF or frequencies of divergent haplotypes (FDH). Substantial increases in FDH and MAF were achieved, with SNP haplotypes in the μ-calpain 1 gene (CAPN1) (haplotypes C-C or G-T at markers CAPN1_316 and CAPN1_4751, respectively) with haplotype increases from 0.456 to 0.530 and 0.242 to 0.363, respectively, and individual markers in the calpastatin (CAST) and growth hormone receptor (GHR) genes with increases from 0.080 to 0.348, and 0.182 to 0.421, respectively. 199 steers born between spring of 2009 and 2011 from this population

(24 sires and 155 dams) were evaluated for: final live weight, dressing percent, hot carcass weight, carcass traits measured by the VBG2000 grading camera {adjusted 12th rib fat thickness, 12th rib longissimus area, marbling, calculated vision yield grade (VYG)}, slice shear force (SSF), and SSF predicted by visible and near-infrared reflectance spectroscopy. Statistical model included effects of marker (CAPN1, CAST, and GHR), year of birth, age of calf, age of dam, and additive polygenic relationships based on a pedigree of 7,433 animals. CAST had a significant effect (P<0.05) on VYG with no evidence (P>0.10) of dominance inheritance. Significant effects were identified for both CAPN1 and CAST (P<0.001 for both) on SSF. There was no evidence (P>0.10) of dominance inheritance for either CAPN1 or CAST on SSF. Furthermore, there was no evidence of an interaction (P>0.10) between CAPN1 and CAST on SSF. Difference between homozygous for the tender and tough genotypes at both CAPN1 and CAST was -4.2 kg (35% of the mean) for SSF. All other genetic marker effects were not significant (P>0.10) for other traits evaluated in this study. These results provide a better understanding of marker effects, mode of inheritance, and independence of markers on beef quality traits.

Key Words: carcass quality, marker selection, tenderness

O187 **Genetic basis of host response to PRRSv infection.** N. J. Boddicker [1,*], J. K. Lunney [2], B. R. R. Rowland [3], D. J. Garrick [1], J. M. Reecy [1], J. C. M. Dekkers [1], *[1]Animal Science, Iowa State University, Ames, [2]USDA, ARS, BARC, Beltsville, [3]Kansas State University, Manhattan.*

Host genetics is an additional tool for controlling the costly disease of Porcine Reproductive and Respiratory Syndrome (PRRS). The objective of this work was to discover the genetic basis of host response to PRRS virus infection by estimating genetic parameters and conducting a genome-wide association study. Eight groups of ~200 commercial crossbred pigs were infected between 25 and 35 days of age with virus isolate NVSL 97-7985. Breeds represented in the crosses included Large White, Landrace, Yorkshire, Duroc, and Pietrain. Blood samples and body weights were collected up to 42 days post infection (dpi). Experimental pigs and their parents were genotyped with Illumina's Porcine 60k Beadchip. Phenotypes analyzed were viral load (VL = area under the curve for log-transformed qRT-PCR based serum virus from 0-21 dpi) and weight gain from 0-42 dpi (WG). Viral load data was only available for the first 7 trials. Heritabilities estimated using pedigree were moderate at 0.41 for VL and 0.29 for WG. Single-nucleotide polymorphism (SNP) associations were identified using Bayes-B of GenSel software. A 1 Mb region on chromosome 4 (SSC4) explained 14.6% of the genetic variance for VL and 9.1% for WG. Effects of the most significant SNP in the region, WUR10000125 (WUR), acted in a dominant manner, with the favorable allele estimated to decrease VL by 4 units (0.53 phenotypic sd) and increase WG by 2 kg (0.49 phenotypic sd). The effect was present irrespective of parental breeds involved in the crosses. All haplotypes that carried the favorable allele (11 of 77) of SNP WUR also had the desirable phenotype. In conclusion, the 1 Mb region on SSC4 explained a sizable proportion of genetic variation in response to experimental challenge with a specific strain of the virus. Heritability estimates were moderate and, with a frequency of 0.15 for the favorable allele, genetic improvement of host response to PRRSv infection is possible. Identification of other genomic regions associated with PRRSv response is underway. This work was supported by PRRS CAP, USDA ARS and NIFA Award 2008-55620-19132, NRSP-8 Swine Genome and Bioinformatics projects, National Pork Board and the breeding companies of the PRRS Host Genetics Consortium.

Key Words: genome-wide association study, PRRSv

O188 **Factors associated with neutralizing antibody response in piglets after experimental infection with the porcine reproductive and respiratory syndrome.** A. Hess[1,*], B. Trible[2], N. Boddicker[1], R. Rowland [2], J. Lunney [3], S. Carpenter [1], J. Dekkers [1], *[1]Animal Science, Iowa State University, Ames, [2]Department of Diagnostic Medicine & Pathobiology, Kansas State University, Manhattan, [3]USDA, ARS, BARC, APDL, Beltsville, MD.*

Identifying genomic markers and pathways associated with host response to porcine reproductive and respiratory syndrome virus (PRRSv) infection will aid in containment of PRRS, which costs the pork industry $664 million annually. Studies have shown that neutralizing antibody (NAb) response contributes to the host's ability to fight infection. This research examined host genetic differences and other factors contributing to variability in NAb response. Data were collected on 464 Large White-Landrace piglets that were experimentally infected with PRRSv isolate NVSL 97-7895. Viremia, evaluated by quantitative RT-PCR, increased and peaked for all pigs at 7-14 days post infection (dpi) and thereafter declined. Viral load was defined as area under the curve of log viremia from 0-21 dpi. Serum samples collected at 42 dpi were assayed for NAb response to the homologous isolate NVSL 97-7895, which was defined as the inverse of the highest 1:2 serial dilution of serum without cytopathic effects and ranged from <8 to >1024. Using an animal model in ASReml, NAb response to NVSL 97-7895 was found to be lowly heritable (h^2=5.7± 9.7%) and to be affected by plate (explained 12.1±4.2% of variance), pen (1.1±2.1%), and litter (2.1±5.9%). A one standard deviation increase in viral load was associated with a 0.35±0.09 decrease in NAb response (P<0.001). Virus rebound, defined as at least a two Log increase in viremia after the virus had started to clear, was observed in 24.4% of pigs and was associated with a 0.78±0.19 increase in NAb response (P<0.001). A SNP on chromosome 4 previously found to be associated with viral load in these data was not associated with NAb response (P=0.84). These data demonstrate that NAb response to PRRSv independently either influences or is influenced by both level of viremia immediately following infection and virus rebound following initial clearance. These data also suggest that there may be a heritable genetic component to NAb response to PRRSv, although further data is needed to confirm this. This work was supported by PRRS CAP, Genome Canada, and members of the PRRS Host Genetics Consortium.

Key Words: neutralizing antibody, pigs, PRRS

O189 **Identification of QTL affecting a piglet's ability to acquire and absorb γ-immunoglobulin from colostrum.** G. A. Rohrer*, L. A. Rempel, J. R. Miles, J. W. Keele, J. L. Vallet, *USDA-ARS-USMARC, Clay Center.*

Consumption of an adequate amount of colostrum is critical to a piglet's survival and productivity. The immunocrit is an inexpensive rapid measurement of the amount of γ-immunoglobulin absorbed by a piglet. Genetic analysis of immunocrits on 5,312 piglets indicated that the heritabilities (se) for direct and maternal effects were 0.13(0.06) and 0.53(0.08), respectively. To identify QTL for direct genetic effects, piglets with the highest and lowest immunocrits from litters of eight or more were selected from 470 litters. The second

highest and second lowest piglets in 24 litters were also selected. Pools were assigned based on sire of the litter. Six sets of high and low pools were created by mixing equal quantities of DNA of ~100 piglets. Pools 1 through 5 were unique and pool 6 contained a subsample of piglets from pools 1 and 2 from litters with the greatest variation. The 12 DNA pools were applied to SNP60 BeadChips. Normalized X and Y values were evaluated with three different methods and the 25 highest ranking SNP were selected from each evaluation for further study. In addition, 10 regions were studied based on a 5-SNP window approach. Selected SNP were individually genotyped in the 988 piglets included in pools as well as 524 piglets that had intermediate immunocrits. Association analyses were conducted fitting an animal model and using genetic parameters previously estimated. Twenty-five SNP were associated ($P < 0.01$) with immunocrit values and 10 remained significant ($P < 0.05$) after Bonferroni correction. These 25 markers were located in 18 genomic regions on 14 different chromosomes. In conclusion, the pooling strategy employed reduced the cost to scan the genome by more than 80% and identified genetic markers that can be used to improve a piglet's ability to acquire γ-immunoglobulin from colostrum. USDA is an equal opportunity provider and employer.

Key Words: passive transfer, pig, QTL

O190 **Estimation of genetic parameters of sow body traits and litter size.** D. Thekkoot [1,*], B. Kemp [2], M. F. Rothschild [1], J. C. M. Dekkers [1], *[1]Animal Science, Iowa State University, Ames, [2]Genesus Inc., Manitoba, Canada.*

Appraisal of sow body composition and condition is important in modern swine breeding programs as these traits affect animal welfare and optimal sow production. The objective of this study was to estimate heritabilities and genetic correlations of sow body weight (BW), body condition score (BCS, measured on a 1 to 5 scale), back fat depth (BF) and loin depth (LD) at the time of farrowing, along with total born (TB) piglets. The data were provided by Genesus Inc. and included information from pure bred Yorkshire and Landrace sows maintained at one of their nucleus breeding facilities and were recorded by company staff as a part of their routine procedures between July 2011 and October 2012. BW, BCS, BF and LD were measured ~5 days before farrowing, when the sows were moved into the farrowing rooms. Genetic parameters were estimated separately for each breed with a multi-trait animal model using ASReml. Fixed effects included in the model were parity (3 levels) and contemporary group (a combination of farrowing year and season – 7 levels). Of the 1110 farrowings from 435 Landrace and 452 Yorkshire sows that were analyzed, 518 were 1st parity, 423 2nd parity, and 169 were 3rd parity. Estimates of heritability of BW, BCS, BF, LD and TB were 0.29 (±0.07), 0.22 (±0.07), 0.44 (±0.07), 0.35 (±0.07) and 0.13 (±0.07) for Landrace and 0.39 (±0.07), 0.18 (±0.06), 0.27 (±0.07), 0.36 (±0.07) and 0.17 (±0.07) for Yorkshire sows. Estimates of genetic correlations among sow body measurement traits were positive and were consistent between two breeds. The estimated genetic correlations between body composition traits (BF and LD) and BW were 0.36 and 0.17 for Landrace and 0.36 and 0.42 for Yorkshire sows. Genetic correlations of sow body measurements with TB were not significantly different from zero. These estimates suggest that sow body measurement traits at the time of farrowing would respond to selection, without negatively impacting litter size, although additional data is needed to confirm the latter. Future work will focus on the relationship of these traits with feed intake and efficiency during lactation and with piglet performance. This work was supported by Genesus inc. and Genome Alberta.

Key Words: body condition, genetic parameter, pig

O191 **Genome-wide association identifies candidate genes for ovulation rate in swine.** D. Nonneman*, J. Schneider, R. Wiedmann, J. Vallet, G. Rohrer, *U.S. Meat Animal Research Center, USDA/ARS, Clay Center.*

Litter size is an economically important trait to producers that is lowly heritable, observable only after considerable investment has been made in gilt development and responds slowly to selection. Ovulation rate, a component trait of litter size, is moderately heritable, sex limited and should respond favorably to genetic selection. The objective of this study was to identify genomic regions associated with ovulation rate. Ovulation rate was collected on pubertal gilts and first and second parity Landrace-Duroc-Yorkshire sows at slaughter (n = 1,180). The animals were genotyped using the Illumina PorcineSNP60 beadchip and analyzed for association using the Bayes C option of GenSel. Over one hundred QTL located on all autosomes and the X chromosome were identified to be significantly (P<0.01) associated with ovulation rate. Fifteen of the most significant QTL accounted for about 48% of the total QTL variance. Candidate genes in these QTL regions that are known to be involved in folliculogenesis include FSHB, ADAMTS19, GDF9, NOBOX and BMP7. One QTL was identified near the ESR1 locus, which has previously been associated with litter size in pigs. While many of these genes are known to be involved in ovulation or associated with litter size in rodents or other species, they have not previously been associated with ovulation rate or litter size in pigs. The identification of candidate genes should lead to the discovery of variation that affects their function and provide useful markers for selection.

Key Words: genome-wide association study, ovulation rate, swine

O192 **The effect of feeding low energy high fiber diets on performance of pigs divergently selected for residual feed intake.** J. Young*, J. Patience, N. Gabler, J. Dekkers, *Iowa State University, Ames.*

Residual feed intake (RFI) is the difference between a pig's observed and expected feed intake based on its growth and backfat, with low RFI (LRFI) pigs being more feed efficient than high RFI (HRFI) pigs. The objective of this research was to determine if pigs selected for LRFI on a high energy low fiber (HELF; 3.31 Mcal ME/kg; 9.5% NDF) diet would still be superior to HRFI pigs when fed a low energy high fiber (LEHF; 2.91Mcal ME/kg; 24.6% NDF) diet. Barrows and gilts (n=168) from the 8th generation of the ISU LRFI and HRFI lines were randomly assigned to one of 12 pens with individual feed intake recording, which were fed either the HELF or LEHF diet. Average daily gain (ADG), average daily feed intake (ADFI) and gain:feed ratio (G:F) were analyzed using PROC MIXED of SAS with fixed effects of line, diet, sex, and the interaction of line and diet, covariates of on-test age and its interaction with line, and random effects of pen and litter. Compared to HRFI pigs, LRFI pigs had better G:F (0.460 vs. 0.401, P<0.001) and lower ADFI (1.41 vs. 1.62 kg/d, P<0.01) when fed the HELF diet but did not significantly differ in G:F (0.353 vs. 0.350, P=0.83) or ADFI (1.40 vs. 1.47 kg/d, P=0.23) when fed the LEHF diet. Diet did not affect ADFI of the LRFI pigs (P=0.92). However, the HRFI pigs had lower ADFI when fed the LEHF vs. HELF diet (1.47 vs. 1.62 kg/d, P=0.14). There were no significant

line differences in ADG, whether fed the HELF diet (637 g for LRFI vs. 645 g for HRFI, P=0.61) or the LEHF diet (514 vs. 533 g, *P*=0.20). Barrows ate more (1.57 vs. 1.39 kg/d, P<0.0001) and grew faster (605 vs. 559 g/d, *P*<0.0001) than gilts but had no significant difference in G:F (0.385 vs. 0.397, *P*=0.25). In conclusion, LRFI pigs fed a LEHF diet did not maintain their superiority in feed intake and feed efficiency compared to HRFI pigs. However, LRFI pigs still grew the same as HRFI pigs when fed the LEHF diet. This project was supported by USDA-AFRI Grant no. 2011-68004-30336.

Key Words: fiber diet, residual feed intake

O193 **Digital evaluation of structural phenotypes common among higher parity crossbred sows.** J. D. Stock [1,*], V. R. Amin [2], D. E. Wilson [2], C. E. Abell [1], K. J. Stalder [1], *[1]Animal Science, Iowa State University, [2]Biotronics, Inc., Ames.*

The objective of this study was to identify similarities among feet and leg soundness traits that contribute to sows' long herd life using digital imagery. Evaluating replacement gilt structural traits has relied on subjective scoring and is subject to bias and error among and between scorers. To reduce the bias and error associated with visual appraisal methods when evaluating feet and leg soundness and provide an objective measurement of these traits; digital methods were used to capture images to evaluate feet and leg soundness traits from older parity sows from two independent populations. There were 21 sows selected from population 1 between parities 5 and 6 and 24 sows from population 2 ranging from parity 6 to 14. Still digital images from the rear and side views for each sow were captured. Rear leg stance and joints of interest included: knee, front pastern, hock, and rear pastern. To assess measurement consistency, angle measures were taken from opposite sides of each joint using the angle measurement tool from image analysis software and then averaged to estimate the joint angle. Using the digital image from the rear of each sow, rear leg angles were measured using the dot tool from image analysis software which supplied a corresponding pixel position and was transformed into an angle measurement for the left and right sides which were also averaged. A mixed model was used to evaluate population and parity effects on each leg angle evaluated. Significant (*P*<0.05) population differences were observed for knee measures. Parity effect was significant (*P*<0.05) for rear leg stance. The present findings indicated that sows from both populations have similar leg conformation values when measured using digital imagining software which may suggest that these values are within some acceptable range to allow for long herd life. This is especially true when considering there were few parity differences observed. However, further work is needed to determine if these associations hold true in other commercial sow and gestation system types. Furthermore, the true value for these digital joint angles should be validated using a large gilt population.

Key Words: digital imagery, structural soundness, swine

DAVID SCHINGOETHE SYMPOSIUM

O194 **The use of co-products in dairy cattle diets.** D. Schingoethe[*], *Dairy Science, South Dakota State University, Brookings.*

Any co-product that contains nutrients can potentially be fed to dairy cattle. Some products are valuable feeds to consider, while others are of minimal value, but may be considered if economical. The intent of this presentation is to review research results when feeding various co-products while providing some insight on feeding considerations with various co-products. Today, more co-products are fed than previously, even in the Midwest, which has had abundant supplies of traditional feeds. It is likely that more co-products will be fed in the future, as supplies and costs of traditional feeds increase. Some areas of the U.S. have been more dependent on feeding co-products for many years. Co-products may be fed primarily as sources of protein, nonfibrous or fibrous energy, or minerals. Co-products may be from non-food sources, food sources, or even result from various processing methods. Co-products evaluated by our research group includes; whey products such as whole whey, partially delactosed whey, whey protein concentrate, lactose, and whey permeate; sunflower products such as sunflower silage, combine tailings, and sunflower hulls; tree products such as aspen pellets; distillers products such as wet and dried distillers grains, condensed distillers solubles, corn germ, high protein distillers grains, and some of the newer modified distillers products; chick peas; and field peas. Some co-products, such as soy hulls and beet pulp, are so commonly used today that many may consider them as standard commodities. Co-products, such as cannery wastes, apple pumice, almond hulls, waste citrus products, etc. may only be available in certain areas and seasons. Some co-products such as whey protein concentrates, have become very valuable as human foods that they are no longer economically viable feeds for animals, except in special situations such as milk replacers. It is conceivable, that in the future, other co-products may become more valuable for human foods or nonfood uses and that other presently undiscovered co-products will become available.

Key Words: co-products, distillers products, whey products

O195 **The evolution of the ever changing co-products.** K. Karges[*], *Industry, AC Nutrition, Winters, TX.*

Continuing evolution of co-products create ever increasing challenges to feed industry personal and nutritionists to stay current with nuances in evolving products. An understanding of the nutritional properties of these new products and what they bring to diet formulation and animal performance is critical in today's economical feeding venue. It is therefore important to have a working general knowledge of how co-products currently being utilized in the market place today are produced and potential nuances of these products. Moreover, the future trends of co-product production are equally important as the evolution of present and future products are continuing to be driven by companies producing these products based on fundamental economic principles. Where this leaves co-products and subsequently their feed value and price in the market place is critical; not only to companies who produce these products, but also brings huge implications which are directly passed on to the feed industry. It is imperative to understand how these products will fundamentally perform at the animal production level which then allows for success of the both separate but yet connected industries; the co-product industry and animal feeding industry. The future of co-product success in the market place will be directly linked to two things: 1) critical mass level of production for a given product and 2) nutritional feed value.

Key Words: coproducts, grain, next generation

O196 **Nutrient variability in co-products affecting ration cost and performance in lactating dairy cows.** D. Kleinschmit [1,*], D. Casper [2], *[1]Agri-King, Inc., Fulton, IL, [2]Dairy Science Dept., South Dakota State University, Brookings.*

The use of corn co-products, such as distillers grains (DG) from ethanol plants are widely used in the dairy nutrition industry, particularly in the Midwest. Distillers grains is typically a very economical sources of feed that provides energy, digestible fiber, protein, and phosphorus, depending on the coproduct used. However, one of the challenges with DG is the plant-to-plant nutrient variability that occurs. If one is purchasing DG through a third party, such as a mill, it may be difficult to guarantee a consistent source. This inconsistency in nutrient quality will affect the value of different sources of DG. If one would look at rations with different sources of DG, one will notice that the costs of these rations will vary because one may need to purchase other feedstuffs to compensate for the changes in DG nutrient content. Furthermore, a change in DG nutrient content may have a significant impact on milk production if not fully accounted for, which will also have a significant effect on a dairy producer's bottomline. It is important to try to guarantee a consistent source of and regularly sample DG to minimize impact that nutrient inconsistencies in DG will have on a producer's bottom line.

Key Words: co-products, dairy cows

O197 **Co-product availability and their value in dairy cattle diets.** M. Jerred*, *Cargill, Elk River.*

Ruminant animals have the ability to effectively utilize a tremendous number of co-products generated from the food processing industry as valuable nutrient sources. This presentation will focus on the availability of various co-products and their value as nutrient sources in dairy cattle diets. Overall value is linked to numerous factors including the price of the co-product, nutrient concentration, nutrient variability, nutrient requirements of the animal, and the price of alternative nutrient sources available to the farm. Based on these and other factors, individual co-products can be evaluated through diet formulation to understand their economic impact on overall diet cost.

Key Words: co-products, price

O198 **Ways to feed dairy cattle to get through current conditions.** L. Whitlock*, *Progressive Dairy Solutions, Merced.*

This presentation will focus on how to feed dairy cows to get through the current economic conditions. The current high prices and lack of available feed ingredients is causing dairy producers to look for new ways to feed dairy cattle.

Key Words: dairy cattle

EXTENSION – BEEF/SMALL RUMINANT

O199 **Predicting marbling score and feedlot gain in angus steers utilizing gene max technology.** G. Fike[1,*], M. King[1], L. Corah[1], M. McCully[2], K. Andersen[3], *[1]Certified Angus Beef LLC, Manhattan, [2]Certified Angus Beef LLC, Wooster, [3]Pfizer Animal Health, Kalamazoo.*

Yearling Angus steers (n=173) originating from a single source and fed at Pratt Feeders, Pratt, KS, in 2012 were used to evaluate the effectiveness of a DNA marker-assisted test known as GeneMax™ (GMX™, Certified Angus Beef LLC; Score range = 1-99) in predicting marbling score and feedlot gain. All steers were managed and fed similarly during the feeding period and harvested when they were visually determined to carry 1.3 cm back fat. A blood sample was drawn from each steer and analyzed using the GMX™ test. The steers were divided into four treatment groups based on the GMX™ Score: high, 80-99 (H, n=83); mid-high, 60-79 (MH, n=32); mid-low, 40-59 (ML, n=30) and low, 1-39 (L, n=28). The effect of GMX™ groups on continuous performance and carcass traits was quantified using multiple regression analysis. The association between GMX™ groups and *Certified Angus Beef*® (CAB®) acceptance rate was determined by logistic regression. Since mean beginning weights were significantly different between treatment groups, models were adjusted for in-weight when appropriate. Marbling score (Small^0=400) was greater (P<0.05) for H steers than for ML and L steers (536.0 vs 488.4 and 470.2, respectively), but was similar to that of MH steers (516.0). Ribeye area was significantly larger in ML steers compared with H steers, but was similar to the other two groups. GMX™ treatment group had no effect (P=0.6513) on feedlot ADG (1.97, 1.98, 1.94 and 1.92 kg/d for H, MH, ML and L groups, respectively), while HCW (416, 416, 414 and 413 kg), back fat thickness (1.3, 1.3, 1.2 and 1.2 cm), DOF (142.0, 142.0, 143.9 and 143.2 d), calculated Yield Grade and carcass value (1923.94, 1926.42, 1893.21 and 1894.07, USD/hd) were also not affected (P>0.05) by treatment group. H and MH steers were 4.96 and 4.62 times more likely to qualify for CAB® (P=0.0013 and 0.0077, respectively) than L steers. In this study, feedlot ADG and GMX™ Score were not significantly related; however, both marbling score and CAB® acceptance rate were positively associated with higher GMX™ Scores.

Key Words: GeneMax, marbling score, steers

O200 **Effect of limit feeding and feeding frequency on cultural energy use and sustainability of yearling beef steers.** H. Koknaroglu[1], T. Akunal[1,*], O. Koskan[1], T. M. Delehant[2], M. P. Hoffman[2], *[1]Animal Science Department, Suleyman Demirel University, Isparta, Turkey, [2]Animal Science Department, Iowa State University, Ames.*

Data of four-year study using 672 predominantly British crossbred yearling steers and aiming to define effect of limit feeding and feeding frequency on feedlot performance was used to assess sustainability cattle feeding programs in terms of cultural energy use efficiency. Cultural energy (CE) is the energy other than solar energy needed to produce food and fiber and energy output/input ratios is one of the most useful methods to examine the potential long-term sustainability of various agricultural practices and this analysis is performed to quantify the energy return from products produced relative to the CE invested to produce the product. Steers were started on feed during May or November and were allotted to 16 pens of seven animals each. Cattle were either fed once per day at 8 AM (1X) or twice per day at 8 AM and 4 PM (2X). The feed intake levels were ad libitum (AL), 95% of ad libitum (95%AL) and 90 % of ad libitum (90%AL). All steers were fed a whole corn grain, chopped alfalfa hay, molasses and diet supplemented with a urea-based 40% crude protein, vitamin and mineral premix which contained Rumensin. Pens of cattle were harvested at approximately 560 kg. CE used for feed and other production inputs was derived from their corresponding lot feed consumption and their corresponding values from literature. Energy value of the carcass comprised the output. Total CE input was highest for cattle fed 90%AL- 1X and was lowest for cattle fed 90%AL-2X (P<0.05). CE expended on feed constituted more than half of the total CE and was higher for cattle fed AL-1X and 90%AL-1X and was lowest for cattle fed 90%AL-2X (P<0.05). CE expended per kg carcass was lower for 90%AL-2X and this was lower than other treatments except

95%AL-1X and 95%AL-2X (P<0.05). Energy use efficiency defined as the Mcal input/Mcal output was better for 90%AL-2X and worse for AL-1X and these two differed from each other (P<0.05). Within each feeding level, increasing feeding frequency tended to improve energy use efficiency (P>0.05). Results show that limit feeding and increasing feeding frequency tended to improve CE use efficiency thus enabling these systems to be more sustainable.

Key Words: feeding frequency, limit feeding, sustainability

O201 **Inclusion of condensed corn distillers solubles in beef cattle diet affects sustainability in terms of cultural energy use efficiency.** H. Koknaroglu [1,*], T. Akunal [1], O. Koskan [1], F. E. Doscher [2], M. P. Hoffman [3], *[1]Animal Science Department, Suleyman Demirel University, Isparta, Turkey, [2]Animal Science Department, North Dakota State University, Fargo, [3]Animal Science Department, Iowa State University, Ames.*

A three-year study integrating pasture and drylot feeding systems was used to assess cultural energy (CE) analysis of cattle production systems. In the first year, 112 crossbred steers of primarily British breed origin were randomly assigned to four treatments. Treatments were: 1) fall-born calves directly into feedlot (F), 2) fall-born calves directly into feedlot and receiving condensed corn distiller soluble (F+CCDS) in place of molasses, 3) fall-born calves put on pasture in May and moved to the feedlot in September (P), 4) fall-born calves put on pasture in May and allowed free choice access to CCDS via a lick tank and moved to the feedlot in September (P+CCDS). In second and third year an additional treatment which consisted of raising cattle on pasture for the entire study and fed shelled corn, a protein, vitamin, and mineral supplement and free choice CCDS was added (PF+CCDS). In feedlot F and P received a diet of shelled corn, alfalfa hay, protein, vitamin and mineral supplements, as well as molasses. On the other hand F+CCDS and P+CCDS received a diet of shelled corn, alfalfa hay, protein, vitamin, and mineral supplements, and CCDS in place of molasses. Bromegrass pasture of 0.69 ha/paddock was rotationally grazed. Pens of cattle were harvested at approximately 590 kg. CE used for pasture establishment and maintenance were calculated using the actual inputs and corresponding energy values from the literature. CE inputs were calculated by multiplying amount of input and their corresponding cultural energy values from the literature. Output in the study consisted of energy value of carcass. Total cultural energy input was highest for F and lowest for F+CCDS (P<0.01). Feed energy comprised more than half of the total cultural energy and was highest for F and lowest for F+CCDS (P<0.01). Energy expended per kg live weight was higher for PF+CCDS and F (P<0.01). In feedlot inclusion of CCDS resulted in better energy use efficiency defined by kcal input/kcal output (P<0.01). Results show that inclusion of CCDS is an effective way of reducing cultural energy expenditure and supports the concept of sustainable agriculture.

Key Words: beef cattle, condensed corn distiller soluble, sustainability

O202 **Sustainability, under which conditions: Sustainability revisited.** H. Koknaroglu [1], O. Koskan [1,*], T. Akunal [1], M. P. Hoffman[2], *[1]Animal Science Department, Suleyman Demirel University, Isparta, Turkey, [2]Animal Science Department, Iowa State University, Ames.*

Cultural energy use efficiency, profitability and environmental impact are indicators of sustainability. Cultural energy use efficiency, profitability and greenhouse gas emissions of three-year study integrating pasture and drylot feeding systems were calculated. Each year, 84 fall-born and 28 spring-born calves of similar genotypes were used. Fall-born and spring-born calves were started on test in May and October, respectively. Treatments were: 1) fall-born calves directly into feedlot; 2 and 3) fall-born calves put on pasture with or without an ionophore and moved to the feedlot at the end of July; 4 and 5) fall-born calves put on pasture with or without an ionophore and moved to the feedlot at the end of October; 6 and 7) spring-born calves put on pasture with or without an ionophore and moved to the feedlot at the end of October. A 12.1 ha bromegrass pasture was divided into 16 paddocks of 0.69 ha each. A new approach combining all three sustainability indicators was used to develop a new sustainability index. Sustainability index was developed by assigning a value of 100 to the best value in each indicator. Later range value for each indicator was found and was divided into 10 percentile. In each percentile, weighted percentage was found by dividing number of observations to 10. Weighted percentages were deducted from 100 and animals were ranked for each indicator. A new sustainability index was developed by combining three indicators. Regression equation for percent sustainability was found as= 154 - 0,0222*greenhouse gas emission - 13,3*cultural energy use efficiency + 0,0412*profitability. Model explained %99.92 of the variation. Treatment means were compared by Tukey method. Results showed that treatments 6 and 7 had higher sustainability index than treatment 1, 4 and 5 (P<0.05). Treatments 4 and 5 had lowest sustainability index even though they had best cultural energy use efficiency and comparable profitability. Thus this index shows that a decision should not be made without considering all indicators.

Key Words: cultural energy, greenhouse gas emission, sustainability index

O203 **Effect of bale feeder design and forage quality on hay waste.** W. Moore*, W. J. Sexten, *Animal Science, University of Missouri, Columbia.*

Forty-eight spring-calving crossbred cows, 124±8 d in gestation were used in a 3X2 factorial arrangement with three bale feeder designs and two forage qualities in a randomized complete block design with period as blocking factor to evaluate the effect of bale feeder design and forage quality on hay waste. Cows were stratified by age (4±2.5 years), weight (517±68.8 kg), body condition score (5.5±0.42 units) and 12th rib ultrasound measured fat thickness (0.4±0.16 cm) into six replicate pens with eight cows per pen. Each replicate was randomly assigned to one of six concrete, bedded pens. Bale feeder designs evaluated include open bottom with 17 slanted feeding stations (Open) (2.4 m diameter, 1.2 m tall), solid bottom with 15 slanted feeding stations and tapering sides (Taper) (2.1 m diameter top, 2.4 m diameter bottom, 1.2 m tall, 0.5 m sheeting), and solid bottom and top with 16 straight feeding stations and chain cone (Cone) (2.3 m diameter, 1.7 m tall, 0.6 m bottom sheeting, 0.5 m top sheeting). Forage qualities were alfalfa haylage (HQ) (41% DM, 17% CP, 49% NDF, 34% ADF) or mature fescue hay (LQ) (92% DM, 7.5% CP, 66% NDF, 36% ADF). We hypothesized cone and sheeting would reduce hay waste with LQ, but not affect HQ waste. Waste was considered forage outside of feeder and was collected at 24, 48, and 72 hours for HQ following a 4 d acclimation period while LQ was collected at 24, 48, 72 and 96 hours following a 6 d acclimation period. Waste was divided into contaminated and clean forage subgroups. Subgroups were then sub-sampled and weighed for determination of dry matter content. Orts were sampled and weighed at 96 hours for LQ and 72

hours for HQ. An interaction ($P<0.05$) for total waste (% of bale weight) was observed between forage quality and feeder design where LQ Open was greatest ($P<0.05$) (20.5%), LQ Taper was intermediate ($P<0.05$) (14.9%) but greater than ($P<0.05$) LQ Cone (7.8%) which was not different ($P>0.10$) from HQ Taper (5.3%), HQ Open (5.3%), or HQ Cone (4.7%). Waste was not different ($P>0.10$) for bale feeder design within HQ. Cone feeder and bottom sheeting are both effective at reducing waste of low quality forage.

Key Words: bale feeder, forage quality, hay waste

EXTENSION – SWINE

O204 **Traits associated with gilt cyclicity in a heat stressed environment.** M. Knauer*, A. Terpening, *Department of Animal Science, North Carolina State University, Raleigh.*

The objective of the study was to identify characteristics related to gilt cyclicity under heat stressed conditions. A cohort of Landrace × Large White composite gilts (n=393) were reared at the NCDA Tidewater Research Station. Gilts were placed in a curtain sided building on fully slatted floors in groups of 15 (0.84 m^2 per pig). Stir fans and timed sprinklers were used for cooling once temperatures reached 27°C. Starting at 130 d of age (May 15, 2012) each group of gilts was penned with three mature boars for seven minutes daily and estrous behavior recorded. Average maximum daily heat index during the 96 d estrous detection period was 33.9°C. Traits measured included; birth weight, weaning age, weaning weight, age at first boar exposure, age at puberty, puberty weight, length of estrus, vulva width, days to 114 kg and 10th rib backfat and loin muscle area at 114 kg. Puberty was defined as the first observed standing reflex for the back-pressure test. Females that attained puberty were classified as having a normal return to second estrus (NORMAL, 18 to 24 d), irregular return to estrus (IRREGULAR, ≥ 25 d) or did not return to estrus (NORETURN). Statistical analyses were carried out in SAS using PROC MEANS and PROC GLM. Only 234 (60%) gilts attained puberty by 226 d of age. Of those, average age at puberty was 192 d (SD ± 21). Mean length of estrus was 1.69 d (SD ± 0.72) and 1.83 d (SD ± 0.72) at puberty and second estrus, respectively. Of the gilts that reached puberty, 71% exhibited a NORMAL second estrus, 16% IRREGULAR and 13% NORETURN. Only age at puberty and length of estrus were significantly ($P < 0.05$) associated with gilt cyclicity. Females with a NORMAL or IRREGULAR return to second estrus were younger ($P < 0.05$) at puberty in comparison to NORETURN gilts (173.8 and 173.2 d, respectively vs. 182.6 d). Gilts with a NORMAL second estrus had a longer ($P < 0.05$) length of estrus at puberty when compared to IRREGULAR or NORETURN females (1.87 d vs. 1.36 and 1.47 d, respectively). Results suggest selection for either a younger age at puberty or longer length of estrus would improve gilt cyclicity in a heat stressed environment.

Key Words: gilt, puberty, reproduction

O205 **Relationships between body condition and subsequent reproductive performance for sows housed in individual pens.** M. R. Bryan[1,*], D. C. Kendall[2], D. Baitinger[3], M. T. Knauer[1], *[1]North Carolina State University, Raleigh, [2]Prestage Farms, Clinton, [3]Baitinger Engineering, Ankeny.*

The objective of the study was to quantify the relationship between sow body condition and subsequent reproductive performance. Landrace × Large White sows (n=75) were measured in early gestation at a commercial farm in eastern North Carolina. A Knauer sow caliper was used to measure the angularity of a sow's topline at the last rib. Sow weight (WT) was estimated from heart girth circumference and parity recorded. Backfat (BF) and loin depth (LD) were measured from a 10th rib cross-sectional image by a Real-Time ultrasound technician. Visual body condition was scored on a 1 to 5 scale by the farm staff (FARMBCS) and an expert (BCS). Sow performance traits obtained or calculated from farm data included: number born alive (NBA), stillbirths (STB), number weaned (NW), whether or not a sow farrowed, number born alive per exposed female (NBA_EF) and number weaned per exposed female (NW_EF). Data were analyzed in SAS using PROC GLM. As WT decreased, NBA increased ($P < 0.05$), STB decreased ($P < 0.01$) and NW tended to increase ($P = 0.08$). Parity was not associated ($P > 0.05$) with STB when WT was in the model. An intermediate optimum caliper angle minimized STB and maximized NW. As BF increased NW decreased ($P < 0.05$). However, sows that farrowed a litter had a greater ($P < 0.05$) caliper angle (126.1 vs. 121.6°), WT (224 vs. 206 kg), BF (23.5 vs. 19.6 mm), FARMBCS (2.97 vs. 2.50) and BCS (2.83 vs. 2.36) than those females that did not farrow. An intermediate optimum LD (55.9 mm), WT (227 kg) and caliper angle (127.5°) maximized both NBA_EF and NW_EF. A higher BCS was associated ($P < 0.05$) with greater NBA_EF and both a higher FARMBCS and BCS tended ($P< 0.10$) to be correlated with greater NW_EF. Thinner sows were favorable for litter size yet heavier conditioned sows were preferable for remaining in the herd and farrowing a litter. Results show an intermediate weight, loin depth and Knauer sow caliper score maximized subsequent reproductive performance.

Key Words: body condition, reproductive performance, sow

O206 **Effect of deviations from predicted lactation feed intake on reproductive performance.** C. Yoder[1,*], J. S. Fix[2], C. R. Schwab[3], T. J. Baas[1], *[1]Iowa State University, Ames, [2]National Swine Registry, West Lafayette, [3]The Maschhoffs, Carlyle.*

The objectives of this study were to quantify significant negative deviations (DEV) from predicted daily lactation feed intake values and estimate the effects on reproductive performance and subsequent intake in purebred and F1 sows. Daily lactation feed intake (LFI) records from day 1 to 22 of lactation in purebred Yorkshire (n = 1587) and Landrace (n = 2197) females, and F1 Yorkshire x Landrace (n = 6932) females were used to predict daily LFI values. The model included fixed effects of breed, season, parity group, day of lactation, and interactions of day with breed and parity group, and a covariate for litter size after cross-fostering. Random effects of litter, contemporary group (herd-year-month), dam, and sire nested within breed were also included. Deviations from predicted LFI values were quantified using an internally studentized residual (SR). A SR ≤ -1.71 was considered a DEV event. Zero DEV occurred in 60% of lactation records, while 18% of lactation records had 1 DEV, and 22% of lactation records had ≥ 2 DEV. Adjusted 21-day litter weaning weight (LW21) was lower ($P < 0.05$) when the number of DEV increased within a lactation period, and wean-to-first service interval (WTSI) increased when at least 3 DEV occurred during lactation. An increase in number of DEV during early lactation did not affect LW21 or WTSI ($P > 0.05$), though increasing number of DEV during mid and late lactation were associated with lower LW21 and longer WTSI ($P < 0.05$). Odds that a negative deviation from predicted LFI would occur in consecutive days (DEV2) were evaluated using logistic regression. A DEV2 was 8.7 and 39.5 times

more likely to occur after a DEV occurred the previous day than after a day with adequate intake for purebred and F1 sows, respectively. A DEV was 3.1 ($P < 0.05$) times more likely to occur during late lactation when a DEV had occurred previously in early lactation in F1 sows. Negative deviations from predicted LFI values significantly decreased reproductive performance, increased the likelihood of multiple DEV occurring during lactation, and had larger effect on performance when they occurred during late lactation.

Key Words: feed intake, lactation, studentized residual

O207 **Feed efficiency of swine—A survey of current knowledge.** J. Flohr [1,*], M. D. Tokach [1], J. L. Nelssen [1], S. S. Dritz [1], J. M. DeRouchey [1], R. D. Goodband [1], J. F. Patience [2], *[1]Kansas State University, Manhattan, [2]Iowa State University, Ames.*

Pork producers and advisers to the swine industry were surveyed about their knowledge of feed efficiency. The questionnaire had 3 objectives: 1) determine the knowledge level related to feed efficiency topics; 2) identify production practices being used that influence feed efficiency, and 3) identify information gaps or areas requiring more research to further improve feed efficiency. A web based survey with 32 knowledge, production, and discovery questions were asked. Demographic questions were used to categorize respondents by industry segment (producer, consultant, academia, or other), and years of experience (0 to 5, 5 to 10, 10 to 20, and 20 or more). Six knowledge questions about the effects of fat inclusion, particle size, pelleting, temperature, feed additives, and sow feed usage on feed efficiency were asked. Answers were categorized as correct (46%), incorrect (28%), or not sure (26%). Further categorizations of these responses are listed below. Overall, results suggest there are gaps in the knowledge about practices that affect feed efficiency. Consultants were the only industry segment who averaged more than 50% correct responses to knowledge questions. As years of industry experience increased correct answer percentage also increased. Knowledge needs varied by industry segment with producer responses indicating that they need more information on the effects of fat inclusion, particle size, feed additives, and temperature on feed efficiency. These results will help extension educators inform specific industry segments with current information and provide for more specific areas of future research where information gaps have now been identified.

Industry Segment	Producers	Consultants	Academia	Other
Correct	42%	58%	35%	32%
Incorrect	23%	30%	35%	32%
Not sure	35%	12%	30%	36%
Years of Experience	0 to 5	5 to 10	10 to 20	20 or more
Correct	37%	39%	41%	48%
Incorrect	17%	28%	29%	33%
Not sure	47%	34%	30%	19%

Key Words: feed efficiency, survey, swine

O208 **Production performance factor analysis of commercial swine operations.** C. Abell [1,*], J. Mabry [1], C. Hostetler [2], K. Stalder [1], *[1]Iowa State University, Ames, [2]National Pork Board, Clive.*

The objective of this study was to determine the factors that explain the variation in production performance between commercial swine operations. The data used for this study was collected from October 2005 through December 2011 from U.S. sow, nursery, and finishing farms. Monthly, averaged company-wide records from over 50 companies were included with an average of over 40 records per company. Different performance indicators were analyzed for each segment of the production system. A factor analysis was conducted to identify production indicators that explain greatest proportion of the variation in production performance between the different companies. The factors evaluated for sow farm production were measurements of sow feed intake, piglet and sow morality, litter size, and sow productivity. The nursery and finisher factors were mortality, exit weight, daily gain, feed conversion ratio, and days in the barn for the respective production system stage. The top three factors from the factor analysis for each production stagewere used to explain the overall variation in each production stage. These three factors explained 50% of the sow farm, 74% of nursery, and 72% of finisher variation. The first factor for the sow farm was dominated by number born alive, total born, and pigs/sow/year. Sow intake controlled the second factor. The third factor was not as dominated by a specific set of production indicators, but litters/sow/year was the indicator with the largest weighting. For the nursery data, exit age and nursery days were given the highest weighting in the first factor, daily gain and start age were given the highest weightings in the second and third factors, respectively. Total gain and exit weight were given moderately high weighting in both the first and second factors. A similar result was found for the finisher data. Finishing age and days at the finisher dominated the first factor, and total gain and finish weight controlled the second factor. Start age was the highest weighted production indicator in the third factor. Identifying production indicators that are most variable between swine operations can allow producers to focus on certain factors to improve their productivity.

Key Words: factor analysis, performance, swine

NONRUMINANT NUTRITION: GROWING-FINISHING NUTRITION AND MANAGEMENT

O215 **Effects of pellet quality and feeder adjustment on growth performance of finishing pigs.** J. Nemechek [1,*], M. Tokach[1], E. Frugé [2], E. Hansen [2], S. Dritz [1], R. Goodband [1], J. DeRouchey [1], J. Nelssen [1], *[1]Animal Science and Industry, Kansas State University, Manhattan, [2]Hubbard Feeds, Inc, Mankato.*

A total of 252 pigs (PIC 327 × 1050, 56.8 kg BW) were used in a 69-d trial to determine the effects of pellet quality and feeder adjustment on growth performance of finishing pigs. There were 5 pens per treatment with 7 pigs and 1 replicate with 6 pigs per pen. Treatments were arranged in a 2 × 3 factorial with main effects of feeder adjustment and diet form. The conventional dry feeders had 2, 35.6-cm-wide by 11.4-cm-deep feeder holes. Feeder adjustments were narrow and wide (maximum gap opening of 1.27 and 2.54 cm). Diet forms were meal, poor-quality pellets (50% fines), and screened pellets with minimal fines. No interactions were observed ($P>0.14$). From d 0 to 22 and d 22 to 48, feeder adjustment did not influence ($P>0.28$) ADG, but ADFI tended to (d 0 to 22; $P<0.07$) or did decrease (d 22 to 48; $P<0.02$) while G:F increased ($P<0.05$)

O215 Table

		Maximum feeder opening						
		1.27 cm			2.54 cm			
	Diet form:	Meal	50% pellet + 50% fines	Screened pellet	Meal	50% pellet + 50% fines	Screened pellet	SEM
d 0 to 22:	ADG, kg	0.97	0.93	1.00	0.98	0.96	0.99	0.029
	G:F	0.422	0.441	0.462	0.407	0.420	0.451	0.007
d 22 to 48:	ADG, kg	0.98	1.05	1.01	1.03	1.05	1.02	0.021
	G:F	0.364	0.402	0.407	0.357	0.369	0.403	0.008
d 48 to 69:	ADG, kg	0.91	0.99	1.01	0.94	0.98	1.00	0.032
	G:F	0.279	0.300	0.324	0.266	0.288	0.323	0.009
d 0 to 69:	ADG, kg	0.95	1.00	1.00	0.98	1.00	1.00	0.019
	G:F	0.349	0.374	0.392	0.337	0.354	0.387	0.006

for pigs fed from the narrow adjusted feeders compared to the wide adjustment. From d 48 to 69, feeder adjustment had no effect on growth.Overall, ADG did not differ ($P>0.46$) between pigs fed from the 2 feeder adjustments, but ADFI decreased ($P<0.03$) and G:F increased ($P<0.03$) for pigs fed from the narrow adjusted feeders compared to the wide adjustment. The response to diet form was similar among phases. Overall, pigs fed meal diets tended to have decreased ($P<0.08$) ADG and had decreased ($P<0.001$) G:F compared with pigs fed screened pellets, with those fed poor-quality pellets intermediate. Feeding meal or poor-quality pellets increased ($P<0.02$) ADFI compared to pigs fed screened pellets. In conclusion, reducing feeder gap reduced feed wastage and improved G:F. Feeding pelleted diets improved G:F, but improvement was greatest when percentage of fines was minimized. (See table above.)

Key Words: feeder adjustment, pellet, pig

O216 **Effects of corn particle size, complete diet grinding, and diet form on pig growth performance, caloric efficiency, and carcass characteristics**. J. A. De Jong [1,*], J. M. DeRouchey [1], M. D. Tokach [1], R. D. Goodband [1], S. S. Dritz [1], J. L. Nelssen [1], C. Hastad [2], *[1]Animal Science, Kansas State University, Manhattan, [2]New Fashion Pork, Jackson.*

A total of 855 pigs (25.6 kg BW) were used in a 111-d trial to determine the effects of corn particle size, complete diet grinding, and diet form (meal or pellet) on finishing pig growth performance, caloric efficiency, and carcass characteristics. Pigs were allotted to 1 of 5 dietary treatments (8 or 9 pens/treatment with 19 pigs/pen). The same corn-soybean meal–based diets containing 30% dried distillers grains with solubles and 20% wheat middlings were used for all treatments. The 5 treatments were: 1) roller ground corn (650 µ) and fed in meal form (596 µ); 2) hammer-mill ground corn (320 µ) and fed in meal form (487 µ); 3) treatment 2 pelleted; 4) complete mixed diet reground through a hammer mill to approximately 360 µ and fed in meal form; and 5) treatment 4 pelleted. Overall (d 0 to 111), reducing corn particle size improved ($P<0.03$) G:F and caloric efficiency on a ME and NE basis. Grinding the complete diet decreased ADG, ADFI, and final BW when fed in meal form, but increased performance when pelleted resulting in diet form × portion ground interactions ($P < 0.02$). Pelleting improved ($P<0.02$) ADG, G:F, ME and NE caloric efficiencies, final BW, HCW, and loin depth. Reducing corn particle size and pelleting complete diets improved performance and carcass characteristics. Fine-grinding the entire diet was detrimental when fed in meal form but improved performance when pelleted.

Treatment:	1	2	3	4	5	
Portion ground:		Corn	Corn	Diet	Diet	
Item, Diet form:	Meal	Meal	Pellet	Meal	Pellet	SEM
ADG, kg	0.92	0.93	0.96	0.90	0.98	0.01
ADFI, kg	2.58	2.53	2.48	2.48	2.55	0.03
G:F	0.36	0.37	0.39	0.37	0.39	0.003
Caloric Efficiency, mcal/kg						
ME	9.15	8.80	8.43	8.89	8.44	0.08
NE	4.41	4.23	4.06	4.28	4.06	0.04
Final BW, kg	122.8	125.0	125.5	121.8	129.4	1.11
HCW, kg	90.9	91.2	93.1	89.3	94.7	0.75
Loin depth, mm	60.1	59.5	61.5	59.4	60.2	0.54

Key Words: finishing pig, particle size, pellet

O217 **Interaction between feeder space availability and corn DDGS on grow-finish pig performance and total tract digestibility in a commercial setting.** E. K. Weber[*], K. J. Stalder, J. F. Patience, *Animal Science, Iowa State University, Ames.*

There is a need to re-evaluate feeder space allowance as the industry moves to diets with higher fiber levels. Our objective was to evaluate three linear feeder space allowances (4.1, 4.9, or 5.7 cm/pig) at two levels of DDGS inclusion (D30 or D60) on grow-finish pig performance, carcass characteristics, and diet digestibility. Treatments were arranged as a 3 X 2 factorial. Diets were formulated to be isolysogenous and isocaloric based on ME. Phases 1, 2, and 3, contained approximately 30% (D30) or 60% (D60) DDGS. Phase 4 diets contained 26% (D30) or 30% (D60) DDGS. Sixty pens fitted with double sided feeders; thus 30 feeders (n = 1,860 pigs; 62 pigs/feeder; initial BW 29.8 kg ± 0.7 kg; final BW 122.6 ± 4.5 kg) were assigned randomly to one of 6 treatments using a completely randomized design. Feeder space allowance was adjusted by covering 1 or 2 feeder sections. Fecal grab samples were collected during dietary phases 2 and 3 and stored at -20ºC for later assay for dry matter, energy, and titanium dioxide content. Data were analyzed using the MIXED procedure of SAS with feeder as the experimental unit and fixed effects of feeder space treatment, diet treatment, and sex. Feeder space allowance and DDGS inclusion level did not affect ADG, ADFI, or G:F ($P>0.10$) from d 57 post-weaning to market. However, for the last 30 d on test, pigs provided with 5.7 cm/pig feeder space had a greater ADG when compared to pigs provided with 4.1 cm/pig ($P<0.05$), and tended ($P<0.10$) to have a greater G:F. Pigs fed the D30 diet had greater HCW, percent yield, and loin depth than pigs fed the D60 diet ($P<0.05$). ATTD for DM and GE was greater ($P<0.05$) for the D30 pigs for both collection periods. When ADG was based on carcass instead of live weight,

pigs on the D30 diet tended (P<0.10) to gain more than those on the D60 diet, although there was no difference for live ADG. Energy content of the D30 diet was greater (P<0.05) than the D60 diet during phase 2, but was lower (P<0.05) in phase 3. Neither feeder allowance nor DDGS inclusion level affected outcomes, but in the final phase indications of inadequate feeder space was observed.

Key Words: feeder space, digestibility, DDGS

O218 **Effects of high-fiber diets and ractopamine HCl on finishing pig growth performance and carcass fat quality.** A. B. Graham*, R. D. Goodband, J. M. DeRouchey, T. A. Houser, M. D. Tokach, S. S. Dritz, J. L. Nelssen, *Kansas State University, Manhattan.*

A total of 576 pigs (PIC 327 × 1050, initially 55.8 kg) were used to determine the effects of dried distillers grains with solubles (DDGS) and wheat middlings (midds) withdrawal 24 d before harvest in diets with or without ractopamine HCl (RAC) on growth performance and fat quality. From d 0 to 49, pigs were allotted to a corn-soybean meal–based control diet (CS) or diets with 30% DDGS and 19% wheat midds (HF). During this period, pigs fed CS diets had increased (P< 0.01) ADG and G:Fcompared with pigs fed HF diets. On d 49, pens of pigs were re-allotted to 1 of 6 dietary treatments; pigs remained on the CS diets, switched from HF to CS (withdrawal diet), or were maintained on the HF diet. These 3 regimens were fed with or without 10mg/kg RAC. There were 12 pens per treatment with 8 pigs per pen. There were no diet regimen × RAC interactions (P>0.10). Overall (d 0 to 73), pigs fed the CS diet throughout had greater (P< 0.03) ADG and G:F and lower (P<0.001) iodine values (IV) than those fed HF diets throughout. Pigs fed the withdrawal diet had greater (P< 0.03) ADG, similar G:F, and lower (P<0.001) IV than those fed HF diets throughout. Pigs fed the CS diet throughout had greater (P< 0.01) carcass yield compared with pigs fed the HF diet throughout, with those fed the withdrawal diets intermediate. Pigs fed RAC had greater (P < 0.01) ADG, G:F, and carcass yield than pigs not fed RAC. Feeding HF diets containing DDGS and midds decreased growth performance and carcass yield and increased IV compared with those fed a CS diet. Withdrawing the HF diet and switching to a CS diet for the last 24 d before harvest partially mitigated these negative effects. Feeding RAC for the last 24 d before market, regardless of dietary regimen, improved growth performance and carcass yield.

		Diet						
	d 0 to 49	CS	CS	HF	HF	HF	HF	
	d 49 to 73	CS	CS	CS	CS	HF	HF	
Item	RAC	-	+	-	+	-	+	SEM
Overall								
ADG, g		980	1032	946	1010	922	969	52.24
G:F		0.337	0.364	0.325	0.346	0.324	0.343	0.01
Carcass yield, %		74.2	75.1	73.7	74.6	72.8	73.6	0.19
Jowl IV, g/100g		65.1	64.3	69.3	70.0	72.4	73.2	0.86

Key Words: DDGS, ractopamine HCl, wheat middlings

O219 **Effects of ractopamine HCl on the efficiency of feed and nutrient utilization of finishing pigs.** K. Coble [1,*], S. Carter[1], M. Pierdon [2], K. Haydon [3], H. Kim [1], M. Bible [1], *[1]Animal Science, Oklahoma State University, Stillwater, [2]University of Pennsylvania School of Veterinary Medicine, Kennet Square, PA, [3]Elanco Animal Health, Greenfield, IN.*

Eighty crossbred pigs (40 kg BW) were utilized in a 91-d study to determine the effects of ractopamine hydrochloride (RAC) on growth performance, nutrient excretion, and gaseous emissions. Pigs were housed in an environmentally-controlled building with 4 identical rooms (20 pigs/room). Pigs were assigned to 1 of 4 rooms, stratified by BW, sex, and ancestry, and randomly allotted to two dietary treatments. During phases 1 to 3, all pigs consumed a common diet. During phase 4 (100 kg BW), pigs received either a diet without RAC (12% CP, 0.63% SID Lys, 0.51% Ca, and 0.19% avail. P) or a diet containing 10 mg/kg RAC (16% CP, 0.89% SID Lys, 0.53% Ca, and 0.22% avail. P) on an ad libitum basis until desired market weight (125 kg). During phases 1-3, when both groups were fed a common diet, few differences (P>0.10) were noted between trts. During phase 4, ADG (0.94 vs. 1.17 kg/d) and G:F (0.30 vs. 0.39) were increased (P<0.01) for pigs fed RAC compared to the control. Thus, pigs fed RAC reached desired market weight 6 days sooner. Slurry pH and estimated water retention were increased (P<0.05) for pigs fed RAC during phase 4. Total excretion (kg/pig) of DM (10.7 vs. 9.0), N (1.01 vs. 0.90), and P (0.20 vs. 0.18) were decreased (P<0.10) for pigs fed RAC during phase 4. Total (kg/pig) CH_4 (0.17 vs. 0.12) and CO_2 equivalents (97 vs. 76) were reduced (P<0.02) during phase 4 with RAC, but there were no differences (P>0.10) in NH_3 or H_2S emissions. For the entire finishing phase, ADG (0.97 vs. 1.02 kg/d), G:F (0.36 vs. 0.40), and lean gain (373 vs. 407 g/d) were increased (P < 0.10) for pigs fed RAC. Also, the total excretion (kg/pig) of DM (30.7 vs. 29.0), N (3.0 vs. 2.9), and P (0.53 vs. 0.51) were reduced (P<0.10) by 10, 9, and 2%, respectively, for pigs fed RAC. Total (phase 1-4) CH_4 emissions and CO_2 equivalents were reduced (P<0.10) by 15% and 9% when pigs were fed RAC. These results suggest that RAC increases G:F while decreasing nutrient excretion of DM, N and P. Additionally, RAC decreased total CH_4 emissions and CO_2 equivalents.

Key Words: nutrient excretion, pigs, ractopamine HCl

O220 **Comparison of the performance of growing pigs offered feeding programs developed using either the ME or NE system.** J. A. Acosta [1], C. E. Zier-Rush [2], M. McGrath [2], R. Palan [2], J. Steckel[2], J. F. Patience [1,*], R. D. Boyd [2], *[1]Animal Science, Iowa State University, Ames, [2]The Hanor Company, Franklin, KY,*

The net energy (NE) system describes the useful energy for growth better than the metabolizable energy (ME) system. This NE system should reduce feed cost where a diverse set of ingredients are used but this needs to be demonstrated in practice. This study compared the growth of pigs on diet programs formulated using either the ME or NE systems. A total of 944 gilts and 1,110 castrates (BW=40.8±2.0 kg) were allotted to separate pens and assigned to one of 5 different feeding programs according to a randomized complete block design. A simple corn-soybean meal control (T1) served as the basis to establish ME (3.44 Mcal/kg) and NE (2.85 Mcal/kg) specifications for both programs. Treatments (T2) ME and (T3) NE included corn DDGS with fat varied to achieve either ME or NE targets. (T4) ME and T5 (NE) contained both DDGS and corn germ meal. Pigs were harvested at a mean BW of 130.3±4.0 kg. No differences were observed among treatments for whole-body ADG (P=0.18), ADFI (P=0.12) or G:F ratio (P=0.18). Total carcass gain was different among treatment programs (P<0.03) with the greatest difference between T1 (66.7 kg) and T4-5 (64.6 kg). Although not statistically different (P > 0.05), carcass gain tended to be greater for the NE vs ME program with DDGS diets (66.4 vs 65.1 kg) and for DDGS + germ programs (65.0 vs 64.3 kg). Carcass G:F ratio behaved similarly for T1-5 respectively: 0.258, 0.254, 0.257 and

0.256, 0.259 (SEM 0.001, P=0.133). FOM lean percent was similar among treatments (P=0.43). We conclude that there is an apparent advantage to the NE program but the difference is small. The value of the NE program would depend on price economics in relation to improved carcass gain and the minor trend toward G:F ratio improvement.

Key Words: metabolizable energy, net energy, pigs

O221 **The impact of duration of feeding and saturation of dietary fats on changes in body fat over time and on final carcass lipid iodine values.** T. A. Kellner [1,*], K. J. Prusa [2], J. F. Patience [1], *[1]Animal Science, [2]Food Science and Human Nutrition, Iowa State University, Ames.*

The inclusion of unsaturated fats in pig diets has raised issues related to decreasing pork carcass lipid quality, negatively impacting shelf life and belly slicing yield. The objective of this experiment was to understand how withdrawal from the diet of unsaturated dietary fat prior to slaughter impacts the composition of jowl fat during the finishing period and at market. Fifty pigs (PIC 337 X C22/29; initial BW = 59.3±3.64 kg), were allotted to an 82d experiment based on sex and initial BW to 10 treatments in a randomized complete block design: 3 dietary fat withdrawal times prior to slaughter (21, 42 or 63d) by 3 fat sources (5% animal-vegetable blend (AV; iodine value (IV)=90.7), 2.5% corn oil (2.5%CO; IV=122.7), 5% corn oil (5%CO), plus a control diet with no added fat (CON) fed throughout the duration of trial. The CON diet was also fed during the assigned withdrawal periods described above. Pigs were individually housed to measure ADFI and dietary fat intake. Pigs were weighed and jowl adipose samples were collected on days 0, 21, 42, 63 and at harvest on d82. Carcass measurements were recorded at harvest using a durometer compression measurement (1 least firm; 100 most firm). Data were analyzed using PROC MIXED with treatment and sex as fixed effects, and pen as a random effect. Carcass IV (CIV) was affected by dietary fat inclusion duration across all lipid source treatments (P<0.01). Dietary fat source affected firmness measured by durometer (CON=36, 2.5%CO=39, AV=40, 5%CO=31; P<0.05). Sex did not affect CIV (P>0.30) or firmness (P>0.13). Duration of lipid inclusion did improve gain to feed (CON=0.31 kg, 21d=0.31 kg, 42d=0.33 kg, 63d=0.34 kg; P<0.001). In conclusion, 2.5% CO and 5% AV maintained CIV below 74 g/100g, while a 21d withdrawal of 5% corn oil was required to maintain CIV below 74 g/100g. (See Table 1 below.)

Key Words: carcass fat, dietary fat, iodine value

O222 **Evaluation of collection method on nutrient digestibility of corn-soybean meal (CSBM) and CSBM-dried distillers grains with soluble (DDGS) based diets in growing pigs.** Y. S. Li [1,*], H. Tran [1], J. W. Bundy [1], T. E. Burkey [1], M. K. Nielsen [1], B. J. Kerr [2], P. S. Miller [1], *[1]Animal Science, University of Nebraska, Lincoln, [2]Agro-ecosystems Management Research Unit, USDA, Ames, IA.*

A total of 24 barrows in 2 replicates (BW = 87.9 ± 2.2 and 88.5 ± 2.6 kg, respectively) were assigned to a 2 × 2 (diet × collection) factorial arrangement to determine the effects of collection method and diet on nutrient digestibility in growing pigs. Pigs were allotted to 12 metabolism crates and provided either corn-soybean meal (CSBM) or CSBM with 20% DDGS diet (2.8 kg/d). Diets were isocaloric and contained 0.5% of titanium dioxide (TiO_2) for estimating nutrient digestibility using the index method. After a 10-d adaptation period, total collection of feces for pigs within each diet was based on exact timing (day collection) or the appearance of the first and second marker (carmen indigo, marker collection) during a 4-d collection period. Urine was collected for a 4-d period in 65 mL of 6 N HCl daily. Subsamples of feed and feces were analyzed for DM, N, GE, and Ti, and urine for N and GE. The DM digestibility, energy digestibility (DE, %), and metabolizability (ME, %) were 2.9%, 2.8%, and 3.5% lower (P < 0.05), respectively in the DDGS vs CSBM diet. The N digestibility, DE (kcal/kg) and ME (kcal/kg) were similar (P > 0.10) in CSBM and DDGS diets (86.85 vs. 86.75%, 3,455 vs. 3,471 kcal/kg, and 3,343 vs. 3,315 kcal/kg, respectively). The DM and N digestibilities were not different (P > 0.10) between collection methods. The marker method tended to decrease (P < 0.10) the estimates of DE (%), ME (%) and DE (kcal/kg) compared to the day method. The ME (kcal/kg) estimated using the marker method was 31 (CSBM) and 92 (DDGS) kcal/kg lower (P < 0.05) than estimated using the day method. Dry matter digestibility was 0.5% lower (P < 0.05); whereas, N digestibility, DE (%), and DE (kcal/kg) were increased (P < 0.05) calculated using the index vs. total collection methods. Although energy digestibility values tended to be lower calculated from the marker vs. day collection, there were no major differences in nutrient and energy digestibility and metabolizability using the different collection methods.

Key Words: collection method, digestibility, pig

O223 **Development and validation of a spectroscopic method to predict fat and fatty acids digestibility.** L. Wang[1,*], M.-L. Swift[1,2], R. Zijlstra [1], *[1]University of Alberta, Edmonton, [2]Alberta Agriculture and Rural Development, Lacombe, Canada.*

Digestibility of crude fat or fatty acids (FA) is determined with analyses for crude fat or fatty acids using the index method. Potentially, digestibility of crude fat or FA can also be predicted by marker concentrations and spectral analyses. Based on Beer's law,

O221 Table 1. Carcass lipid iodine value sampled from the jowl measured by direct titration

Trt	CON	2.5% Corn Oil			5% AV Blend			5% Corn Oil		
Duration	0d	21d	42d	63d	21d	42d	63d	21d	42d	63d
CIV (g/100g)	68.7^{ab}	70.2^{ab}	70.5^{abc}	72.3^{bc}	67.3^{a}	70.4^{abc}	71.9^{abc}	70.3^{abc}	74.2^{cd}	77.4^{d}

[a,b,c] Means with different superscripts differ, P<0.05

which states peak intensity (PI) is proportional to the concentration of analytes, a spectroscopic non-calibration method was developed to estimate the apparent ileal digestibility (AID) of FA and apparent total tract digestibility (ATTD) of crude fat. To validate, diets incorporating 4 samples of flaxseed and field pea mixtures plus a basal diet were fed to pigs (initial BW: 23.1 kg) in a 5 × 5 Latin square design. Ingredients, diets, digesta and feces were scanned on a Fourier transform mid-infrared (FTIR) instrument with a single-reflection attenuated total reflectance attachment. The PI of anti-symmetric stretch at 2,923 cm^{-1} (r = 0.95, $P < 0.01$) or symmetric stretch at 2,852 cm^{-1} (r = 0.94, $P < 0.01$) of methylene (main component of FA) were strongly correlated to total FA content of ingredients, diets, and digesta, indicating the PI of either of two peaks can be used as an index for total FA content; the functional group digestibility (FGD) of both peaks were highly correlated (r = 0.87, $P < 0.01$) to the AID of total FA. The mean and standard deviation of the difference in diet AID of FA values between FTIR and gas-liquid chromatography (GLC) was 0.54 ± 3.78%. Fecal crude fat content was highly correlated (r = 0.96, $P < 0.01$) to the sum of PI of 2nd derivative spectra at 1,735 and 1,710 cm^{-1}. The ATTD of crude fat of test diets was highly correlated (r = 0.95, $P < 0.01$) with the FGD in area at 1766–1695 cm^{-1} which is associated with ester carbonyl (C=O) in mono-, di-, or triglycerides and C=O in free fatty acids. In conclusion, a non-calibration method using FTIR spectra and marker concentration appears promising for the prediction of AID of FA and ATTD of crude fat.

Key Words: digestibility, fat, spectroscopy

O224 **Effects of amino acid supplementation of reduced crude protein (RCP) diets on performance and carcass composition of growing-finishing swine.** J. K. Apple[1,*], B. E. Bass[1], T. C. Tsai[1], C. V. Maxwell[1], J. W. S. Yancey[1], A. N. Young[1], M. D. Hanigan[2], R. Ulrich[3], J. S. Radcliffe[4], B. T. Richert[4], G. Thoma[3], J. S. Popp[5], *[1]Animal Science, University of Arkansas Division of Agriculture, Fayetteville, [2]Dairy Science, Virginia Polytechnic Institute and State University, Blacksburg, [3]Chemical Engineering, University of Arkansas, Fayetteville, [4]Animal Science, Purdue University, West Lafayette, [5]Agricultural Economics & Agribusiness, University of Arkansas Division of Agriculture, Fayetteville.*

Barrows and gilts (n = 210/gender) were used to test the effects of crystalline AA supplementation of reduced CP diets on growth performance and carcass composition of growing-finishing swine. Pigs were blocked by BW, and pens (6 pigs/pen) within each block and gender were assigned randomly to either corn-SBM diets (**C**) devoid of crystalline LYS and formulated to 95% SID AA requirements or 1 of 4 RCP diets (CP and crystalline LYS levels for dietary treatments during each feeding phase are presented in the accompanying table). During the last 3-wk feeding phase, 10 ppm of Paylean was included in all diets. Individual BW and pen feed disappearance were recorded at the end of each feeding phase to calculate ADG, ADFI, and G:F. At slaughter, HCW and FOM data were recorded before carcass chilling and a subsample of fresh hams (3/pen) were knife-dissected into muscle, fat, bone, and skin. ADG increased 2.1% between C and RCP3 but declined 6.1% between RCP3 and RCP4 (quadratic, $P < 0.01$). G:F increased 4.6% in gilts between C and RCP2 before decreasing to values similar between C and RCP4; yet, G:F was relatively unchanged in barrows across the dietary treatments (quadratic gender × RCP diet, $P = 0.04$). Fat depth increased (linear, $P < 0.01$) and fat-free lean yield decreased (linear, $P < 0.01$) as CP was reduced in swine diets. Percent ham muscle decreased (linear, $P < 0.01$), and percent ham fat increased (linear, $P < 0.01$), with decreasing dietary CP. Results imply that dietary CP can be reduced 19.7 to 28.6% across the 5 feeding phases by using crystalline AA without affecting live pig performance; however, in general, performance and carcass composition declined at the highest synthetic AA inclusion to levels below or similar to C diets.

CP (added LYS) of experimental diets for each feeding phase (% as fed)

Phase	C	RCP1	RCP2	RCP3	RCP4
1	23.70	21.61 (0.19)	19.58 (0.37)	17.61 (0.56)	15.72 (0.75)
2	21.53	19.46 (0.18)	17.44 (0.36)	15.49 (0.54)	13.61 (0.71)
3	18.97	17.34 (0.15)	15.74 (0.29)	14.16 (0.44)	12.68 (0.59)
4	17.66	16.30 (0.13)	14.96 (0.24)	13.64 (0.36)	12.37 (0.48)
5	20.24	18.60 (0.15)	17.01 (0.30)	15.44 (0.45)	13.93 (0.60

Key Words: live performance, reduced CP, swine

O225 **The effects of SID Trp:Lys ratio and Trp source in diets containing DDGS on growth performance and carcass characteristics of finishing pigs.** S. Nitikanchana[1,*], M. Tokach[1], S. Dritz[1], J. Usry[2], R. Goodband[1], J. DeRouchey[1], J. Nelssen[1], *[1]Kansas State University, Manhattan, [2]Ajinomoto Heartland LLC, Chicago, IL.*

A total of 2,290 pigs (PIC 1050×337; initially 71 kg) were used to determine the effect of Trp level and source in diets containing 30% DDGS on finishing pig performance. Pens of pigs were allotted to 1 of 7 dietary treatments in a completely randomized design with 26 to 28 pigs per pen and 10 to 13 pens per treatment. Treatments were arranged as a 2×3 factorial with the main effects of Trp source (L-Trp or soybean meal; SBM) and standardized ileal digestible (SID) Trp:Lys ratio (18, 20, or 22%). The 7th treatment was a negative control diet formulated to 16% SID Trp:Lys. Overall, a Trp source×SID Trp:Lys ratio interaction (P=0.03) was observed for G:F. Increasing SID Trp:Lys to 20% improved (quadratic, P<0.01) G:F when SBM was the source of Trp, but the optimum ratio was 18% with L-Trp. There was a Trp source × SID Trp:Lys interaction (P=0.01) for yield. Differences in response at 22% SID Trp:Lys led to a linear increase (P=0.01) in yield for L-Trp, but a quadratic increase (P=0.03) for SBM. For the main effect of SID Trp:Lys ratio, ADG and G:F improved (quadratic, P<0.01) as SID Trp:Lys ratio increased to 20%. Loin depth was greatest in the control diet and lowest at 18% SID Trp:Lys (quadratic, P=0.02). For the main effect of Trp source, no differences were observed in ADFI or G:F between sources; however, a trend (P=0.07) for greater ADG when using SBM as the Trp source was observed. Backfat was greater (P=0.04) and percentage lean (P=0.02) was lower in pigs fed with L-Trp than those with SBM as the Trp source. This study indicates an optimum SID Trp:Lys ratio of 20% for 71 to 127-kg pigs when fed 30% DDGS. Because SBM or L-Trp provided a similar growth response, differences in feed cost will be a major factor in choosing the optimal source of Trp.

Effects of Trp sources and increasing SID Trp:Lys ratio on finishing pigs

	Control	L-Trp			SBM			
	16.0	18.0	20.0	22.0	18.0	20.0	22.0	SEM
ADG, g	897	915	948	908	926	968	928	11.72
G:F	0.317	0.337	0.328	0.322	0.326	0.336	0.327	0.003
Yield, %	74.3	75.4	74.7	75.8	75.8	74.6	74.6	0.608
Lean, %	58.5	58.2	58.4	58.5	58.6	58.8	58.6	0.630

Key Words: DDGS, SID Trp, Trp source

O226 **Effect of sampling method on the accuracy and precision of estimating the distribution of pig weights in a population.** C. Paulk [1,*], G. Highland [2], M. Tokach [1], J. Nelssen [1], S. Dritz [3], R. Goodband [1], J. DeRouchey [1], K. Haydon [4], *[1]Animal Science and Industry, [2]Statistics, [3]Diagnostic Medicne Pathobiology, Kansas State University, Manhattan, [4]Elanco Animal Health, Greenfield.*

Estimating pig BW variation can enhance a producer's ability to determine the optimal time to market pigs. Thus the objective of this study was to determine the effects of sample size and method for estimating the SD of BW for a barn of pigs. We evaluated weighing: 1) a completely random sample of 10 to 200 pigs from the barn, 2) an increased number of pigs per pen from 1 to 15 pigs and increased number of pens until all pens in the barn had been sampled, and 3) select the heaviest and lightest pig (visually) in 15 pens, and subtract the lightest weight from the heaviest weight and divide by 6. Computer generated random samples (10,000) were used to calculate to calculate each sample SD using R (R Foundation for Statistical Computing, Vienna, Austria). The different sampling procedures were evaluated using 3 data sets where all pigs had been individually weighed. Dataset A consisted of 1,260 pigs in 48 pens (mean=114.8 median=115.2, and SD=14.9 kg). Dataset B consisted of 1,261 pigs in 19 pens (mean=96.9, median=97.1, and SD=9.8 kg). Dataset C consisted of 1,069 pigs in 40 pens (mean=100.8, median=101.6, and SD=14.5 kg). Increasing the number of random pigs sampled or number of pens sampled decreased the 95% confidence interval about the SD (CI; Table 1) with diminishing improvement as sample size increased. For a defined sample size (ex. 30 pigs), CI was reduced as the number of pens sampled was increased for all data sets but the reduction was modest. The CI was further reduced using sampling method 3. In conclusion, taking the difference between the heaviest and lightest of the 30 selected pigs (Method 3), and dividing by 6 resulted in a lower CI than any of the pig by pen combinations of sampling 30 pigs.

Table 1. Effect of sampling on range between the upper and lower 95% CI of SD

Method 1				Method 2				
Pigs	A	B	C	Pigs	Pens	A	B	C
10	14.6	9.4	14.5	15	2	9.0	5.9	11.4
30	8.5	5.3	8.3	10	3	8.9	5.9	10.7
50	6.4	4.0	6.3	6	5	8.8	5.6	9.7
70	5.4	3.4	5.2	5	6	8.6	5.6	9.5
90	4.7	3.0	4.7	3	10	8.5	5.3	8.7
110	4.2	2.7	4.1	2	15	8.6	5.2	8.4
130	3.9	2.4	3.8	1	30	8.4	N/A	7.9
				Method 3	15	5.4	2.0	7.6

Key Words: finishing pig, sample size, standard deviation estimation

NONRUMINANT NUTRITION: MINERALS

O227 **The site of absorption of calcium from the intestinal tract of growing pigs.** J. C. González-Vega [1,*], C. L. Walk [2], H. H. Stein [1], *[1]Animal Sciences, University of Illinois, Urbana-Champaign, [2]AB Vista feed ingredients, Marlborough, United Kingdom.*

An experiment was conducted to determine the standardized duodenal digestibility (SDD), standardized ileal digestibility (SID), and standardized total tract digestibility (STTD) of Ca in calcium carbonate and Vistacal at 2 different levels of Ca, and to determine if phytic acid affects digestibility of Ca in these 2 ingredients. An additional objective was to determine the basal endogenous loss of Ca in the stomach, small intestine, and large intestine. Nine pigs (initial BW: 23.8 ± 1.3 kg) were cannulated in the duodenum and in the distal ileum and allotted to a 9 × 6 Youden square design with 9 diets and 6 periods. Diets contained calcium carbonate or Vistacal as the sole source of Ca, 0 or 1% phytic acid, and 0.4 or 0.8% Ca. A Ca-free diet was also formulated and used to measure the basal endogenous loss of Ca. Fecal, ileal, and duodenal samples were collected on d 5 and 6, d 7 and 8, and d 9 and 10, respectively. The basal duodenal endogenous loss of Ca (1.03 g/kg of DMI) was greater ($P < 0.05$) than the ileal (0.42 g/kg of DMI) and total tract basal endogenous loss (0.67 g/kg of DMI). The SDD, SID, and STTD of Ca were not affected by the level of phytic acid in the diet. Increasing the level of Ca from 0.4 to 0.8% reduced ($P < 0.05$) the SDD, SID, and STTD of Ca if Vistacal was the source of Ca, but that was not the case if calcium carbonate was used (Ca level × Ca source, $P < 0.05$). The SID and STTD of Ca was greater ($P < 0.05$) than the SDD of Ca when Vistacal was fed, but no differences between the SDD, SID, or STTD of Ca in calcium carbonate were observed (Ca source × site of absorption, $P < 0.05$). In conclusion, the basal duodenal endogenous loss of Ca is greater than the basal ileal and total tract endogenous loss. Standardized digestibility of Ca is not affected by level of phytic acid, but is affected by dietary Ca level if Vistacal is the source of Ca, but not if calcium carbonate is used. Calcium from calcium carbonate is mostly absorbed before the duodenum, but Ca from Vistacal is mostly absorbed in the jejunum and ileum.

Key Words: calcium, pigs, standardized digestibility

O228 **Standardized total tract digestibility of phosphorus in *Brassica napus* black and *Brassica juncea* yellow in growing pigs.** P. Adhikari[*], J. M. Heo, M. Nyachoti, *Animal Science, University of Manitoba, Winnipeg, Canada.*

Eighteen growing barrows (initial BW, 19.9 ± 0.22 kg) were used to determine the apparent (ATTD) and standardized (STTD) total tract digestibility of phosphorus (P) in canola meals from *Brassica napus* black (BNB) and *Brassica juncea* yellow (BJY). The experiment was conducted in two consecutive blocks each with 9 pigs that were individually housed in metabolism crates that allowed for total but separate collection of feces and urine. Each block lasted for 14 d that allowed pigs to adapt their respective diets and environmental conditions for 9 d and followed by total collection of feces and urine for 5 d. Pigs were allotted to one of the three experimental diets, with factors being cornstarch-based diets containing either (1) BNB (320 g/kg), (2) BJY (308 g/kg) as the sole source of P or (3) a cornstarch-gelatin based P-free diet in a completely randomized block design to give 6 replicates per treatments. The P-free diet was used to measure endogenous P losses to determine STTD of P in pigs and was formulated to contain 180 g/kg CP. The pigs were fed their respective diets in two equal portions at 0830 and 1630 h. Daily feed allowance was based on the BW at the beginning of each block and was calculated to supply 2.6 times the estimated maintenance energy requirements. Titanium dioxide (3 g/kg) was included in the diets as an indigestible marker. The ATTD of DM (74.0 vs. 79.0%), P (29.0 vs. 28.0%), and Ca (48.0 vs. 52.0%) were not different ($P > 0.10$) either in pigs fed diets containing BNB or BJY, respectively. The endogenous losses of P estimation were 209 ± 96 mg/kg DMI (mean ± SD). The STTD of P for BNB and BJY was, therefore, calculated

to be 30.7 and 28.3%, respectively. The study demonstrated that the STTD of P in canola meals from BNB or BYJ fed to growing pigs was similar and averaged 29.5%.

Key Words: phosphorus, pigs, standardized total tract digestibility

O229 **Inclusion of high levels of phytase (Quantum Blue) improves the performance of pigs between 20 and 55 kg live weight.** C. Walk [1,*], T. Santos [1], J. Chewning [2], P. Wilcock [1], *[1]AB Vista, Marlborough, United Kingdom, [2]SRS, Fayetteville.*

Phytase research has focused on the hydrolysis of phytate (PHY) to improve PHY-phosphorus (PP) digestibility rather than reducing the anti-nutritional effect of PHY to improve pig performance. This study was set-up to determine if high levels of phytase would elicit a performance benefit beyond phosphorus (P) release. Pigs (n = 360; 22.9 kg) were allotted to 1 of 6 treatments with 12 replicates and 5 pigs per pen: T1) positive control (PC); T2) PC -0.10% available phosphorus (AVP) and 0.11% calcium (Ca); T3) T2 + 250 FTU/kg phytase; T4) PC -0.15% AVP and 0.16% Ca; T5) T4 + 500 FTU/kg phytase; and T6) T4 + 2000 FTU/kg. All pigs were fed a 2 phase feed program (22-37 kg (P1) and 37-55 kg (P2)) for 43 d. In P1 and P2 the PC met the pigs' nutritional requirement with the following AVP, Ca and PP; P1: Ca 0.71%, AVP 0.32%, PP 0.26%; P2: Ca 0.61%; AVP 0.27%, PP 0.25%. At 43 d, 1 pig per pen was euthanized and the 4th metacarpal taken and bone breaking strength (BS), ash weight (AW), and percentage ash (PA) measured. Reduction of AVP in T2 and T4 significantly reduced AW ($P < 0.05$). The addition of 250 FTU/kg of phytase to T2 (T3) and 500 FTU/kg to T4 (T5) restored AW back to the PC ($P < 0.05$) supporting a mineral release for both doses. Pigs fed 2000 FTU/kg phytase had greater ADG ($P < 0.05$) and were more efficient ($P < 0.05$) than animals fed the PC, with no differences ($P > 0.05$) in bone parameters, while animals fed 500 FTU/kg phytase showed only a significant improvement ($P < 0.05$) in gain. These results show that the performance benefits at 2000 FTU/kg phytase was not related to just a P release but also to a reduction in the anti-nutritional effects of PHY.

Table 1. The impact of phytase on pig performance (22-55 kg)

Treatment	BW0 (kg)	BW43 (kg)	ADFI (kg/d)	ADG (kg/d)	G/F (g/g)	BS (kg)	AW (g)	PA (%)
T1	22.9	55.1^{c}	1.50	0.749^{c}	0.501^{bc}	77.4^{abc}	3.64^{a}	42.3
T2	22.9	55.7^{bc}	1.55	0.762^{bc}	0.493^{c}	69.4^{bc}	3.17^{b}	39.5
T3	22.9	56.3^{ab}	1.54	0.776^{ab}	0.506^{ab}	80.9^{ab}	3.57^{a}	41.2
T4	22.9	54.8^{c}	1.52	0.740^{c}	0.490^{c}	65.9^{c}	3.17^{b}	39.4
T5	22.9	56.7^{ab}	1.55	0.785^{ab}	0.509^{ab}	81.2^{ab}	3.61^{a}	40.3
T6	22.9	57.4^{a}	1.57	0.803^{a}	0.513^{a}	85.8^{a}	3.76^{a}	41.3
Prob.	0.980	0.001	0.222	0.001	0.001	0.043	0.001	0.228
SE	0.146	0.100	0.097	0.081	0.041	0.063	0.031	0.081

Key Words: phytase, pigs

O232 **The effect of the lysine:calorie ratio on the response to zinc supplementation in late finishing diets containing ractopamine hydrochloride.** J. Patience [1,*], A. Chipman [1], M. Wilson [2], *[1]Animal Science, Iowa State University, Ames, [2]Zinpro Corp, Eden Prairie.*

The objective of this experiment was to determine if the lysine:calorie ratio of a late finishing diet containing ractopamine (7.5 ppm) influences the response to zinc supplementation. A total of 528 mixed sex pigs (BW = 46.0 ± 1.6 kg) were assigned within weight blocks to pens of 11 pigs to one of 4 dietary treatments arranged as a 2 X 2 factorial during the late finishing phase: 2 levels of lysine (2.69 g vs 3.14 g SID lysine per Mcal ME) and 2 sources of zinc supplementation (50 g Zn/kg as either zinc sulfate or an organic zinc product). Pigs received their assigned zinc source in phase 1 and 2 diets, prior to the introduction of ractopamine and the above dietary treatments in phase 3. Lysine levels were similar across zinc source in phases 1 and 2. Phase 3 commenced when the pigs weighed 101.2 ± 2. 6 kg. Total zinc content of the phase 3 experimental diets was determined to be between 150 and 162 mg/kg. There were no statistically significant interactions between zinc source and lysine level for any measured variable ($P > 0.10$). There was no effect of zinc source on market weight ($P > 0.10$; 125.0 vs 125.3 kg for the zinc sulfate and organic zinc treatments, respectively), average daily gain (1.04 vs 1.07 kg/d), average daily feed intake (2.92 vs 2.96 kg/d) or feed efficiency (0.347 vs 0.350). Actual days on ractopamine also were not different (23.0 vs 22.4 days). Similarly, there were no differences in dressing percentage (74.0 vs 73.9), loin depth (69.5 vs 68.4 mm) or backfat depth (16.7 vs 16.8 mm). We concluded that under the conditions of this trial, there were no differences between adding zinc to the diets as the sulfate or as an organic source on growth performance or carcass quality. Lysine:calorie ratio did not explain differences in the response to organic zinc observed in a previous experiment.

Key Words: ractopamine, swine, zinc source

O231 **Effect of dietary zinc level and source and ractopamine level on performance and carcass traits of finishing pigs.** S. Fry*, W. Hu, N. Paton, D. Cook, *Provimi North America, Brookville.*

Three experiments were conducted to determine the effect of zinc (Zn) level and source and ractopamine (RAC) level on performance and carcass traits of finishing pigs. In experiment 1, 576 pigs (110.1 ± 1.32 kg BW) were randomly assigned to one of the following treatments: 1) control, 2) 5 mg/kg RAC, 3) 5 mg/kg RAC + 40 mg/kg of Zn from Zn sulfate (ZnS), 4) 5 mg/kg RAC + 40 mg/kg of Zn from Availa Zn (AvZn). In experiment 2, 672 (103.2 ± 1.17 kg BW) pigs were utilized in a trial with a 2 × 2 arrangement of treatments: 1) control, 2) 5 mg/kg RAC, 3) control + 60 mg/kg Zn from ZnS, or 4) 5 mg/kg RAC + 60 mg/kg Zn from ZnS. In experiment 3, 1008 pigs (105.7 ± 0.73 kg BW) were randomly assigned to one of the following treatments: 1) control, 2) 5 mg/kg RAC, 3) 7.5 mg/kg RAC, 4) 5 mg/kg RAC + 40 mg/kg Zn from AvZn, 5) 5 mg/kg RAC + 40 mg/kg Zn from ZnS, 6) 7.5 mg/kg RAC + 40 mg/kg Zn from AvZn, or 7) 7.5 mg/kg RAC + 40 mg/kg Zn from ZnS. In each experiment, Zn was supplemented in addition to the 79 mg/kg Zn supplied by the premix. Pens of pigs were marketed at approximately 130 kg BW and data were analyzed using the MIXED procedure of SAS. In experiment 1, pigs fed RAC had greater ($P < 0.01$) ADG and G:F, and tended ($P = 0.06$) to have greater carcass yield vs. controls. Supplemental Zn tended ($P = 0.09$) to further improve G:F when added to RAC diets. Carcass yield tended ($P = 0.06$) to be higher in pigs fed AvZn vs. ZnS. In experiment 2, pigs fed RAC had higher ($P < 0.01$) ADG, G:F, and carcass yield vs. controls. Supplementing Zn did not further improve growth and carcass responses to RAC. In experiment 3, pigs fed RAC had greater ($P < 0.01$) ADG and G:F, and tended ($P = 0.06$) to have greater carcass yield vs. controls. Pigs fed 7.5 mg/kg vs. 5 mg/kg RAC tended ($P = 0.09$) to have a lesser ADFI, but G:F did not differ ($P = 0.11$). Zinc level did not affect performance; however, AvZn fed pigs tended ($P = 0.06$) to have greater ADFI vs. ZnS fed pigs. These data suggest that supplemental Zn may improve the RAC response but responses are inconsistent across trials.

Key Words: pigs, ractopamine, zinc

O230 **High Cu supplementation improves growth performance in weaned pigs, but the sudden removal of the high Cu level may reduce pig performance.** P. Bikker*, A. W. Jongbloed, *Wageningen UR Livestock Research, Lelystad, Netherlands.*

According to NRC (2012) nursery pigs require 5-6 mg Cu/kg of diet. However, European pig diets generally contain the maximum legal level of 170 mg/kg until 12 wk of age and 25 mg/kg thereafter. A study was conducted in young growing pigs (8-40 kg BW) to estimate the effect of incremental levels of dietary Cu in antibiotic free diets on growth and liver Cu. We added 0 to 18 mg Cu from copper sulfate per kg in 6 steps, to a basal diet (7 mg Cu/kg from feed ingredients) during an 8-wk test period. An additional treatment included 160 mg Cu from copper sulfate/kg of diet. Each of the 7 treatments comprised 10 pens with 8 pigs each as experimental units. Growth performance was determined in 2-wk periods and liver Cu was determined in a selection of pigs at the end of the 8-wk period. After this 8-wk period, growth performance of pigs receiving the diets with 12 and 160 mg added Cu/kg was determined during an extra 4-wk period after change-over to a grower diet with 15 mg Cu/kg. Increasing added dietary Cu from 0 to 18 mg/kg did not affect growth performance (P>0.2) but linearly increased liver Cu from 21 to 38 mg/kg DM (P<0.01). Cu inclusion levels below 18 mg/kg caused a depletion of the liver Cu depot present at weaning. Inclusion of 160 mg Cu/kg of diet improved FI (940 vs 852 g/d, P<0.001), ADG (587 vs 540 g/d, P<0.001), FCR (1.60 vs. 1.63, P=0.032), fecal consistency, visually scored by an expert panel (P<0.001), and increased liver Cu (105 vs 29 mg/kg DM, P<0.001) compared to the mean of all other treatments, in an age dependent manner. No significant differences were observed after withdrawal of the high Cu supplement. Nonetheless, ADG during the first 2 wk was numerically lower (816 vs 877 g/d) in pigs previously receiving the high Cu supplement. In conclusion, Cu supplementation below 20 mg/kg did not improve growth performance but the liver Cu depot was depleted. A Cu supplement of 160 mg/kg drastically improved growth performance but sudden withdrawal numerically reduced the subsequent performance of the pigs.

Key Words: copper, growth and efficiency, nursery pigs

O233 **Effect of supplementing Zn, Mn and Cu metal amino acid complexes for two reproductive cycles on performance of sows.** M. E. Wilson [1,*], C. Rapp [2], J. Torrison [1], T. L. Ward [3], *[1]RNS, Zinpro Corporation, Eden Prairie, [2]RNS, Zinpro Corporation, Boxmeer, Netherlands, [3]Global RNS director, Zinpro Corporation, Eden Prairie.*

The objective of this trial was to evaluate the effect of a partial replacement of inorganic Zn, Mn and Cu with metal amino acid complexes (TMC) for two reproductive cycles on sow and piglet performance. Primiparous and multiparous hybrid sows (n = 236) were blocked based on parity, weight and backfat thickness prebreeding and randomly assigned at breeding to one of two dietary treatments. Diets contained Zn, Mn and Cu from inorganic sulfate sources (Inorganic) or diets with 50% of the Zn, Mn, and Cu replaced by metal amino acid complexes (TMC) during gestation and lactation. All diets contained a total supplemented level of 100 ppm Zn, 40 ppm Mn, and 20 ppm Cu. In gestation each sow received a fixed quantity (2.5 kg) of feed once a day. Sows in both treatments received lactation diets starting on 110 d of gestation upon transfer to farrowing crates. Sows were limit fed the first four days and ad libitum fed the duration of the 21d lactation. Cross fostering was allowed within treatment for 48 hours after birth to achieve approximately 12 pigs per litter. All sows were scored for claw lesions and locomotion at weaning prior to breeding. Data were analyzed by analysis of variance with general linear model procedures. Mean separation was conducted using Tukey's ω-procedure for sow and litter production data. Lactation length was used as a covariate for analysis of sow feed intake, piglet body weight at weaning and from cross fostering to weaning. Lactation feed intake per d increased (P < 0.05) for sows fed TMC (6.24 vs. 5.95 kg ± 0.075). Body weight loss during lactation was less (P < 0.05) in sows fed TMC (-9.2 vs. -12.1 kg ± 0.86). Pigs born to sows fed TMC were heavier (P < 0.05) at weaning (7.02 vs. 6.83 kg ± 0.06). Wean to estrus interval was shorter (P < 0.10) for sows fed TMC (4.5 d vs. 4.7 d). Farrowing rate, pigs born alive, piglet birth weight, and health disorders in lactation were not different (P > 0.10) between treatments. In conclusion, TMC fed sows in gestation and lactation improved (P<0.05) feed intake in lactation /d 0.31 kg and tended (P < 0.06) to improve average pig weaning weight 0.19kg.

Key Words: performance, sow, trace minerals

O234 **Effects of partial replacement of trace metal amino acid complexes during gestation and lactation on sow performance over three parities.** M. E. Wilson [1,*], J. L. Torrison [1], T. L. Ward [2], *[1]RNS, [2]Global RNS director, Zinpro Corporation, Eden Prairie.*

The objective of this study was to evaluate the effects of partial replacement of inorganic trace minerals with metal amino acid complexes (TMC) on sow productivity. Sows (F1 cross, n=853) were blocked by parity (2 to 9) and randomly allotted to one of two treatments following weaning. The control dietary treatment (CON) was standard corn-soybean meal-based gestation (1.15 kg/2x d) and lactation diets (ad lib fed 3 d after farrowing) containing inorganic sulfate trace minerals. The second dietary treatment TMC was the same feeding procedure and diets as CON for gestation and lactation with a partial substitution of inorganic Zn, Mn and Cu at total added levels iso for both treatments. Trace minerals from TMC were substituted at 50 ppm Zn, 20 ppm Mn and 10 ppm Cu. Litter and reproductive performance were measured on all sows. Data was analyzed by PROC MIXED model of SAS with repeated measures while all binomial data were tested by Chi square. Individual sow data was used from each of the three cycles for the breeding events (1,769 sows) and sow data (2,466 sows) 3 farrowing cycles. Milk data was subsample of 615 sows. Culling rate improved (P< 0.05) in sows fed TMC (39.1% vs. 46.2%) while retention also tended to improve (P<0.16, 50.1% vs. 45.3%). Conception rate (88.1% vs. 85.6%) and farrowing rate (82.5% vs. 79.6%) tended to improve in the sows fed TMC. Sow weighed more (P< 0.05) post farrowing (259.9 kg vs. 256.1 kg) and ate more (P<0.05, 6.4 vs. 6.3 kg/d) in lactation. Total born and live born were not different between treatments (P>0.5). Pigs from sows fed TMC had increased (P<0.08) birth weights (1.42 vs. 1.39) and weaning weights (7.26 vs. 7.10; P<0.05). Milk components were measured on samples of 300 sows over the three cycles. Protein % of the milk was greater (P<0.05) in TMC fed sows (5.37 % vs. 4.82% ± 0.50) and somatic cell counts were lower (620 vs. 1,106, P<0.01). These data show that feeding sows TMC improves lactation performance, reproductive performance and longevity compared to feeding solely inorganic trace minerals.

Key Words: longevity, sow, trace minerals

PHYSIOLOGY SYMPOSIUM: CHARACTERISTICS OF THE FOLLICLE AND OOCYTE THAT IMPACT FERTILIZATION, EMBRYONIC DEVELOPMENT, AND PREGNANCY SUCCESS

O235 **Molecular determinants of oocyte competence.** G. W. Smith*, *Animal Science, Michigan State University, East Lansing.*

A growing body of evidence suggests oocyte developmental competence is a limiting factor in pregnancy success in livestock species and humans, but the inherent phenotypic characteristics of competent oocytes are not well understood. Oocytes gradually and sequentially acquire developmental competence (during the course of folliculogenesis) by accumulating transcripts and proteins critical for successful meiotic maturation, fertilization, and early embryogenesis. We have conducted fundamental studies using the bovine model to elucidate differences in oocyte transcriptome associated with poor oocyte competence and the functional significance and therapeutic utility of such results. Of particular interest were studies that showed a positive association of follistatin mRNA abundance with oocyte competence in two distinct bovine models. Follistatin treatment of bovine embryos during initial stages of in vitro culture increased proportion of embryos developing to the blastocyst stage and numbers of blastocyst trophectoderm cells. Comparative studies in the rhesus monkey model demonstrated stimulatory actions of exogenous follistatin on rates of blastocyst development and support potential clinical relevance of results in the bovine model. Complementary loss of function studies in early embryos established a functinal role for follistatin in control of bovine blastocyst development and cell allocation. Current studies are focused on understanding the mechanism of action of follistatin in mediating its above described embryotropic actions and impact of follistatin treatment during embryo culture on pregnancy rates following embryo transfer. Such studies are critical to further understanding of the functional significance of follistatin to early embryogenesis and the translational relevance of above findings to improvements in human assisted reproductive technologies and reproductive biotechnologies in cattle.

Key Words: bovine, embryo, oocyte

O236 **Small RNA expression and function during oocyte maturation and embryo development in the pig.** C.-X. Yang, E. C. Wright, Z.-Q. Du, B. Hale, M. F. Rothschild, J. W. Ross*, *Animal Science, Iowa State University, Ames.*

Small RNA represent several unique noncoding RNA classes having important functions in the development of germ cells and early embryonic development. MicroRNA (miRNA) are a small RNA class that can influence the mRNA and protein abundance through post-transcriptional gene regulation (PTGR) following interactions with the 3′UTR that lead to translation inhibition and/or mRNA degradation. Emerging evidence suggests the ability of RNA binding proteins such as dead end homolog 1 (DND1) to interact with mRNA and influence miRNA mediated PTGR events. We have utilized massively parallel deep sequencing to characterize small RNA expression in the maturing cumulus oocyte complex and during early embryo development in pigs. Numerous miRNA, piRNA and other small RNA molecules were identified and mapped to the pig genome. Following mapping and quantification of small RNA sequence reads unique miRNA and piRNA clusters were identified. Changes in total small RNA predicted to interact with specific mRNA were used to identify potential PTGR events following germinal vesicle breakdown in the oocyte during maturation. Despite a substantial increase in MIR21 in both the oocyte and the cumulus cells during in vitro maturation, MIR21 expression in the MII-arrested oocytes was not affected by the presences of cumulus cells, suggesting MIR21 biogenesis occurs at some level in the oocyte. Functional characterization of MIR21 and its ability to regulate two potential target mRNA, PDCD4 and PTEN, was conducted in the maturing cumulus oocyte complex. Increased MIR21 expression during oocyte maturation is temporally associated with the PDCD4 protein suppression, which was inhibited in the presence of an anti-MIR21 oligonucleotide. Additionally, we have demonstrated the expression of DND1 in the maturing oocyte and early embryo, and have begun identification of critical mRNA expressed in the oocyte potentially bound by DND1. This project was supported by National Research Initiative Competitive Grant no. 2008-35205-05309 and 2008-35205-18712 from the USDA National Institute of Food and Agriculture.

Key Words: miRNA, oocyte, pig, MIR21, reproduction

O237 **How our basic understanding of the ovarian reserve is improving reproductive management in domestic farm animals.** R. A. Cushman*, A. McNeel, C. Chase, Jr., C. Lents, *Reproduction Research Unit, USDA-ARS U.S. Meat Animal Research Center, Clay Center.*

Mammalian females are born with a finite number of oocytes in their ovaries, the majority of which are stored as dormant primordial follicles. This finite supply of female gametes, termed the ovarian reserve, is established before birth and slowly depletes through the processes of follicle activation, recruitment, selection and atresia until reproductive senescence occurs. While most females of domestic farm species do not remain in the production herd long enough to reach reproductive senescence, research focused on the ovarian reserve has made it clear that variations in the ovarian reserve that are present at birth affect many aspects of reproductive function. This variation in follicle numbers directly contributes to the variation in response to multiple ovulation embryo transfer (MOET) protocols, because there are positive correlations between the numbers of preantral follicles and the numbers of antral follicles. However, in *Bos indicus* cows the number of antral follicles detectable by ultrasonography is increased without a corresponding increase in the number of preantral follicles or an increase in ovulation rate, suggesting that mechanisms that enhance secondary to antral follicle transition cause this increase. The number of ovarian follicles is positively associated with reproductive tract development in replacement females. In gilts, selection for increased uterine capacity resulted in an increased number of antral follicles without any differences in the numbers of preantral follicles. Antral follicle numbers are positively associated with fertility. This is due to a positive relationship between follicle number and oocyte competence because in 4-month-old heifers, in vitro fertilization rates were positively associated with follicle numbers. Evidence from aged cows indicates that depletion of the ovarian reserve can alter reproductive function and influence length of productive life. Application of this information has improved

selection decisions and assisted reproductive technologies in farm species. USDA is an equal opportunity provider and employer.

Key Words: antral follicle count, ovarian reserve, reproductive management

O238 **Follicular determinants of pregnancy establishment and maintenance in beef cattle.** M. Smith [1,*], K. G. Pohler [1], J. A. Atkins [1], G. A. Perry [2], E. M. Jinks [1], M. D. MacNeil [3], T. W. Geary[3], *[1]Animal Science, University of Missouri, Columbia, [2]Animal Science, South Dakota State University, Brookings, [3]Fort Keogh Livestock and Range Research Laboratory, USDA ARS, Miles City.*

Physiological maturity of a dominant/ovulatory follicle can affect establishment and maintenance of pregnancy in cattle. More specifically, GnRH-induced ovulation of small verses large dominant follicles reduced pregnancy rates and increased late embryonic/fetal mortality. In contrast, ovulatory follicle size had no apparent effect on fertility when ovulation occurred spontaneously. Reduced pregnancy rates following induction of ovulation of a physiologically immature dominant follicle is likely mediated through inadequate oocyte competence and a compromised maternal environment. Therefore, we conducted a reciprocal embryo transfer study to differentiate between follicular effects on oocyte quality and uterine environment on pregnancy success in beef cattle. Donor and recipient cows were classified as having either a small (<12.5 mm) or large (≥12.5 mm) diameter follicle at GnRH-induced ovulation and transfers occurred in a 2x2 factorial arrangement of these categories. We used path analysis to describe relationships among the complex array of factors affecting pregnancy success. Single embryos (n = 394) were recovered from donor cows (d 7) and all live embryos were transferred into recipient cows on the same day. Increased fertilization success was directly associated with increased donor cow weight, serum concentrations of estradiol at the time of GnRH-induced ovulation and artificial insemination (d 0), days postpartum, and ovulatory follicle size (in order of importance). Interestingly, increased ovulatory follicle size was the only factor that directly improved embryo quality on d 7. Embryo survival in recipient cows from d 7 to 27 was enhanced by increased circulating estradiol concentration on d 0 and progesterone concentration on d 7 indicating that these hormones helped prepare the uterus for a successful pregnancy. In summary, there are numerous variables that affect the successful establishment of pregnancy. However, increased estradiol at the time of insemination is critically important to fertility and embryo survival.

Key Words: follicle, pregnancy, cattle

O239 **Follicle development and insemination technology and its impact on fertility in swine.** R. Knox*, *Animal Sciences, University of Illinois, Urbana.*

Fertility in swine breeding herds is often assessed as pigs/sow/year, which results pregnancies/year that produces pigs born alive. To reach a target approaching 30 pigs/sow/year requires high fertility in the female breeding herd, excellent reproductive management for estrus detection, AI timing and technique, and use of high fertility semen. Estrus induction and expression in gilts and sows relies on management procedures that optimize neuroendocrine control of reproductive hormone synthesis and release for optimal ovarian follicle development. High conception rate with maximal litter size requires ovulation of a number of large follicles with mature oocytes. This cohort of large follicles must originate from a pool of selectable, healthy, medium follicles at the start of the follicle phase. Synchrony in ovulatory follicle development may optimize follicle production of growth factors and hormones that improve oocyte quality. Heterogeneity in follicle size may be responsible variation in oocyte quality. It is possible that the origin of these problems arise from physiological stressors that perturb the development of the pool of follicles before or during selection. It is possible that ovulation of oocytes from a pool of heterogeneous follicles can alter transport to the site of fertilization, sperm fertilization, and early embryo development. These problems could explain the high rate of early embryonic loss and noted asynchrony in embryo development before and at the time of maternal recognition of pregnancy. In modern breeding herds, two inseminations spaced at a 24 h interval are delivered after detection of estrus to help compensate for up to a 30 hour variation in the interval from onset of estrus to ovulation. This variation may become limiting to fertilization and healthy embryos since each depends upon an insemination window occurring within 24 h before ovulation. New reproductive management strategies to reduce variation and remove limitations now include induced and synchronized follicle development, induced ovulation, selection of sires or semen for extended in-vivo fertility, sustained sperm release, intrauterine insemination, and fixed time AI.

Key Words: swine, follicles, fertility, insemination

RUMINANT NUTRITION: GENERAL RUMINANT NUTRITION II

O240 **The effect of commensal microbial communities on the fecal shedding of Shiga toxin-producing E. coli (STEC) in beef cattle.** N. D. Aluthge*, Y. A. Wanniarachchi, G. E. Erickson, T. J. Klopfenstein, B. L. Nuttelman, C. J. Schneider, S. C. Fernando, *Animal Science, University of Nebraska, Lincoln.*

Shiga toxin-producing *E. coli* (STEC) are important foodborne pathogens whose major natural reservoir is thought to be the gastrointestinal tract (GIT) of ruminants, especially cattle. The main route of entry of STEC to the environment is through cattle feces. Previous research has shown that the level and frequency of STEC shedding in cattle feces varies widely among individual animals. In this study, we hypothesize that differences in gut microbial community composition may play a role in the shedding pattern of STEC by beef animals. STEC high-shedders and low-shedders were identified among 170 beef steers over 3 time periods using selective microbiological culture methods and molecular methods. Based on shedding numbers 48 high-shedders (>10^4 STEC cfu/g of feces) and 48 low shedders (<10^2 cfu/g of feces) were selected for phenotyping for gut microbial composition using 16s rRNA-based amplicon sequencing. Among the high-shedders, as determined by latex agglutination reactions, the prevalence of the 7 major STEC serogroups was as follows: O157 (4.2%), O26 (4.2%), O111 (8.4%), O103 (12.5%), O121 (27.1%), O45 (18.8%), and O145 (91.7%). In 25% of animals, more than one serogroup was detected. A total of ~525,000 high-quality DNA sequences generated through 454-pyrosequencing was used to evaluate microbial community composition. Bioinformatic analysis of the sequences from high-shedders and low-shedders revealed that members of the phylum Bacteroidetes were more abundant in the low-shedders, while members of the phylum Proteobacteria were more abundant in the

high-shedding animals. At the family level, Prevotellaceae were represented more in the low-shedders than in the high-shedders. Further analysis showed that 9 operational taxonomic units (OTUs) were significantly more abundant ($P < 0.05$) in low-shedders than in high-shedders. Most of these OTUs represented members of the genus *Prevotella*.

Key Words: *E. coli* , microbiome, pyrosequencing

O241 **Meta-analysis examining the effects of *Saccharomyces cerevisiae* fermentation product on feedlot performance and carcass traits.** J. J. Wagner [1,*], T. E. Engle [1], C. R. Belknap [2], *[1]Animal Sciences Department, Colorado State University, Fort Collins, [2]Diamond V, Cedar Rapids, IA.*

Results from 28 studies were compiled for a meta-analysis evaluating the effects of *Saccharomyces cerevisiae* fermentation product (SCFP) manufactured by Diamond V on feedlot performance and carcass traits. Data consisted of 67 treatment means from 234 pens and 7660 feedlot cattle. Data were analyzed using mixed model procedures. Fixed class variables (no = 0, yes = 1) included SCFP, monensin, tylosin, and use of implants. Gender was also included as a fixed class variable. Days on feed (DOF) were included in models as a fixed continuous variable when significant ($P < 0.05$). Study was included in all models as a random class variable. The analysis was weighted by pen replicates per treatment mean. Cattle fed SCFP had 2.8 kg heavier ($P < 0.10$) final body weight (BW), achieved greater ($P < 0.01$) ADG (1.42 vs. 1.38 kg/head), and gained 3.0% more ($P < 0.01$) weight per kg DM (GF) consumed versus control. Dry matter intake was similar ($P = 0.81$) between control and SCFP. Eleven studies were suitable for an analysis of receiving period data (31 records, 104 pens, 1066 cattle). There were trends for increased ($P = 0.11$) final BW (1.2 kg), increased ($P < 0.08$) ADG (1.27 vs. 1.21 kg/head), and 4.4% improved ($P = 0.11$) GF for SCFP versus control. Daily DMI was not influenced ($P = 0.78$) by SCFP supplementation. An analysis of finishing period data (28 records, 108 pens, 1906 cattle) indicated a trend ($P < 0.14$) for a 2.5% improvement in GF for SCFP over control. Remaining performance differences were not significant ($P > 0.20$). Analysis of carcass data revealed an increase ($P < 0.01$) in percent Choice and Prime combined (66.5 vs. 54.8%) and a reduction ($P < 0.05$) in percent Select carcasses (28.7 vs. 40.9%) for SCFP versus control. Remaining carcass differences were not significant ($P > 0.20$). These results indicate that feeding SCFP was positively associated with feedlot performance and quality grade.

Key Words: feedlot, performance, *Saccharomyces cerevisiae* fermentation product

O242 **Effects of ractopamine hydrochloride on performance and carcass characteristics in finishing steers: 32-trial summary.** N. A. Pyatt*, G. J. Vogel, J. W. Homm, R. L. Botts, C. D. Bokenkroger, *Elanco Animal Health, Greenfield, IN.*

A meta-analysis was conducted to quantify the effects of ractopamine hydrochloride (RAC; Optaflexx, Elanco Animal Health, Greenfield, IN) on growth performance and carcass characteristics in feedlot cattle following a search of the literature. Selection criteria was pen-level studies evaluating a negative control and at least one RAC treatment, on-label dose (10-30 mg/kg DM basis and 70-430 mg/hd/d) and duration (28-42 d prior to slaughter), and incremental performance (last 28-42 d). Further, a critical mass of greater than 5 trials was required per dose and cattle type, excluding 5 studies each with 400 mg/hd/d or Holstein steers. This summary represents analysis of 32 beef steer studies encompassing 26,483 feedlot cattle. All data were analyzed in SAS using mixed regression models with RAC intake (mg/hd/d) as the primary predictor. Within-trial variance was set equal to the squared inverse of the standard error, while a random intercept term accounted for between-trial differences. Cook's D statistics were used to identify influence on parameter estimates. Yield grade and quality distributions were evaluated using a random effects proportional odds cumulative logit model. Live weight (linear), ADG (quadratic) and feed efficiency (quadratic) improved ($P<0.01$) with increasing dose of RAC supplementation compared to controls. DMI was not affected ($P=0.29$) by RAC level. Increasing RAC level improved (linear; $P<0.001$) HCW and dressing percent. Fat thickness was not affected, however, marbling score, KPH, and calculated yield grade decreased (linear; $P<0.01$), while LM area, lean maturity, and conformation score increased (linear; $P<0.01$) with level of RAC. Similarly, RAC shifted quality and yield grade distributions slightly lower (linear; $P<0.01$). Feeding an elevated level of RAC improves beef production efficiency with expected outcomes of 3.4, 6.8, and 10.2 kg live weight and 3.1, 6.1, and 9.2 kg carcass weight improvements in steers fed 100, 200 or 300 mg/h/d (respectively) relative to controls.

Key Words: Optaflexx, ractopamine, steers

O243 **Effects of monensin level during grain adaptation on animal performance and carcass traits.** C. J. Schneider*, M. K. Luebbe, K. H. Jenkins, S. A. Furman, G. E. Erickson, T. J. Klopfenstein, *Animal Science, University of Nebraska, Lincoln.*

Yearling crossbred steers (BW=375 ± 29 kg) were used to evaluate effects of monensin concentration during grain adaptation on feedlot performance and carcass traits. Cattle were separated into 3 weight BW blocks, stratified by BW, and assigned randomly within strata to 18 feedlot pens, with 10 or 11 steers per pen and 9 pens per treatment. Treatments were imposed during grain adaptation (20 d) by feeding 360 or 480 mg/hd daily (DM) of monensin. Excluding monensin level, the grain adaptation program was the same for all cattle consisting of 3 grain adaptation diets fed for 6 d each which increased dry-rolled corn inclusion from 25 to 55% of diet DM while alfalfa hay inclusion decreased from 30 to 0% of diet DM. All step diets and the finishing diet contained 25% wet distillers grains with solubles, 12% corn silage, and 6% liquid supplement (DM basis). Subsequent to grain adaptation, all steers were fed a common finishing diet that provided 360 mg per animal daily of monensin and provided 90 mg per steer daily of tylosin for the remainder of the feeding period. Monensin level did not affect DMI ($P=0.39$) during grain adaptation with DMI of 9.1 and 9.0 kg for low and high monensin, respectively. No differences in ADG or G:F ($P>0.44$) were observed during the grain adaptation period. Among day DMI variance was not different as a result of monensin level during the adaptation period ($P=0.56$) or for the first 6 d cattle were fed a common finishing diet ($P=0.75$). No effects of monensin level during the grain adaptation period were observed over the entire feeding period for DMI or ADG ($P>0.40$). Feed efficiency was not different across treatments ($P=0.99$) with G:F of 0.173 for both treatments. Carcass traits were not affected ($P > 0.21$) by monensin level. Feeding 480 mg per animal daily monensin during the adaptation period did not improve feedlot performance or carcass characteristics when compared 360 mg per animal daily when fed to yearling steers.

Key Words: feedlot cattle, grain adaptation, monensin

O244 **Intake and digestibility of heat-damaged hay by Katahdin ewes.** W. B. Smith [1,*], K. P. Coffey [1], E. B. Kegley [1], J. D. Caldwell [2], A. N. Young [1], E. A. Backes [1, 2], J. Kanani [1], D. Philipp [1], *[1]Department of Animal Science, University of Arkansas Division of Agriculture, Fayetteville, [2]Department of Agriculture and Environmental Sciences, Lincoln University, Jefferson City.*

The nutritional limitations of heat-damaged forage are well documented. However, ruminant animals have been observed to readily consume forages heated to the point of caramelization. Therefore, our objective was to determine intake and in vivo digestibility of bermudagrass hay with varied degrees of caramelization. Large round hay bales of predominantly bermudagrass with varying degrees of caramelization among and within bales were identified. Bales were labeled and core samples taken from specific locations within the bales to validate visual degree of heat-damage with ADIN analyses. Hay from the bales was then separated into 3 levels of heat-damage (LOW, MED, and HIGH) based on visual color. Prior to feeding, hay was chopped using a bedding chopper to an approximate fiber length of 2.5 cm. Fifteen non-pregnant, non-lactating Katahdin ewes (66.2 ± 1.33 kg initial BW) were stratified by weight within age and allocated randomly to 1 of the 3 treatments. Ewes were offered their respective hays for ad libitum consumption through a 10 d adaptation period followed by 5 d of total fecal collection. On the final day of collection, blood samples were gathered via jugular venipuncture immediately prior to feeding and 4 and 8 h post-feeding and analyzed for concentrations of serum urea nitrogen (SUN). Dry matter intake and digestibility of DM, NDF, and ADF, as well as digestible DM and OM intake were greater ($P < 0.05$) from LOW and MED compared with those from HIGH. Organic matter digestibility and concentrations of SUN were greater ($P < 0.05$) from LOW compared with MED and from MED compared with HIGH ($P < 0.05$). Therefore, when provided as the only dietary choice, intake and digestibility of severely caramelized hay may be reduced compared with that of non-caramelized hay.

Key Words: dry matter digestibility, heat-damaged forage, serum urea nitrogen

O245 **Influence of dam residual feed intake (RFI) phenotype on milk production and progeny growth performance.** N. O. Minton [1,*], R. L. Barnett [2], R. L. Kallenbach [2], M. S. Kerley [1], *[1]Animal Sciences, [2]Plant Sciences, University of Missouri, Columbia.*

Identifying metabolically efficient from non-efficient cattle is economically relevant to beef production. Metabolically efficient cattle (RFI-) yield equivalent to or greater amounts of output with reduced dietary intake compared to average (RFI_0) or inefficient (RFI+) cattle. Objectives were to compare progeny production measures and feed efficiency traits amongst dam RFI phenotypes measured as heifers (RFI_H), dry cows (RFI_D) and lactating cows (RFI_L).We hypothesized dam RFI phenotype would be correlated at various production stages and RFI_H was more accurate in predicting feed efficiency of progeny compared to RFI_D or RFI_L. Simmental x Angus cross cows were initially phenotyped as virgin heifers (RFI- (n=8), RFI_0 (n=8), RFI+ (n=8)) and re-phenotyped as dry and lactating cows. Milk production was measured at an average of 75 d and 155 d postpartum using the weigh-suckle-weigh method. Milk production was added to the prediction model of RFI_L. RFI_H was not correlated to RFI_D or RFI_L, however, a moderate correlation (0.60; $P \leq 0.01$) occurred between RFI_D and RFI_L. Milk production numerically ($P \geq 0.10$) increased while milk efficiency linearly ($P \leq 0.10$) increased from RFI_{H+} to RFI_{H-}. Compared to RFI_D and RFI_L phenotypes, RFI_H produced steer progeny with lower F:G and greater BW gain. Steers from RFI_{H-} had greater BW gain (2.04 vs. 1.87 kg; $P \leq 0.10$) and lower F:G (5.27 vs. 6.09, $P \leq 0.10$) than steers from RFI_{H+}. Both RFI_{D-} and RFI_{L-} produced steers with lower BW gains ($P \leq 0.10$) and no difference in F:G compared to RFI_{D+} and RFI_{L+}. Disagreement among RFI_H, RFI_D and RFI_L phenotype may be a result of unaccounted for variables influencing DMI in dry and lactating cows. Selection for more efficient animals may indirectly select for cows capable of greater milk production and efficiency. RFI_H was the best indicator of progeny BW gain and efficiency.

Key Words: beef, feed efficiency, RFI

O246 **The effect of trace mineral source and concentration on ruminal digestion and mineral solubility.** O. Genther*, S. Hansen, *Animal Science, Iowa State University, Ames.*

The objective of this experiment was to compare sulfate and metal hydroxy trace mineral (TM) sources at 2 inclusion rates on DM and NDF digestibility, and solubility of TM in the ruminant digestive tract. Five ruminally-fistulated steers were used in a 5 x 5 Latin square and fed a corn-silage based diet on an ad libitum basis. Treatments included a Negative Control (CON): with no supplemental Cu, Mn or Zn; Low Sulfate (LS): 5 ppm Cu as $CuSO_4$, 15 ppm Mn as $MnSO_4$, and 30 ppm Zn as $ZnSO_4$; Low Metal-hydroxy (LMH): 5 ppm Cu as tribasic copper chloride, 15 ppm Mn as tribasic manganese chloride, and 30 ppm Zn as tribasic zinc chloride; High Sulfate (HS): 25 ppm Cu, 60 ppm Mn, and 120 ppm Zn (as sulfates); and High Metal-hydroxy (HMH): 25 ppm Cu, 60 ppm Mn, and 120 ppm Zn (as metal hydroxys). Periods lasted 12 d, with 10 d of adaptation. On d 11, 24 Dacron bags containing dried, ground CON TMR were inserted prior to feeding (0 h) and six bags per time point were removed at 6, 12, 24 and 36 h post-insertion. Rumen fluid was collected at the 36 hr time point. Dry matter and NDF disappearance, as well as rumen fluid TM concentrations and in vitro abomasal solubilities were evaluated. Dietary treatment did not impact DMI ($P = 0.6$). Dry matter disappearance of the CON treatment was greater than the sulfate supplemented treatments ($P = 0.03$), while there was no difference between CON and metal hydroxy treatments ($P = 0.18$). The NDF disappearance rate between hours 6 and 12 for HS and HMH tended to be lower than other treatments ($P < 0.10$), but overall NDF disappearance was not affected by treatment ($P = 0.7$). Rumen soluble Cu and Mn concentrations were lowest in CON, and were lower in LMH vs. LS ($P < 0.01$), and HMH vs. HS ($P < 0.01$). In the abomasum, solubility of metal hydroxy treatments tended to be equal to their respective sulfate treatments ($P < 0.10$). Rumen and abomasal soluble Zn was greatest in the HMH treatment ($P < 0.01$). Metal hydroxy trace minerals do not impact DM digestibility, unlike sulfate minerals, and are relatively insoluble in the rumen, but solubilize in the pH found in the abomasum.

Key Words: NDF, ruminant, trace mineral

O247 **Relationship between heifer feed efficiency measures and intake of good-quality and poor-quality forage in mature beef cows.** C. Cassady*, T. B. Wilson, K. Retallick, D. B. Faulkner, D. W. Shike, *Animal Sciences, University of Illinois, Urbana.*

The objective of this study was to determine the relationship between measures of heifer feed efficiency and mature cow intake of good-quality and poor-quality forage. Measures of feed efficiency

were determined in Angus and Simmental X Angus heifers (n=139). Individual intakes were recorded using the GrowSafe® automated feeding system. Residual feed intake (RFI) was assumed to represent the residuals from a multiple regression model regressing DMI on ADG and mid-metabolic BW. Residual BW gain (RG) was assumed to represent the residuals from a multiple regression model regressing ADG on DMI and mid-metabolic BW. Residual intake and BW gain (RIG) was calculated as the sum of -1 x RFI and RG standardized to a variance of 1. Ranking of high, medium, and low feed efficiency groups were established by calculation of the mean and SD of the heifers and grouping them within ± 0.5 SD of the mean. These heifers were kept as replacements and, as 5- or 6-yr old cows, were placed on GrowSafe® during mid-gestation to record individual voluntary forage intake. Cows were randomly allotted to 1 of 2 diets: 1) good-quality forage diet (GQ; 50% alfalfa haylage, 50% grass hay), and 2) poor-quality forage diet (PQ; 80% switchgrass, 20% corn condensed distillers solubles). After 10d of intake were recorded for each diet, cows switched diets and another 10 d of intake were recorded. Performance traits evaluated were DMI, BW, BCS, and backfat via ultrasound. As heifer RFI improved, cow GQDMI decreased (r=0.29; $P<0.01$) and cow PQDMI tended to decrease (r=0.13; $P=0.14$). There was no relationship ($P\geq0.51$) between heifer RG and cow DMI. As heifer RIG improved, cow GQDMI decreased (r =-0.20; $P=0.02$). There was no relationship ($P=0.19$) between heifer RIG and PQDMI. Cows classified with the least desirable heifer RFI and heifer RIG had the greatest ($P\leq0.05$) GQDMI. Cows classified with the least desirable heifer RFI had greater ($P=0.04$) PQDMI than those with the most desirable heifer RFI, medium heifer RFI cows were intermediate. Heifer RFI appears to have the strongest relationship to cow intake when cows are fed good-quality forage.

Key Words: cow, efficiency, intake

O248 **Applying corn condensed distillers solubles to hay windrows prior to baling: Ii. effects on growing steer calf performance.** J. M. Warner*, C. J. Schneider, R. J. Rasby, G. E. Erickson, T. J. Klopfenstein, *Animal Science, University of Nebraska, Lincoln.*

The objective of this experiment was to evaluate the effect of feeding grass hay bales previously treated in the windrow before baling with corn condensed distillers solubles (CCDS) and supplementing to meet metabolizable protein requirements on growing calf performance. Individually fed crossbred steers (n = 60, initial BW = 288 ± 11.6 kg) were used in an 84 d trial, which was a completely randomized design with a 3 x 2 factorial arrangement of treatments resulting in six dietary treatments. Factors included level of CCDS (0, 15, or 30% of diet, DM) with or without supplemental metabolizable protein (MP or No MP). Supplemental UIP was provided with a 1:1 ratio (DM) of Soypass® and corn gluten meal to meet MP requirements (NRC) for all MP-diets. Large-round hay bales with CCDS ground prior to feeding served as the basal diet with the supplement top-dressed at feeding. Individual animal (n = 10 per treatment) was considered the experimental unit. As intended, initial BW was similar among treatments. Gain and final BW linearly ($P \leq 0.01$) improved as CCDS inclusion increased, but were only greater for MP-diets at 0% CCDS. Additionally, DMI increased linearly ($P \leq 0.01$) with greater dietary CCDS, but was similar ($P = 0.60$) between MP and No MP-diets. Gain efficiency improved in linear fashion ($P \leq 0.01$) as dietary CCDS increased, but was only enhanced by MP-diets up to 15% CCDS. Supplementing growing cattle to meet metabolizable protein requirements had little impact on gain or efficiency beyond 15% dietary CCDS, but steers responded to increasing CCDS levels, thereby validating that within-bale storage occurs and CCDS-treated bales do not need MP supplementation when used in growing diets.

Key Words: beef cattle, distillers solubles, growing

O249 **Applying corn condensed distillers solubles to hay windrows prior to baling. I. Procedure, and effects on bale temperature and nutrient composition.** J. M. Warner*, G. E. Erickson, R. J. Rasby, *Animal Science, University of Nebraska, Lincoln.*

Two experiments were conducted to evaluate an alternative method of storing liquid ethanol co-products while concurrently improving hay bale nutrient quality. Corn condensed distillers solubles (CCDS) was applied to native grass hay windrows in a completely randomized design, and large-round bales were subsequently produced from treated windrows. In each trial, CCDS was added within 24 h of baling, bales were sampled for nutrient analysis, and internal temperature was measured. Bale was the experimental unit. Inclusion levels of CCDS (% of bale weight, DM) equaled: 0 or 20% (Exp. 1); and 0, 16, or 32% (Exp. 2). In Exp. 1, CCDS level had no effect ($P = 0.58$) on internal temperature or DM. Bales treated with 20% CCDS had increased ($P \leq 0.001$) CP, fat, and S compared to bales with 0% CCDS. Accordingly, 20% CCDS bales had lower ($P \leq 0.001$) NDF than did 0% bales (60.0 vs. 69.2%, respectively). In Exp. 2, internal bale temperature linearly ($P \leq 0.01$) increased with greater CCDS levels when measured at 3 wk post-baling. Regardless, temperature declined ($P \leq 0.05$) across all levels from 0 to 3 wk after baling. No effect ($P = 0.68$) of level was observed for DM in Exp. 2 despite increasing CCDS levels. Fat and CP content were increased significantly ($P = 0.03$) by adding CCDS when compared to bales that had no CCDS added, but were not different between 16 and 32% bales. Relative to 0% bales, NDF decreased ($P \leq 0.01$) by 14.6 and 24.7% for 16 and 32% bales, respectively. Data suggest up to 32% CCDS can be applied to grass hay windrows prior to baling without impacting internal bale heating or moisture retention. Nutrient analyses indicate successful within-bale storage of CCDS occurred. Applying CCDS to hay windrows prior to baling is a viable strategy for storage of liquid co-products and improvement of bale nutrient quality.

Key Words: distillers solubles, forage, nutrient quality

O250 **Including NEXT ENHANCE essential oils in finishing diets on performance with or without monensin and tylosin.** C. J. Bittner [1,*], G. E. Erickson [1], K. H. Jenkins [2], M. K. Luebbe [2], T. Wistuba [3], *[1]Animal Science, University of Nebraska, Lincoln, [2]Animal Science, University of Nebraska, Scottsbluff, [3]Animal Science, Novus International, Inc., St. Charles, MO.*

A finishing study was conducted evaluating the effects of NEXT ENHANCE (NEX) and monensin/tylosin (MT) on feedlot performance, carcass characteristics, and liver abscesses in finishing diets. Four hundred calf fed steers (BW= 291 ± 29 kg) were utilized in a randomized block design (n=3 BW blocks) using a 2 x 2 factorial treatment structure. Factors included the presence or absence of NEX and presence or absence of MT resulting in 4 treatments: 1) control, no additives (CON); 2) NEX; 3) MT; and 4) NEX plus MT. The essential oils (NEX) were included at 300 mg/steer daily,

monensin at 360 mg/steer daily and tylosin at 90 mg/steer daily. A common basal diet was used for all four treatments consisting of 53% dry-rolled corn, 25% wet distillers grains plus solubles, 16% corn silage, and 6% supplement (DM basis). Steers were fed for either 141 or 161 d based on BW block. There were no significant MT x NEX interactions ($P > 0.05$) for finishing performance or carcass characteristics. There was a tendency ($P = 0.07$) for cattle fed MT to have improved ADG, while feeding NEX had no effect ($P = 0.85$). In diets containing MT, a 3.9% improvement in G:F ($P < 0.01$) was observed but when feeding NEX, G:F was not affected ($P > 0.86$). There was a trend ($P = 0.07$) for an increase in HCW and a significant ($P < 0.01$) increase in marbling score when steers were fed MT. Incidence of liver abscesses decreased 45.7% when MT ($P < 0.01$) was fed compared with diets that did not contain MT. Feeding NEX did not statistically impact ($P > 0.74$) carcass characteristics. The prevalence of liver abscesses decreased with the addition of MT and G:F improved when MT was included in the diet. Feeding NEX with or without MT had no impact on feedlot performance and carcass characteristics.

Key Words: essential oil, feedlot cattle, liver abscesses

O251 **Preliminary efficacy of two colostrum replacement products for preventing bovine leukosis virus transmission in calves.** P. Patrick*, D. W. Nagy, *Univerity of Missouri, Columbia.*

The objective of this study was to quantify the efficacy of two commercial colostrum replacement products (CR) compared with fresh bovine colostrum (MC) *for reducing the periparturient risk of* Bovine Leukosis Virus (BLV) transmission in at-risk calves. Heifer calves born to BLV positive cows were separated from their dams soon after birth and randomly assigned to one of 3 treatment groups: In treatment group 1, the calves were fed 3.8 L of MC collected from their BLV positive dams. In treatment groups 2 and 3, the calves were fed either 1 dose (100 g/L of IgG) of a lacteal-derived CR (Product A, n = 8) or 1 dose (150 g/L of IgG) of a plasma-derived CR (Product B, n = 8) after reconstitution in accordance with the manufacturers recommendations. Next, whole blood samples were collected from each calf prior to and after feeding colostrum at 0 h, 8 d, 15 d, 22 d, 29 d, 36 d, 43 d, 50 d, and 57 d of age and tested for evidence for BLV DNA using conventional PCR. Calves were declared BLV positive when they turned at least one positive PCR test outcome over the duration of follow-up. Data was summarized in contingency tables and the proportion of calves that were BLV positive in each group calculated. Preliminary calculations indicate that 29% (2/7) of the calves fed product A and 38% (3/8) of calves fed product B tested BLV positive compared with 0 (0/ 4) in the group of calves fed MC from BLV positive cows. These results are preliminary and no attempts should be made to draw final conclusions regarding the efficacy of the CR products evaluated as final results are pending the completion of this trial.

Key Words: bovine leukosis virus, colostrum replacer, colostrum

POST MEETING WORKSHOP

TEMPORARY IMMUNOLOGICAL CASTRATION OF SWINE: IMPACT OF NUTRITION REQUIREMENTS, GROWTH AND MEAT QUALITY

O252 **Use of anti-GnRF immunization for temporary castration of male pigs: Mechanism of action and pork value chain implications.** M. A. Mellencamp*, A. Schroeder, J. R. Bradford, S. R. Webster, *Pfizer Animal Health, Madison, NJ.*

In the US, male pigs destined for market are physically castrated (PC) soon after birth to reduce the risk of boar taint and control aggressiveness. Boar taint is a distinctive, often offensive, aroma that is primarily caused by androstenone and skatole. Androstenone is a male sex pheromone produced in the testes. Skatole is a product of intestinal tryptophan metabolism. Both are fat soluble and high concentrations in fat of some boars results in boar taint. An alternative to physical castration is immunization against gonadotropin releasing factor (GnRF) using Improvest® (GnRF analog diphtheria toxoid conjugate; Pfizer Animal Health). Improvest® is an FDA-approved veterinary prescription product that is given as two immunizations to finisher pigs. The 1st immunization primes the immune system but elicits little change in boar physiology. The 2nd dose, given 3-10 weeks prior to slaughter, elicits a high titer of antibodies that block GnRF, thus reducing LH, FSH, and testosterone, and inhibiting testicular function. Immunological castration is temporary. Testicular function gradually returns as antibodies decay. There are two unique growth phases of Improvest® -treated pigs: the boar phase prior to the 2nd dose, and shortly after the 2nd dose, when boars transition to castrate-like metabolism. Because pigs are immunologically castrated (IC) later in life, increased lean growth and improved FE are maintained into finishing without the risk of boar taint. US studies showed that Improvest® improved FE by 6-10%, ADG by 3-6% and carcass cutout yield by 2-2.5%. Improvest® implementation includes potential nutrition program adjustments, carcass and meat quality evaluations, and management changes. Farm management considerations include split-sex requirements, proper Improvest® application, farrowing house adjustments, marketing economics, etc. Improvest® technology allows the pork chain to benefit from the inherent advantages of intact male efficiencies while providing an alternative to physical castration and maintaining high quality pork.

Key Words: boar taint, immunological castration, swine

O253 **Nutritional management of entire male pigs and immunologically castrated barrows.** C. De Lange*, *Animal and Poultry Science, University of Guelph, Canada.*

The global trends towards using entire male pigs (EM) for pork production is driven by improvements in efficiencies, reductions in the environmental footprint and public concerns about physical castration (PC) of EM. The recent approval of ImprovestTM for immunological castration (IC) of EM presents a new opportunity to control boar tainted meat and aggressive (sexual) behaviour. Prior to the 2nd injection with Improvest (booster), IC barrows are physiologically similar to EM. When compared to PC barrows,

EM have higher lean growth (i.e., body protein deposition; Pd) capacity and lower feed intake. In EM, energy intake, rather than the animal's Pd capacity, generally determines lean growth. Therefore, energy intake of EM should be maintained high. During the 10-14 day transition period after injecting the booster, IC barrows show a substantial increase in feed intake and body lipid deposition, as well as slight reductions in Pd and maintenance energy requirements, in order to achieve a target body fatness that is reflective of barrows and higher than EM. At slaughter—generally 4 to 6 weeks after injecting the booster—body fatness of IC is intermediate to that of EM and PC barrows, and generally lower than gilts. The effect of restricting energy intake after injecting the booster on body fatness remains to be explored. Given the lack of studies defining nutrient requirements of EM and IC in North America, the factorial approach (modelling) has been used for estimating nutrient requirements, reflecting differences in feed intake, Pd and maintenance energy requirements among genders (e.g., NRC, 2012; Nutrient Requirements of Swine). Based on a recent review of field studies in the US, the difference in Pd between EM and gilts or PC barrows appears higher that estimated in NRC (2012). Based on these analyses, typical nutrient requirements of EM may be underestimated by about 5% in NRC (2012). Timing of administering the booster dose to IC barrows and feeding PayleanTM are means to manipulate pork production efficiencies and carcass fatness of pigs, but their impact on carcass quality and nutrient requirements should be carefully considered.

Key Words: castration, Improvest, pigs

O254 **Comparison among gilts, physical castrates, entire males and immunologically castrated males in terms of growth performance and nitrogen metabolism.** A. J. Elsbernd*, J. F. Patience, *Animal Science, Iowa State University, Ames.*

The objective of this study was to compare growth performance and nitrogen metabolism of immunological castrates (IC), entire males (EM), physical castrates (PC), and gilts (G). This study used individually housed pigs to evaluate performance from an initial BW of 35.7±4.1 kg to a final weight of 145.0±8.6 kg. Six pigs were selected for each treatment based on pre-test average daily gain for each of the two replicates. Diets were formulated to meet or exceed the nutrient requirements of entire boars and were fed ad libitum. Pigs selected for the IC treatment were vaccinated with a gonadotropin releasing factor (GnRF) analog (Improvest®, Pfizer) at 13 and 18 weeks of age. Urine, feed and fecal samples were collected, homogenized, sub-sampled and analyzed for nitrogen, and feed and feces for dry matter and titanium dioxide, an indigestible marker. Nitrogen intake and excretion were measured during three 72-h collection periods starting at BW of 39.5±4.1 kg, 73.7±5.7 kg and 105.5±6.1 kg for Periods 1, 2, and 3, respectively, with Period 3 occurring two weeks after the 2nd vaccination. EM and IC had a higher ADG compared to PC and G (1.17 and 1.14 kg/d versus 1.06 and 1.05 kg/d, respectively; $P < 0.001$). PC had a significantly higher ADFI than EM and G, with IC being intermediate (PC=3.16 kg/d, IC=3.04 kg/d, EM=2.93 kg/d, and G=2.91 kg/d; $P < 0.03$). EM had the highest gain to feed ratio compared to all the other treatments, while IC were the second highest and G and PC were not significantly different from each other (EM=0.43, IC=0.40, G=0.38, PC=0.36; $P < 0.0001$). In all N-balance periods, nitrogen excretion in the feces was not significantly different among the treatments ($P > 0.10$). In Periods 1 and 2, EM and IC had the lowest urinary nitrogen excretion ($P < 0.0001$). In Period 3, EM had the lowest urinary nitrogen excretion, while IC were not significantly different from G and PC ($P < 0.0001$). These results suggest that IC have higher nitrogen excretion two weeks after vaccination, which suggests the need for a feeding program similar to PC and G during this time.

Key Words: immunocastration, nitrogen metabolism, pig

O255 **Growth responses of immunologically-castrated barrows and gilts to varying intakes of fiber and energy.** N. Augspurger[1,*], E. Parr[1], A. Schroeder[2], *[1]JBS United, Inc., Sheridan, [2]Pfizer Animal Health, Madison.*

The objective of this research was to compare the growth and carcass performance of gilts and immunologically-castrated (IC) barrows as affected by dietary intake of fiber and energy. At 6 wk postweaning, 1,720 pigs (PIC 337 × C29 genetics, 26 ± 2 kg) were blocked by sex (gilts and entire males) and body weight to form eight (8) replicates of 27 pigs per sex, according to a randomized complete-block design with a split-plot arrangement of treatments, with sex as the whole plot and dietary treatment the split-plot. Pigs were allowed ad libitum access to common diets prior to the start of the experiment, and then fed experimental diets to market (N = 133 d). The dietary treatments included 1) corn-SBM, 2) 30% DDGS (89% DM, 28% CP, 8% fat, 26% NDF), 3) As 2 + 3% added fat (choice white grease), 4) As 2 + ascending inclusion of fat (1/2/3/4% fat to 59/73/91 kg/mkt). Gilt diets were formulated according to PIC (2011) requirements for SID lysine (g/Mcal ME), and those requirements were adjusted for the IC barrow diets according to Dritz et al. (2011). Immunological castration was carried out in the male pigs via a 2-dose treatment with Improvest®. The 1st injection occurred at an average of 11 wk of age (range 9-13 wk), and the 2nd injection occurred 5 wk prior to market. Pigs were harvested by pen in a commercial processing facility, where carcass weights were obtained and tissue depths (BF and LM) were measured via ultrasound. IC barrows achieved heavier ($P < 0.001$) BW, 7% greater ADG ($P < 0.01$), and 5% greater G/F ($P = 0.05$) compared to gilts. Fat supplementation effected reduced ($P < 0.05$) feed intakes and greater ($P < 0.01$) G/F, with a trend towards lower ($P < 0.10$) G/F in the ascending relative to the constant strategy. There was also a trend towards lower ($P < 0.10$) G/F in the DDGS-supplemented treatments relative to the corn-SBM treatment. DDGS supplementation effected a trend towards greater reductions in carcass weights in IC barrows than gilts (sex × treatment, $P < 0.10$). Similarly, added energy effected a trend towards greater carcass weights in IC barrows (sex × treatment, $P < 0.10$), but similar carcass weights in gilts. This experiment suggests a differential response in carcass growth performance to fiber and energy in IC barrows relative to gilts.

Key Words: energy, fiber, immunological castration

O256 **Effects of immunocastration and dried distillers grains with solubles (DDGS) withdrawal on growth performance and carcass characteristics of grow–finish pigs.** M. Asmus[1,*], A. L. Schroeder[2], M. A. Tavarez[3], M. D. Tokach[1], J. L. Nelssen[1], S. S. Dritz[1], J. M. DeRouchey[1], R. D. Goodband[1], *[1]Animal Science and Industry, Kansas State University, Manhattan, [2]Pfizer Animal Health, Kalamazoo, [3]University of Illinois, Urbana.*

A total of 1,360 pigs (24 kg BW) were used in a 125-d study to determine the effects of DDGS withdrawal post-immunocastration (Improvest) on growth performance of grow-finish pigs. Treatments were arranged in a 2 × 3 factorial with the main effects of sex

(physical castrated barrow; PC or immunological castrate; IC) and diet (no DDGS throughout, 30% DDGS throughout, or 30% DDGS through d 75 then withdrawn to no DDGS to d 125). Pens of pigs were randomly allotted by BW and sex to dietary treatments with 8 replicate pens with 27 to 29 pigs per pen. No sex × diet interactions (P>0.12) were observed. For the period before the 2nd Improvest injection (d 0 to 74), boars had lower (P<0.001) ADFI, but were more efficient (P<0.001) than PC. During this period, pigs fed 30% DDGS had reduced (P<0.003) ADG and G:F. After the 2nd Improvest injection (d 74 to 125), IC had increased (P<0.01) ADG, ADFI, and G:F. Overall (d 0 to 125), IC had improved (P<0.003) ADG and G:F and lower (P<0.003) ADFI than PC. The inclusion of 30% DDGS regardless of withdrawal or sex decreased (P<0.001) G:F.Carcass yield was lower (P<0.001) for IC (74.5%) than PC (76.2%) regardless of diet. Pigs fed 30% DDGS throughout had decreased (P<0.001) carcass yield (74.8%) than pigs fed corn-soy diets (75.6%); however, withdrawing DDGS on d 74 was effective at fully recovering the yield loss (75.5%). In summary, IC had reduced carcass yield, regardless of diet type; however, they also had lower ADFI and improved ADG, which resulted in improved F/G.

Gender: d 0 to 74: d 74 to 125:	PC Corn-soy Corn-soy	PC DDGS Corn-soy	PC DDGS DDGS	IC Corn-soy Corn-soy	IC DDGS Corn-soy	IC DDGS DDGS	SEM
d 0 to 74							
ADG, kg	0.92	0.89	0.89	0.91	0.87	0.88	0.009
ADFI, kg	1.97	1.99	1.94	1.78	1.77	1.78	0.026
G:F	0.47	0.45	0.46	0.51	0.49	0.49	0.005
d 74 to 125							
ADG, kg	0.94	0.95	0.97	1.03	1.05	1.05	0.017
ADFI, kg	3.02	3.11	3.17	3.13	3.23	3.31	0.052
G:F	0.31	0.31	0.31	0.33	0.33	0.32	0.004
d 0 to 125							
ADG, kg	0.92	0.91	0.92	0.95	0.94	0.94	0.009
ADFI, kg	2.35	2.39	2.38	2.27	2.29	2.33	0.031
G:F	0.39	0.38	0.39	0.42	0.41	0.40	0.004

Key Words: DDGS, Improvest, withdrawal

O257 **Combined effects of immunological castration and distillers dried grains with solubles (DDGS) on carcass yield of pigs slaughtered at two time points.** M. A. Tavárez [1,*], A. L. Schroeder [2], M. D. Asmus [3], F. K. McKeith [1], A. C. Dilger [1], *[1]Animal Science, University of Illinois, Urbana, [2]Pfizer Animal Health, Kalamazoo, MI, [3]Animal Science and Industry, Kansas State University, Manhattan.*

Male pigs were randomly assigned to sex treatments at birth and allotted to 48 pens (25 pigs/pen) in a grow-finish barn. Physical castrates (PC) were castrated at 5 d of age; immunological castrates (IC) were injected with Improvest at 16 and 20 wk of age. Diets included 0% DDGS fed from weaning to slaughter (control) and 30% DDGS fed from weaning to 2nd injection (step-down) or slaughter (DDGS). Four pigs closest to the median of pen weight were selected; 2 were slaughtered at 5 wk and 2 at 7 wk after 2nd injection. Data were analyzed as a split plot in time using the MIXED procedure of SAS with the main effects sex, diet, time and their interactions with pen as the experimental unit. For BW, IC were heavier than PC at 7 wk (137.93 vs. 132.68 kg; P<0.01), but not at 5 wk (119.90 and 117.95 kg; P=0.85). At each time point, HCW was similar between PC and IC, but HCW increased more in IC barrows from 5 to 7 wk (15.06 vs 12.35 kg; sex×time P<0.01). Diet had no effect on BW and HCW (P>0.19). Dressing percentage was reduced in IC compared to PC (73.55% vs. 75.21%; P<0.01). At each time point, back fat depth (BF) and lean percentage (LP) were similar, but BF increased more (5.99 vs. 3.17 mm) and LP decreased more (3.48 vs. 1.93 percentage units) in IC than in PC from 5 to 7 wk (sex×time P<0.01). Furthermore, at each time point, BF and LP were similar among diets, but BF increased more (6.31 vs. 3.72 mm) and LP decreased more (3.85 vs. 2.14 percentage units) in control compared with the other diets from 5 to 7 wk (diet×time P<0.01). Sex by diet interactions were only significant for bone-in (P=0.08) and boneless (P<0.05) carcass cutting yields. In each case, carcass cutting yields of control PC were 2-3% less than those of other diets, but all diets were similar in IC. These results suggest PC and IC barrows react to diets containing DDGS in a similar fashion and time after 2nd injection may be of more importance than diet for carcass characteristics.

Key Words: carcass leanness, DDGS, Improvest

O258 **Behavior of immunologically-castrated barrows in comparison to gilts, physically-castrated barrows, and intact males.** C. L. Puls [1,*], A. Rojo [1], M. Ellis [1], D. D. Boler [1], F. K. McKeith [1], J. Killefer [1], P. D. Matzat [2], A. L. Schroeder [2], *[1]University of Illinois, Urbana, [2]Pfizer Animal Health, Kalamazoo, MI.*

The behavior of immunologically-castrated (IC) barrows, gilts, physically-castrated (PC) barrows, and intact males was investigated with 160 commercial crossbred pigs using a RCBD (blocking factor date of start on test) with 4 genders: 1) Intact males (IM), 2) IC barrows (with Improvest®), 3) PC barrows, and 4) Gilts (G). Start of test was time of 1st Improvest® dose (16-wk of age; 67.2 ± 2.50 kg BW) and end of test was 8-wk later. The 2nd dose was given 4-wk after the 1st dose. Pigs were housed in groups of 4 and had ad libitum access to feed and water. Diets were formulated to meet the requirements of IM. Behavior was observed by 2 trained observers over a 12-h period from 0600 to 1800 h on the day before the start of test (day of 1st dose) and end of week 2, 4 (day of 2nd dose), 5, 6, and 8 (end of test) of the study period. General behavior (number of pigs lying, sitting, standing, eating, and drinking) was recorded every 10 min on all pens (10 pens/gender) and aggressive (frequency of head butts, bites, and fights) and sexual (frequency of mounts) behavior was recorded continuously during the 12-h period on a subsample of 16 pens (4 pens/gender). In the first 4-wk of study (prior to 2nd dose), general behavior of IM and IC was similar (P > 0.05). Also, IM and IC had a greater (P ≤ 0.05) number of mounts (27.3, 25.5, 1.5, and 2.5 for IM, IC, G, and PC, respectively; SEM 4.37) compared to PC and G. In the last 4-wk of study (after 2nd dose), IM and IC spent more (P ≤ 0.05) time standing compared to G and PC (10.1, 9.2, 8.5, and 6.7%, respectively; SEM 0.54), and IM spent less (P ≤ 0.05) time eating (7.1, 10.1, 8.8, and 10.0%, respectively; SEM 0.50) and had a greater frequency of aggressive behaviors compared to the other genders, which were similar in these respects. In the 1st 7 d after 2nd dose, IC and IM behavior was similar (P > 0.05), but thereafter IC behavior became more similar to PC. These results suggest the behavior of IC was similar to IM in the period from 1st to 2nd Improvest® dose and transitioned to become more similar to the behavior of PC after the 2nd dose.

Key Words: behavior, immunological castration, pigs

O259 **Effects of feeding ractopamine to immunologically- and physically- castrated barrows, and gilts on physical and physiological responses to animal handling and transport procedures.** C. L. Puls [1,*], M. Ellis [1], F. K. McKeith [1], A. L. Schroeder [2], *[1]University of Illinois, Urbana, [2]Pfizer Animal Health, Kalamazoo, MI.*

The effects of gender and of ractopamine (RAC) on physical and physiological responses to handling and transport were evaluated with 180 pigs using a split-plot design with a 3 × 3 × 3 factorial arrangement of treatments: 1) Gender [Physically-castrated barrows (PC), Immunologically-castrated barrows (with Improvest®; IC), and Gilts (G)], 2) RAC inclusion level (0, 5, and 7.5 ppm), and 3) Handling Intensity [Gentle, Moderate, and Aggressive). The Gender × RAC subclass was the whole plot and Handling Intensity treatment was the sub-plot. The 1st and 2nd Improvest® doses were administered at 16 and 20 wk of age, respectively. RAC was fed for 21 d after which the Handling Intensity treatment was applied (at 131.2 ± 11.76 kg BW) which consisted of moving pigs individually through a handling course (total length = 50 m) using Gentle (8 slaps from paddle), Moderate (4 shocks from electric goad), or Aggressive (8 shocks from electric goad) handling. Pigs were then loaded onto a livestock trailer, transported for 30 min, and left on the stationary trailer for 15 min before being unloaded. Physical indicators of stress (skin discoloration and open mouth breathing) were assessed throughout the handling and transportation procedures. Venous blood samples (to measure blood acid-base and cortisol) and rectal temperatures were taken 2 h before handling (baseline) and after pigs were unloaded. Four pigs (3 PC and 1 G) exhibited the fatigued pig syndrome. PC had greater ($P < 0.01$) rectal temperature and blood lactate after transport than IC, with G being intermediate for these traits. RAC at 5 ppm, but not 7.5 ppm, increased ($P < 0.05$) blood plasma cortisol after transport compared to the control (0 ppm). Aggressively handled pigs had greater ($P < 0.05$) post-handling rectal temperature and exhibited a greater ($P < 0.05$) incidence of physical indicators of stress after handling than pigs on the Gentle and Moderate treatments. The results of this study suggest that responses to handling and transportation were less in IC than in PC.

Key Words: handling, immunological castration, pigs

O260 **Effects of feeding ractopamine to immunologically- and physically-castrated barrows, and gilts on pig growth performance.** C. L. Puls [1,*], M. Ellis [1], F. K. McKeith [1], A. L. Schroeder [2], *[1]University of Illinois, Urbana, [2]Pfizer Animal Health, Kalamazoo, MI.*

The impact of gender and of feeding ractopamine (RAC) on growth performance was evaluated with 180 pigs using a RCBD (blocking factor date of start on test) with a 3 × 3 factorial arrangement of treatments: 1) Gender [Physically-castrated barrows (PC), Immunologically-castrated barrows (with Improvest®; IC), and Gilts (G)], and 2) RAC inclusion level (0, 5, and 7.5 ppm). Start of test was time of 1st Improvest® dose (16 wk of age; 69.6 ± 2.96 kg BW) and end of test was 8 wk later (131.3 ± 6.89 kg BW). The 2nd dose was given 4 wk after the first dose. RAC was fed for the final 21 d of the study period. Pigs were housed in groups of 4 (5 groups/Gender × RAC subclass) and had ad libitum access to feed and water throughout the study period. Diets were formulated to meet requirements of intact males fed RAC. There were no Gender × RAC interactions for any measures, suggesting that the response to RAC was similar across genders. For the 8-wk study period, IC had the highest ADG and G the lowest ($P \leq 0.05$) with PC being intermediate and different ($P \leq 0.05$) from the other genders (1076, 1209, and 1024 g for PC, IC, and G, respectively; SEM 18.2). Overall ADFI was lower ($P \leq 0.05$) for G than IC and PC, which were similar ($P > 0.05$) in this respect. Overall G:F was greatest ($P \leq 0.05$) for IC and lowest for PC, with G being intermediate and different ($P \leq 0.05$) from the other genders (0.338, 0.394, and 0.379 kg/kg, respectively; SEM 0.0072). For the 4-wk after 2nd Improvest® dose, IC had 25.2% and 27.8% greater ($P \leq 0.05$) ADG, 9.3% and 22.1% greater ($P \leq 0.05$) ADFI, and 15.0% and 4.3% greater ($P \leq 0.05$) G:F than PC and G, respectively. This was mainly due to gender differences in growth over the final 3 wk of study. Pigs fed RAC at 5 and 7.5 ppm had similar ($P > 0.05$) growth performance but had greater ($P \leq 0.05$) ADG and G:F and similar ($P > 0.05$) ADFI compared to those fed 0 ppm. These results confirm previously observed gender differences and effects of RAC on growth performance and show that IC have superior growth performance compared to PC in the period from the 1st Improvest® dose to harvest.

Key Words: immunological castration, pigs, ractopamine

O261 **Effects of feeding ractopamine to gilts, physical castrates, and immunological castrates on carcass characteristics, yields, and meat quality.** B. K. Lowe [1,*], C. L. Puls [1], A. L. Schroeder [2], M. Ellis [1], F. K. Mckeith [1], A. C. Dilger [1], *[1]Animal Sciences, University of Illinois, Urbana, [2]Pfizer Animal Health, Kalamazoo, MI.*

Forty-five pens with 4 pigs per pen were used to evaluate effects of feeding ractopamine (RAC) to gilts, physical castrates (PC), and immunological castrates (IC) on carcass characteristics, carcass yields, and meat quality. Final treatment arrangement was a 3 x 3 factorial with sex (gilts, PC, and IC) and RAC feeding level (0 [control], 5, or 7.5 mg/kg). Pigs in the IC treatment were injected with Improvest at 16 wk (69.6 kg BW) and 20 wk of age. All pigs were fed control diets until start of diet treatments (7 d post-2nd Improvest injection), and then dietary treatments (with or without RAC) were fed for 26 d prior to slaughter (33 d post 2nd injection) at a commercial plant. The two pigs closest to the pen mean for ending BW were selected for carcass yield and meat quality evaluation. Data were analyzed using PROC MIXED in SAS with fixed effects of sex, diet, and their interactions; experimental unit was pen. Carcasses of IC pigs averaged 104 kg and were 7.4 kg heavier ($P<0.01$) than gilt carcasses while being similar ($P=0.45$) to PC carcasses. Additionally, IC pigs had dressing percentages that were 1.8 and 2.3 percentage units less ($P<0.01$) than PC pigs and gilts, respectively. Gilts had 0.4 cm less ($P<0.01$) fat than IC pigs which had 0.4 cm less ($P<0.01$) fat than PC pigs. Loins from PC pigs had 0.5 NPPCunits more ($P<0.01$) marbling than those from IC pigs which were similar ($P=0.41$) to those from gilts. There were no differences ($P>0.12$) among sex treatments for LM area, color, firmness, or pH. Carcasses of IC pigs had greater ($P<0.05$) cutting yields than PC pigs but were similar ($P>0.10$) to gilts. Carcasses from pigs fed 5 and 7.5 mg/kg RAC were 3.7 and 3.2 kg heavier ($P<0.03$), respectively, than carcasses from control-fed pigs. In contrast, RAC treatments had little effect ($P>0.16$) on fatness, LM area, meat quality, or yields in this study. These results show that immunological castration improves cutting yields while having minimal effects on meat quality. Additionally, immunological castration and feeding RAC are additive in improving carcass weight.

Key Words: carcass quality, Improvest, ractopamine

O262 **Effects of feeding ractopamine (Paylean) to physical and immunological castrates (Improvest) in a commercial setting on growth performance.** B. K. Lowe [1,*], G. D. Gerlemann [2], A. L. Schroeder [3], S. N. Carr [4], P. J. Rincker [4], F. K. McKeith [1], A. C. Dilger [1], G. L. Allee [2], *[1]Animal Sciences, University of Illinois, Urbana, [2]Animal Sciences, University of Missouri, Columbia, [3]Pfizer ANimal Health, Kalamazoo, MI, [4]Elanco Animal Health, Greenfield, IN.*

Sixty-four pens with 22 pigs per pen were used to evaluate effects of feeding ractopamine (RAC; 5 mg/kg) to physical castrates (PC) and immunological castrates (IC). Male pigs were randomly assigned to sex treatments at birth and fed the same nursery diets prior to allotment in a grow-finish barn. Pigs in the PC treatment were surgically castrated at 5 d of age and pigs in the IC treatment were injected at 11 and 18 wk of age with Improvest. Diet treatments (control or RAC) were initiated on d 87 of study and final treatment arrangement was a 2 x 2 factorial of sex and diet. Body weights were collected at d 0 (allotment), d 21, d 42, d 65 (2nd Improvest injection), d 87 (start of diet treatment), d 99 (1st marketing), d 106 (2nd marketing), and d 120 (final marketing). Pens were standardized to 17 pigs per pen for marketing group 1, 9 pigs per pen for marketing group 2, and all remaining pigs were marketed in group 3. Data were analyzed using PROC MIXED in SAS with fixed effects of sex, diet, and their interaction; pen was experimental unit. From d 21-65, IC pigs had 12% greater (P<0.01) G:F and 11% less (P<0.01) ADFI than PC pigs while having similar (P=0.38) ADG. From d 65-87, IC pigs had 7% greater (P<0.01) ADG and 12% greater (P<0.01) G:F than PC pigs while having similar (P=0.16) ADFI. Neither sex (P=0.32) nor diet (P=0.65) had an effect on diet treatment starting (d 87) BW. From d 87-120, IC pigs had 10% greater (P<0.01) ADG and 10% greater (P<0.01) ADFI than PC pigs while having similar (P=0.64) G:F. Additionally, RAC-fed pigs had 17% greater (P<0.01) ADG and 18% greater (P<0.01) G:F than control-fed pigs while having similar (P=0.42) ADFI from d 87-120. There were no significant interactions between sex and diet on growth performance from d 87-120. For the entire study (d 0-120), IC pigs had 2% greater (P<0.01) ADG, 4% decreased (P<0.01) ADFI, and 7% greater (P<0.01) G:F than PC pigs. These results show that the effects of immunological castration and feeding RAC are additive in terms of improving growth performance.

Key Words: growth and efficiency, Improvest, Paylean

O263 **Changes in ultrasound carcass measures of immunologically-castrated barrows in comparison to physically-castrated barrows, intact males, and gilts.** C. L. Puls [1,*], M. Ellis [1], F. K. McKeith [1], A. L. Schroeder [2], *[1]University of Illinois, Urbana, [2]Pfizer Animal Health, Kalamazoo, MI.*

Gender effects on changes in ultrasound carcass measures during late finishing were evaluated in a study with 160 pigs carried out as a RCBD (blocking factor date of start on test) with 4 genders: Immunologically-castrated barrows (with Improvest®; IC), Physically-castrated barrows (PC), Intact males (IM), and Gilts (G). Start of test was time of 1st Improvest® dose (16 wk of age; 67.2 ± 2.50 kg BW) and end of test was 8-wk later (127.9 ± 6.72 kg BW). Pigs were housed in groups of 4 (10 groups/gender) with ad libitum access to feed and water. Diets were formulated to meet requirements of IM. Pigs were weighed and ultrasound measures (backfat depth and LM area) were taken at the 10th rib and belly thickness was measured (anterior and ventral to the last rib) at start of test, end of wk 4 (2nd dose), and weekly thereafter. Regression analysis was performed to determine effects of Gender on changes in carcass traits with increasing BW. As BW increased, all measures increased linearly (P < 0.05). For the 8-wk study, PC had the greatest and IM had the lowest (P < 0.05) increase in backfat depth (slope of regression line 0.019, 0.021, 0.014, and 0.017 cm/kg BW for IC, PC, IM, and G, respectively; SEM 0.0015). LM area (0.27, 0.30, 0.28, and 0.32 cm^2/kg BW, respectively; SEM 0.032) and belly thickness (0.009, 0.017, 0.016, and 0.013 cm/kg BW, respectively; SEM 0.0034) increased at a lower (P < 0.05) rate for IC than PC. In the 4-wk after 2nd dose, IC and PC had greater (P < 0.05) rates of increase for backfat than IM and G (0.026, 0.024, 0.015, and 0.017 cm/kg BW, respectively; SEM 0.0032). LM area (0.22, 0.28, 0.25, and 0.30 cm^2/kg BW, respectively; SEM 0.032) and belly thickness (0.009, 0.021, 0.023, and 0.018 cm/kg BW, respectively; SEM 0.0034) of IC increased at a lower (P < 0.05) rate than PC. These results suggest that IC compared to PC had lower rates of increase in backfat over the entire study period but similar rates of increase after 2nd dose, and that rates of increase in LM area and belly thickness were less for IC than PC after 2nd dose.

Key Words: immunological castration, pigs, ultrasound

O264 **Effect of immunocastration and time after second anti-GnRF (Improvest) injection on fatty acid profile of finishing pigs.** M. A. Tavarez [1,*], A. L. Schroeder [2], F. K. McKeith [1], A. C. Dilger [1], *[1]Animal Science, University of Illinois, Urbana, [2]Pfizer Animal Health, Kalamazoo, MI.*

The effect of immunocastration and time after 2nd Improvest injection on fatty acid profile of the belly and jowl was determined. Physically castrated (PC) and immunologically castrated (IC) barrows were assigned to sex treatments at birth; PC were physically castrated at 5 d of age; IC were injected with Improvest at 16 and 20 wk of age. Diets were formulated with corn and soybean meal and did not contain ethanol co-products. Subsequently, PC (n=23) and IC (n=24) were slaughtered biweekly from 18 to 26 wk of age, 2 to 8 wk following 2nd Improvest injection. Adipose tissue (AT) samples were collected from the belly and jowl. Main effects of sex and time after 2nd Improvest injection, and their interaction were analyzed with the MIXED procedure of SAS. Belly AT from IC had less lipid than PC bellies (75.31 vs. 82.72%; P<0.01). Belly AT lipid content was unchanged with time (P=0.34). Total SFA and MUFA content of the belly were similar for both IC and PC barrows. Belly AT from IC had greater concentration of PUFA than PC barrows (16.20 vs. 14.72%; P=0.01). In IC, concentration of PUFA decreased (P<0.01) from 18.43 at 2 wk to 15.37% at 8 wk. These were unchanged (P>0.17) with time in PC. From 2 wk to 8 wk, belly AT IV of PC was unchanged (P>0.56) at an average of 61.93 while IV of IC decreased (P<0.01) from 67.00 to 60.09. Meanwhile in the jowl AT, IC had less lipid than PC (72.92 vs. 77.11%; P=0.04). Lipid content was increased (P=0.05) percentage units from 72.48 at 2 wk to 78.37% at 6 wk. Total MUFA content was greater (42.53 vs. 44.76%; P=0.04) in PC, however PUFA content was greater (16.94 vs. 14.83%; P<0.01) in IC. Time reduced (P=0.04) PUFA content from 17.50 at 2 wk to15.44% at 8 wk. There was an interaction (P=0.03) between sex and time for IV of the jowl. In PC, IV was unchanged with time (P>0.05). However, in IC barrows IV was reduced (P<0.01) from 68.93 at 2 wk to 61.87 at 8 wk. Results indicate that as time after 2nd Improvest injection progresses, IV of the jowl and belly tends to decrease while lipid content of these depots increases.

Key Words: belly, Improvest, iodine value

O265 **The effects of immunocastration and dried distillers grains with solubles (DDGS) withdrawal on carcass fat quality of grow-finish pigs.** M. Asmus[1,*], A. L. Schroeder[2], M. A. Tavarez[3], M. D. Tokach[1], J. L. Nelssen[1], S. S. Dritz[1], J. M. DeRouchey[1], R. D. Goodband[1], *[1]Animal Science and Industry, Kansas State University, Manhattan, [2]Pfizer Animal Health, Kalamazoo, [3]University of Illinois, Urbana.*

A total of 1,360 pigs (PIC 337 × 1050, initially 24 kg BW) were used in a 125-d study to determine the effects of DDGS withdrawal post-immunocastration (Improvest) on carcass fat quality of grow-finish pigs. Treatments were arranged in a 2 × 3 factorial with main effects of sex (physical castrate; PC or immunological castrate; IC) and diet (no DDGS throughout, 30% DDGS throughout, or 30% DDGS through d 75 then withdrawn to no DDGS to d 125). There were 8 replicate pens per treatment with pigs harvested on d 107 and 125 to obtain belly, clear plate, jowl, and backfat samples. No 3- or 4-way interactions were detected ($P<0.09$), however, multiple 2-way interactions ($P<0.05$) were detected including sex × DDGS, sex × depot, sex × time, DDGS × depot, DDGS × time, and time × depot. Carcass fat iodine values (IV) were consistently higher ($P<0.001$) regardless of fat depot or harvest time when 30% DDGS were included in the diet. IC had reduced ($P<0.04$) MUFA and increased ($P<0.01$) PUFA causing increased ($P<0.02$) IV on d 107. By d 125, however, IC tended ($P<0.10$) to have reduced MUFA with no difference in IV between IC and PC. This improvement from d 107 to 125 could be caused by the dilution of unsaturated fatty acids, specifically C18:2 and C 18:3, due to increased de novo fat synthesis in IC pigs.

Gender:	PC	PC	PC	IC	IC	IC	
d 0 to 74:	Corn-soy	30% DDGS	30% DDGS	Corn-soy	30% DDGS	30% DDGS	
d 74 to 125:	Corn-soy	Corn-soy	30% DDGS	Corn-soy	Corn-soy	30% DDGS	SEM
IV on d 107							
Belly	62.1	67.4	70.9	64.3	66.4	71.8	0.81
Clearplate	60.2	66.5	70.4	63.5	67.1	72.9	0.80
Jowl	64.7	71.5	74.2	68.4	71.5	74.8	0.80
Backfat	60.2	65.3	70.8	63.2	66.8	71.8	0.80
IV on d 125							
Belly	61.0	66.2	72.2	61.6	64.2	70.8	0.80
Clearplate	60.4	66.6	72.6	61.7	65.7	72.9	0.81
Jowl	66.7	73.3	76.4	68.2	73.1	76.6	0.81
Backfat	58.7	63.6	70.5	58.7	61.8	69.7	0.80

Key Words: DDGS, fatty acids, immunocastration

O266 **Sensory characteristics of loins from immunologically castrated barrows.** K. Jones-Hamlow[1,*], D. D. Boler[2], A. L. Schroeder[3], K. J. Prusa[4], F. K. McKeith[1], A. C. Dilger[1], *[1]Animal Science, University of Illinois, Urbana-Champaign, [2]Animal Science, Ohio State University, Columbus, [3]Pfizer Animal Health, Kalamazoo, [4]Animal Science, Iowa State University, Ames.*

The objective of this study was to evaluate the sensory characteristics of loin chops from immunologically castrated barrows. Chops from control-fed immunological castrates (IC), physical castrates (PC), gilts (G), intact males (IM), and from ractopamine-fed (5 mg/kg) IC (IC+RAC) were evaluated for Warner-Bratzler shear force (WBSF), star probe tenderness, and sensory characteristics. Canadian back loins (n= 188) were obtained from pigs harvested at the University of Illinois Meat Science Laboratory and pork quality was measured. Four (2.54 cm) chops were cut from each loin to determine tenderness aging curves using the WBSF method. Chops were vacuum packaged, stored at 4°C, and aged for 1, 7, 14, or 21 post-mortem. At the end of each aging period, chops were frozen and held for further analysis. Upon completion of all aging points, chops were removed from freezer, trimmed of excess fat, cooked to an internal temperature of 70°C, and six 1.25 cm cores were sheared. A trained sensory panel evaluated samples for boar aroma, juiciness, tenderness, chewiness, pork flavor, and off flavor. Chops were scored on a 15 cm unstructured scale, with 0 representing the least amount of the characteristic and 15 representing the most. Chops were also evaluated for star probe tenderness. There were no differences ($P > 0.05$) in WBSF tenderness between treatments at 1 d aging; however, IC were more tender ($P < 0.05$) than G, IM, and IC+RAC, and similar ($P > 0.05$) to PC at 7, 14, and 21 d of aging. Boar aroma was increased ($P < 0.05$) in IM compared with other treatments. Gilts had the most ($P < 0.05$) intense pork flavor but the least ($P < 0.05$) intense off flavor, while IM had the least ($P < 0.05$) intense pork flavor and the most ($P < 0.05$) intense off flavor. There were no differences among the other treatments for these traits, and no differences ($P > 0.05$) between all treatments for juiciness, tenderness, chewiness, or star probe tenderness. Color, marbling, firmness, pH, and drip loss were not different ($P > 0.05$) among treatments. Overall, immunological castration reduced boar aroma but had no detrimental effects on sensory characteristics and meat tenderness.

Key Words: immunological castration, sensory, tenderness

O267 **A comparison of fresh and frozen chops and roasts from gilts, physical castrates, entire males and immunologically castrated males.** A. J. Elsbernd[1,*], J. F. Patience[1], K. J. Prusa[2], *[1]Animal Science, [2]Food Science and Human Nutrition, Iowa State University, Ames.*

This study evaluated the effect of gender treatment, including immunological castrates, on meat quality and sensory characteristics of fresh and frozen pork. This experiment included gilts (G), physical castrates (PC), entire males (EM), and immunologically castrated males (IC). Pigs selected for the IC treatment were vaccinated with a gonadotropin releasing factor (GnRF) analog (Improvest®, Pfizer) at 13 and 18 weeks of age. Pigs (BW=145.0±8.6kg) were harvested six weeks after the 2nd injection. Loins were collected and cut into roasts and chops. Fresh and frozen chops and roasts were evaluated for loin purge %, pH, marbling score, color score, Minolta L*, A*,and B* score, % cook loss, and star probe force, and no significant differences ($P < 0.05$) were found among treatments in the fresh samples. Marbling score was significantly different among treatments in frozen samples (G=1.58^{b}, SC=2.05^{a}, EM=1.46^{b}, IC=1.73^{ab}; $P < 0.005$). A trained sensory panel evaluated samples for boar aroma, juiciness, tenderness, pork flavor, and off flavor. An intensity scale, ranging from zero to fifteen, was used to evaluate each sample by each panelist. No significant differences were found among gender treatments for juiciness, tenderness, chewiness or off flavor. Boar aroma and pork flavor results are presented in Table 1. These results suggest that gender treatment was similar between fresh and frozen product, and that vaccination against GnRF removes aroma and flavor issues associated with meat from intact males. (See table on next page.)

O267 Table

	G	PC	EM	IC	SEM
Boar aroma					
Fresh chop	1.2[b]	0.8[b]	3.2[a]	1.1[b]	0.49
Fresh roast	0.5[b]	1.0[b]	3.2[a]	0.6[b]	0.49
Frozen chop	0.8[b]	0.7[b]	3.3[a]	1.3[b]	0.43
Frozen roast	0.8[b]	0.6[b]	4.2[a]	0.4[b]	0.60
Pork Flavor					
Fresh chop	3.1	3.5	2.6	3.1	0.25
Fresh roast	3.5[a]	3.3[ab]	2.7[b]	3.5[a]	0.23
Frozen chop	3.7[a]	3.0[ab]	2.5[b]	3.3[ab]	0.45
Frozen roast	3.3[a]	3.3[a]	2.2[b]	3.3[a]	0.28

Key Words: boar aroma, immunocastration, pork quality

O268 **Effects of immunological castration (Improvest) on commercial bacon slicing yields of finishing pigs.** J. M. Kyle [1,*], B. M. Bohrer [1], A. L. Schroeder [2], D. D. Boler [1], *[1]Animal Sciences, Ohio State University, Columbus, [2]Pfizer Animal Health, Kalamazoo.*

The objectives were to compare fresh and further processed belly characteristics, and commercial bacon slicing yields of immunologically castrated (IC) barrows, IC barrows fed ractopamine hydrochloride (IC + RAC), physically castrated (PC) barrows, intact males (IM), and gilts (G). Bellies from pigs (n = 188) slaughtered at 130 kg were used in the experiment. Trimmed and squared fresh bellies were evaluated for flop distance, length, width, and thickness. Fatty acid profiles of belly fat were determined on fat tissue collected along the dorsal edge from anterior end of the belly. Squared bellies were transported to a U.S.D.A inspected bacon facility for processing. Thermally processed bellies were chilled, weighed, pressed, and sliced according to standard plant protocol. Bellies were sliced for a targeted thickness of 24 slices per kg. The number of slices and a total sliced belly weight was recorded. The number of slices (116.8 to 118.0) from bellies of each sex did not differ (P=0.76). Fat content in IM bellies (23.95) were lower (P<0.0001) than PC bellies (36.97). Fat content of pooled representative belly slices did not differ (P>0.05) between IC (32.16), IC+RAC (30.82) and G (30.01), however, were different (P < 0.05) from PC.Total PUFA percentage of IC (14.71%) was not different (P = 0.20) from PC (14.17%) or G (15.46%), but G had a greater (P < 0.05) percentage of total PUFA than PC. Differences in total PUFA proportions were reflected in calculated iodine values. There were no differences (P > 0.05) in calculated iodine value among IC (68.26), PC (67.55) and G (69.45). Commercial slicing yields of IC (93.61%) were 4.81 percentage units lower (P < 0.01) than PC (98.42%) and 4.58 percentage units lower (P = 0.01) than G (98.19%). Commercial slicing yields of IC and IM (93.31%) were not different (P > 0.05). Ractopamine improved commercial slicing yields of IC + RAC by 2.96 percentage units when compared with IC not fed RAC. Overall, fresh belly characteristics of IC barrows appear to be more similar to fresh belly characteristics of G than to PC, but commercial slicing yields of bacon manufactured from IC barrows are lower than both PC and G.

Key Words: immunological castration, Improvest, slicing yield

POSTER PRESENTATIONS

ANIMAL BEHAVIOR, HOUSING & WELL-BEING

P001 **Can feeding stalls be used by low ranking sows as hiding spaces at mixing?** J. Swanson [1, 2,*], Y. He [1, 3], L. J. Johnston [1], Y. Li[1], *[1]West Central Research and Outreach Center, University of Minnesota, [2]Dept. of Biology and Psychology, University of Minnesota, Morris, [3]Dept. of Animal Science, University of Minnesota, St Paul.*

The welfare of low ranking sows in group-housing systems has become a concern because they usually suffer from more injuries. The objective of this study was to determine whether feeding stalls could be used as hiding spaces by low ranking sows to escape aggression and reduce aggression-associated injuries at mixing in a group-housing system. Multiparous sows (n = 150, Parity 1 to 9) were allocated to two treatments (5 replicate pens/treatment, 15 sows/pen, space allowance = 2.2 m^2/sow) after weaning. The treatments included: 1. feeding stalls only accessible for one hour during feeding (LIMIT) or; 2. feeding stalls accessible at all times (FREE). All sows were video-recorded and aggression during the first 4 h after mixing was registered. A ranking index was determined for each sow based on outcomes of aggression. Injury scores were evaluated before and 48 h after mixing. Body weight, back fat thickness and condition scores were measured before mixing and at the end of gestation. Data were analyzed using the Glimmix Procedure of SAS. Frequency of aggressive interactions was higher in the LIMIT than in the FREE pens (50.8 vs. 39.6 fights/4h/sow, SE = 3.3; $P = 0.01$). Consequently, sows in the LIMIT pens had higher total injury scores caused by aggression than sows in FREE pens (13.37 vs. 11.57, SE = 0.56; $P = 0.01$). High and middle ranking sows had higher injury scores caused by aggression to their head and shoulders (6.02 and 6.39 vs. 4.91, SE = 0.63, $P = 0.01$), but low ranking sows had the highest injury scores to their bodies (7.25 vs. 5.66, 6.76, SE = 0.47; $P = 0.01$). Neither treatment nor ranking affected changes in body weight, condition scores or back fat thickness during the gestation period. These results suggest that feeding stalls can be used by all sows as hiding spaces to reduce the number of fights and injuries to sows at mixing.

Key Words: group-housing, sows, ranking, aggression

P002 **The relationship between surface temperature and welfare measures at loading and transport losses in market weight pigs at the plant.** R. K. Kephart [1,*], A. Johnson [1], J. J. McGlone [2], A. Sapkota [2], K. J. Stalder [1], *[1]Animal Science, Iowa State University, Ames, [2]Animal and Food Science, Texas Tech University, Lubbock.*

Aggressive handling at loading may impact transport losses experienced at the plant as it can affect both the behavior and physiology of market weight pigs. One hundred and one loads of market weight pigs (~170 pigs/load; n=20,085 pigs weighing 121.8±6.1 kg) were used in a completely randomized design to determine the relationship between total transport losses at the plant and welfare measures and surface temperature at loading. This study was conducted in June and July of 2011 in the Midwestern USA. During loading, pigs were moved by farm personnel (4 to 18 pigs/group) using a combination of sort boards, paddles, rattles, and electric prods onto pot-belly trailers. At loading, 100 pigs/load were scored for vocalizations, slips and falls, and stress signs (defined as open mouth breathing, blotchy skin and muscle tremors) as a percent. At loading, skin temperatures were measured on 10 pigs/load. Skin temperature was measured caudal, near the midline using a dual laser infrared thermometer gun. Pigs were provided with ~0.41 m^2/pig and transported 2.5±0.7 h to a commercial plant. At the plant, non-ambulatory (defined as non-ambulatory injured and non-ambulatory-non-injured) and deads (defined as dead on arrival and killed on arrival) were recorded. Transport losses (TL) were defined as the sum of dead and non-ambulatory pigs. Data were analyzed using Proc Glimmix of SAS with the experimental unit as a trailer of pigs. There were no ($P > 0.05$) relationships between the amount of vocalizations, slips and falls, or skin temperature on non-ambulatory, deads or overall TL at the plant. However, more stress signs measured on farm tended (P=0.06) to result in more non-ambulatory pigs at the plant. In conclusion, recording the amount of vocalizations, slips and falls, stress signs and skin temperature at the time of loading on farm was not predictive for the number of total transport losses experienced at the plant.

Key Words: handling, market-weight pig, transport losses

P003 **Interactive effects of distillers dried grains with solubles (DDGS) and housing system on litter performance, sow productivity, and sow longevity over 3 reproductive cycles.** X. Li [1], G. C. Shurson [1], S. K. Baidoo [2], Y. Li [3], L. J. Johnston [3,*], *[1]Department of Animal Science, University of Minnesota, Saint Paul, [2]Southern Research and Outreach Center, University of Minnesota, Waseca, [3]West Central Research and Outreach Center, University of Minnesota, Morris.*

An experiment was conducted to evaluate the interactive effects of DDGS and housing system on litter performance, sow productivity, and longevity. Sows (n = 311 for parity 0; n = 90 for parity 1) were assigned randomly to 1 of 4 treatments for up to 3 reproductive cycles. Sows were fed either a fortified corn-soybean meal control diet (CON: n = 203) during gestation and lactation, or diets containing 40% DDGS in gestation and 20% DDGS in lactation (DDGS; n = 198), and were housed either in individual stalls (n = 200) or dynamic group pens (n = 201; about 50 sows per pen) with electronic sow feeders during gestation. Sows were offered 2.04 kg daily of their assigned diets adjusted for body condition during gestation and allowed *ad libitum* access to their assigned diets during lactation (avg = 19 d). Litters from sows fed DDGS and housed in pens were lighter at weaning ($P < 0.05$) than litters from sows fed DDGS and housed in stalls (63.4 vs 67.0 kg; Pooled SE = 1.04). Pigs farrowed by sows fed DDGS in pens grew slower ($P < 0.05$) than pigs farrowed by sows fed DDGS and housed in stalls (268 vs. 274 g/d; Pooled SE = 3.23) but the opposite was observed for sows fed CON in pens and stalls (276 vs 268 g/d; Pooled SE = 3.31). Group-housed, CON-fed sows farrowed fewer pigs than stall-housed, CON-fed sows; however, this difference did not exist for

DDGS-fed sows between stall and group housing. In general, sows fed DDGS tended ($P < 0.10$) to wean fewer pigs (23.7 vs. 24.5; Pooled SE = 0.49) per sow for 3 reproductive cycles compared with sows fed CON. Stall-housed sows farrowed more ($P < 0.05$) live pigs (28.4 vs. 25.2; Pooled SE = 0.51) and weaned more pigs (25.2 vs. 23.1; Pooled SE = 0.48) per sow for 3 reproductive cycles compared with group-housed sows. Stall housing increased ($P < 0.05$) the retention rate of sows over 3 reproductive cycles (68.9% vs. 55.8%) compared with group housing. In conclusion, long-term feeding of DDGS and group housing compromised litter performance. Feeding DDGS decreased sow productivity and group housing reduced sow productivity and longevity.

Key Words: DDGS, housing, sow, longevity

P004 **Effect of chamber stocking density on the efficacy of carbon dioxide euthanasia of suckling pigs.** K. Fiedler*, L. Sadler, S. Millman, *Iowa State University, Ames.*

The objective of this study was to evaluate the effect of chamber stocking density on facets of animal welfare and efficacy during gas euthanasia of suckling piglets. Crossbred piglets (n = 390, mixed sex, <72 h of age, 0.79 ± 0.28 kg) that had been selected for euthanasia at commercial swine production farms were randomly assigned to treatment group sizes of 1, 2, 4, or 6 pigs. Gas euthanasia of each treatment group was performed in an acrylic Euthanex AgPro chamber (43 cm x 60 cm x 30 cm) with a Smartbox control system for automated administration of 100% CO_2 at an exchange rate of 35% chamber vol/min for 5 min to establish an approximate in-box concentration of 80% CO_2. Pigs remained in the chamber for an additional dwell period of at least 5 min after 80% concentration was achieved. Direct observations included latency to loss of posture (as a metric for insensibility) and latency to last movement (as a metric for initiation of the dying process) for a randomly selected focal pig. Latencies to loss of posture for focal pigs with normal starting posture (n = 112) were similar across treatment groups (estimated mean ± SE: 85.4 ± 3.1 s, 85.7 ± 3.0 s, 85.2 ± 2.9 s, and 78.5 ± 2.9 s, for treatments 1, 2, 4, and 6, respectively). No difference was evident between the latencies to loss of posture for focal pigs euthanized singly and those euthanized in groups of 6, after accounting for day of trial (PROC GLM, p = 0.12, n = 112). Latencies to last movement for all focal pigs (n = 120) were also similar across treatment groups (estimated mean ± SE: 374.1 ± 17.5 s, 359.5 ± 17.5 s, 406.8 ± 17.6 s, and 378.8 ± 17.5 s, for treatments 1, 2, 4, and 6, respectively), and there was no evidence of a difference between the latencies to last movement for focal pigs euthanized singly and those euthanized in groups of 6, after accounting for day of trial (PROC GLIMMIX, p = 0.85, n = 120). These data suggest that variation of chamber stocking density in the range of 1 pig/box to 6 pigs/box did not impact animal welfare or efficacy during CO_2 euthanasia of neonatal cull piglets.

Key Words: carbon dioxide, euthanasia, pigs

P005 **Short investigation of eating behavior of Eurasian collared dove found within 4 Arizona dairy operations experiencing bird depredation.** J. Allen [1, 2,*], L. Hall [2], J. Smith [2], *[1]Agriculture Sciences, Northwest Missouri State University, Maryville, [2]Animal Sciences, University of Arizona, Tucson.*

The objective of this study was to investigate the impact of the Eurasian collared dove (ECD**;** *Streptopelia decaocto*) population and its depredating behavior within livestock operations. The invasive and depredating behavior of ECD has lead to hunting regulations in Southern Arizona allowing the ECD to be harvested year-round and on dairy operations located within metropolitan boundaries. On a single day in May 2012, body weights and crop contents were collected from ECD harvested by licensed hunters within the feed storage facilities of 4 closely-located Arizona dairies (n > 25 birds/dairy). Each dairy was visited at a different period of day. Body weights (176 ± 12 g) and crop content DM (3.4 ± 2.0 g) were similar ($P < 0.10$) across dairy; however, crop fill may have been skewed due to the number of birds yielding crop contents at each dairy (n = 2 of 30, 4 of 25, 13 of 31, and 21 of 32). Grit/unidentifiable (2.3%) and wild seed (3.7%) proportions of crop content DM were similar ($P > 0.10$) across dairies. However, the 2 identifiable feedstuff portions of corn (0 to 97.6%) and almond (0 to 54.4%) differed ($P < 0.05$) and birdseed portion (1.6 to 50.0%; crop seeds not fed by dairies) tended to differ ($P < 0.10$) by dairy. Overall, corn was the greatest crop content portion (47.2%), followed by almond (28.8%), birdseed (18.0%), wild seed, and grit/unknown portions. Results indicate ECD frequenting dairy operations prefer feedstuffs to native and crop plant seeds. Feedstuffs lost to these birds can result in economic loss. Future sampling is necessary to confirm these results.

Key Words: bird depredation, dairy, Eurasian collared dove

P006 **Impact of providing shade on grazing dairy heifer performance.** T. Dennis*, H. Schmitz, A. Mosiman, J. Tower, T. Nennich, *Purdue University, West Lafayette.*

Providing shade for grazing animals is recommended to improve productivity and animal welfare, but little information is available on the effects of providing shade to young dairy heifers on pasture. The objective of this study was to determine the impact of using shade structures on dairy heifer performance when grazed on pasture during the summer months. Forty-four Holstein heifers (189.6 ± 25.2 kg of BW, 144 ± 23 d of age) were randomly assigned by BW to 1 of 4 paddocks. Paddocks were allocated to treatments of no shade (NONE) or 1.7 m^2 of shade per heifer (SHADE). Measurements were collected monthly for BW, hip and withers heights (HH and WH), body condition score (BCS), hip width (HW), heart girth (HG), respiration rate (RR), and rectal temperature (RT). Blood samples were collected monthly to measure plasma urea N (PUN) and glucose. Temperature and relative humidity in paddocks and under shade were measured using HOBO data loggers and temperature-humidity indices (THI) were calculated. Performance data were analyzed by heifer within treatment as repeated records and environmental data were analyzed by location (within paddock or under shade) using PROC MIXED in SAS. Heifer BW, ADG, and skeletal measurements were similar between NONE and SHADE. At the end of the study, blood glucose tended to be elevated for NONE compared to SHADE (82.2 and 75.6 mg/dL, respectively; $P = 0.10$) and PUN was significantly elevated for NONE compared to SHADE (17.5 and 16.0 mg/dL, respectively; $P = 0.04$). Plasma urea N was positively correlated with THI ($P < 0.05$) in both NONE (r = 0.25) and SHADE (r = 0.21). Shade resulted in lower ambient temperatures (32.1 and 33.1°C, respectively; $P < 0.01$) and THI (26.7 and 27.3 °C, respectively; $P < 0.01$) compared to NONE during mid-day (1200 to 1500 hr). Correlations of RR and RT with ambient temperature were r = 0.71 and 0.37 for NONE ($P < 0.01$) and r = 0.73 and 0.29 for SHADE ($P < 0.01$). However, RR and RT were similar between NONE and SHADE. Providing shade for grazing dairy heifers did not improve performance in the current study, but ambient temperatures and THI were reduced under shade.

Key Words: dairy heifers, grazing, shade

BREEDING & GENETICS

P007 **Association between hair coat shedding and ADG in weaned calves.** B. Richardson*, J. Cassady, *Animal Science, North Carolina State University, Raleigh.*

The objective of this study was to examine the relationship between hair coat shedding and post-weaning gain in fall down calves. While recording hair coat scores on Angus dams, it was observed that calves often showed little to no signs of shedding. Because the rate of shedding had not previously been studied in calves, it was of interest to determine if hair coat shedding in calves was related to post-weaning weight and average daily gain (ADG). Data were available on Angus calves (n = 91) grazing pasture which included endophyte- infected tall fescue at the Upper Piedmont Research Station in Reidsville, NC. Calves were scored for hair coat shedding (HCS) by two trained technicians using a 1 to 5 scale, with 1 being a slick, summer coat and 5 being a full, winter coat. At the beginning of July and August hair coat scores and weights were recorded. For analysis, calves were placed into one of three groups based on HCS within date. Roughly, these groups represented an early shedding group (n = 27, n = 22), a middle group (n = 30, n = 35) and a late shedding group (n = 34, n = 34), respectively (date 1, date 2). Data were analyzed using the Proc GLM procedure of SAS. The model included fixed effects of group, sex, and sire, and age (Age1 and Age2) was included as a fixed regression covariate. Traits analyzed were WT at the beginning of July and August. The model for ADG during the month of July included the fixed effect of HCS group based on August HCS, sex, and sire. The July weight was affected by sex, HCS group, sire, and Age1 ($P < 0.05$). The August weight was affected by sex, HCS group, and sire. Average daily gain was affected by HCS group and sire. Calves in the early hair coat shedding groups were heavier than calves in the late shedding group by 21 kg at the beginning of July and 58 kg at the beginning of August. Calves in the early hair coat shedding group based on August HCS gained 0.27 kg per day more than calves in the late hair coat shedding group. In conclusion, calves that shed their winter hair coat earlier in the summer were heavier and had greater ADG during the month of August.

Key Words: beef cattle, growth, heat stress

P008 (GS-PHD) **Lifetime reproductive performance in mice divergently selected for heat loss.** A. S. Bhatnagar*, M. K. Nielsen, *University of Nebraska, Lincoln, United States.*

Feed intake to meet maintenance energy requirements is the largest component of total feed consumption, and selection to reduce maintenance without changing output would improve feed efficiency. However, decline in reproductive performance may be a correlated response and negate the benefit in reduced feed intake. Mice in Nebraska lines, selected for heat loss (MH = high, ML = low, MC = control) in 3 replicates, differ greatly in feed intake at the same mature weight (MH/ML ~1.38). For this study, 21 mating pairs, assigned at 7 wk of age, were sampled from each line by replicate combination (189 pairs) and maintained for up to 1 yr. No pairs survived to the 1-yr mark. Number fully formed (NFF), number born alive (NBA), number weaned (NW), and litter weaning weight (WW) were recorded for every parity. Weaning weight per pup (WWP) was calculated as WW/NW, fraction alive at birth (FAB) as NBA/NFF, and fraction alive at weaning (FAW) as NW/NBA. Traits were summed across parities for each pair to obtain lifetime performance. Contrasts were used to test for selection response (MH–ML) or asymmetry of response [(MH–ML)/2–MC]. Line was insignificant for all litter traits, while parity was significant for NFF, NW, and FAB ($P < 0.05$) and tended toward significance for WWP ($P < 0.07$). There was a line by parity interaction for WW ($P < 0.01$), due to a significant difference between MH and ML mice at parity 6 ($P < 0.03$) and asymmetry of response at parity 7 ($P < 0.01$). For lifetime production, there was evidence of asymmetry for NW, WW, and WWP ($P < 0.04$). Results indicate that selection for reduced maintenance energy did not result in substantial decreases in reproductive performance, as there were few significant differences between MH and ML mice for measured litter traits. Differences in lifetime performance across parities showed that reproductive performance was greatest in MC mice, partly because the control line was less inbred than either selection line (F = 0.38 vs. 0.46). Correlated response in reproductive performance is unlikely to outweigh benefits of reduced feed intake.

Key Words: feed intake, mice, reproduction

EXTENSION – BEEF/SMALL RUMINANT

P009 **Estimating beef cow maintenance efficiency with a fasting protocol.** G. Dahlke*, D. Loy, *Animal Science, Iowa State University, Ames.*

Generally feed efficiency is discussed and described in the context of growing cattle and their conversion of feed dry matter into pounds of beef. Conversion of feed to beef is only one component of the efficiency equation though since the conversion of feed to milk and the conversion or utilization of feed for maintaining existing tissues are also components that cannot be ignored, especially when improvements in the efficiency of the cow herd are the focus. An induced fast with the measurement of subsequent weight loss is a means by which this trait can be evaluated and selected for in a commercial setting. Using a privately owned herd of 54 Simmental, Angus and Sim-Angus cows ranging in age from first to tenth parity evaluated in late fall after weaning through the first couple weeks of the third trimester of pregnancy, the induced 48 hour fast provided a means to significantly account for 14% (Prob >F was < 0.006) of the resulting RFI measure obtained on these cows. The cows selected for the trial, besides having individual feed intake measures collected also had ultrasonic scans of carcass ribeye area, 12th rib back fat and rump fat at the start and then at the end of the trial to assist in the system's validation.

Key Words: beef cow efficiency

P010 **Prevalence of caprine paratuberculosis in boar goat herds in Missouri.** P. Patrick*, N. S. Kollias, *Univerity of Missouri, Columbia.*

The objective of this study was to estimate true animal-level and herd-level prevalence of MAP antibodies in Missouri Boer goat herds. Sera harvested from blood samples collected from goats approximately 24 months of age and older in 25 Missouri Boar goat herds were tested for presence of MAP antibodies using a commercial ELISA kit. Herds were declared positive for MAP if one or more goats in the herd tested positive for MAP antibodies. True animal-level, intra-herd, and herd-level prevalence were calculated

using the Rogan-Gladen estimator and were 1.2% (95% CI =0.1 to 3%), 2.2% (95% CI = 0.2% to 4.2%) and 13.8% (95%= 5.5% to 30.6%), respectively. Findings in this study confirmed that MAP infection is endemic in Missouri Boer goat herds.

Key Words: prevalence, *Mycobacterium avium* subsp. *paratuberculosis*, absorbed ELISA, Boer goats

P011 **Cow Herd Appraisal Performance Software (CHAPS): Improving beef production from conception to carcass.** J. Ramsay*, L. Tisor, W. Ottmar, P. Ashley, K. Ringwall, *Dickinson Research Extension Center, North Dakota State University, Dickinson.*

Cow Herd Appraisal Performance Software (CHAPS), developed by the Dickinson Research Extension Center (DREC), is a data intensive system, used by beef producers throughout the United States, for collecting, storing, and evaluating beef cattle performance from conception to carcass. Production benchmark traits are calculated by CHAPS, using the National Cattlemen's Beef Association's Integrated Resource Management Standardized Performance Analysis, as 5 year rolling averages of herd means for each trait (Table 1). Individual herd productivity can be evaluated using the benchmarks, allowing producers to implement management changes and improve herd output. The objectives of this paper are to 1) present CHAPS benchmark calculations 2) evaluate the DREC research herd using CHAPS and 3) present additional correlational and time-series analyses of the DREC herd benchmarks. Continued herd analyses and innovative approaches to analyzing CHAPS data will provide beef producers with complete and accurate information to evaluate and streamline operations to sustain profitability.

Table 1: Benchmark traits produced by CHAPS (rolling averages of 55 herds over 5 years: 2007-2011; n=275). Weights and weight gains are expressed in kilograms (kg).

Standardized Performance Analysis (SPA)	Critical Success Factors	
pregnancy (%)	93.5 average daily gain (kg)	1.1
pregnancy loss (%)	0.7 weight per day age (kg)	1.4
calving (%)	92.8 birth weight (kg)	39
calf death loss (%)	3.2 adjusted 205 day weight (kg)	287
weaning (%)	90.5 frame score	5.7
replacement rate (%)	15.6% heifers early	38
calf death loss (based on number born) (%)	3.7% heifers at 21 days	73
age at weaning (days)	190% heifers at 42 days	87
% calves at 21 days	63% cows at 21 days	60
% calves at 42 days	88% cows at 42 days	85
% calves at 63 days	96 cow age (years)	5.7
wean weight (kg)	255 cow weight at weaning (kg)	634
kilograms weaned/cow exposed	227 cow condition at weaning	5.8

Key Words: beef production, benchmark traits, standardized performance analysis

P012 **Effects of pasture size on the efficacy of off-stream water or restricted stream access to alter the spatial/temporal distribution of grazing cows.** J. Bisinger*, J. Russell, *Iowa State University, Ames.*

Two blocks of three replicated pastures with cool season grass and legume species without (BL1) and with warm season grass species (BL2) were divided into 5 equal-sized paddocks to determine the effects of mob grazing on pasture forage and soil characteristics. In each pasture, one paddock was not grazed (U) and 4 were strip (S; moved once per day with a back fence) or mob (M; moved 4 times per day with a back fence) grazed beginning in May of 2011 (BL1) and 2012 (BL2) by 10 cows at a live forage allowance of 2% BW/d. One mob (MR) and strip (SR) paddock in each pasture were rotationally stocked to remove 50% of the live forage with 35-d rest periods beginning 60 d after spring grazing in yr 1 of each block. Water infiltration over 90 min and soil penetration resistance to a depth of 15 cm were measured in May and October of each year. Pasture botanical composition was measured by the line transect method in May, July, and October of each year. Ground nesting bird habitat was measured as visual obstruction to a 1x1 m board by image analysis of digital photos in July and October of each year. In BL1, there were no significant differences in water infiltration or penetration resistance between treatments in 2011. The proportions of annual grasses and bare ground were greater ($P < 0.05$), and cool season grasses lower ($P < 0.05$) in grazed than U paddocks in July 2011. In 2012, the proportion of legumes was greater ($P < 0.05$) in M and SR paddocks in May and in M, S, and SR paddocks in July than U paddocks. In BL2, proportions of annual grasses in M and S paddocks and bare ground in MR, S, and SR paddocks were greater ($P < 0.05$) than U paddocks in July 2012. In 2011, visual obstruction to 1 m was greater ($P < 0.05$) in U than grazed paddocks of BL in July. However, in October, visual obstruction did not differ between S and U paddocks to 40 cm and was greater ($P < 0.05$) in S and M than SR and MR paddocks to a height of 30 cm. Strategic spring mob grazing increases the proportion of legumes and creates more suitable habitat for ground nesting birds in perennial grasslands.

Key Words: beef cattle, distribution, grazing

P013 (UGS) **Effects of pyrethroid insecticide on reproductive parameters of beef cows.** A. M. Kloth [1,*], C. F. Shipley [2], H. M. French [2], V. L. Jarrell [1], D. B. Faulkner [1], D. W. Shike [1], *[1]Animal Sciences, [2]College of Veterinary Medicine, University of Illinois, Urbana.*

Application of insecticide commonly coincides with breeding season in beef cattle. Pyrethroids are common insecticides; however, they have been shown to reduce progesterone concentrations and viable ovarian cell counts in vitro. Data in vivo are lacking. The objective of this experiment was to determine if pyrethroid insecticides reduce progesterone concentrations, AI conception rates, and pregnancy rates when applied during the breeding season. Angus and crossbred cows (n = 126) were blocked by breeding date (April and July) and breed, then randomly assigned to a control or treatment group. The treatment group received both CyLence® pour-on insecticide (active ingredient 1% cyfluthrin, a pyrethroid) and CyLence Ultra® insecticide cattle ear tags (active ingredient 8% beta-cyfluthrin). Application followed labeling guidelines. Control groups were not treated with insecticides. Control and treatment cows were maintained in non-adjacent pastures. Cows were synchronized with CO-Synch+CIDR® and bred by timed AI. Insecticide was applied to the treatment group at time of CIDR insertion. Cows bred in April were exposed to clean-up bulls for 30 days following AI. Cows bred in July were exposed to clean-up bulls for 45 days following AI. Blood samples were collected via jugular venipuncture on day 10 and 17 post-AI to evaluate progesterone concentrations. Cows were rectally palpated at 35 days post AI to determine AI conception rates. At 60 days post-AI, cows were palpated again to determine overall pregnancy rates. Cows that received insecticide treatment had decreased ($P = 0.03$) progesterone concentrations at day 10 when compared to control cows (5.51 vs. 6.40 ng/ml). Progesterone

concentrations did not differ (P = 0.94) at day 17. No differences (P = 0.65) were observed in AI conception rate between treatment cows (45%) and control cows (40%). No differences (P = 0.79) were observed in overall pregnancy between treatment cows (65%) and control cows (63%). Cyfluthrin and beta-cyfluthrin products, used in accordance with the label, did not reduce pregnancy rate.

Key Words: progesterone, pyrethroid, reproduction

EXTENSION - SWINE

P014 **Backfat thickness at farrowing affects litter size in the subsequent litter.** P. Ramaekers*, H. V. Hees, *Nutreco R&D and Quality Affairs, Nutreco Nederland BV, Boxmeer, Netherlands.*

Data of 154 Hypor sows were used to examine relation between sow parameters in the previous lactation on the litter size and birth weight in the subsequent litter. The analysed lactation sow parameters were parity number, body weight and backfat thickness at farrowing and mating, change in body weight (BW) and backfat thickness (BF) between farrowing and mating, lactation length, number of weaned piglets. In subsequent litter, numbers of total born and born alive piglets were recorded together with the individual birth weight. Proc Reg and Proc GLM procedures of SAS were used to select the sow lactation parameters that were related with total born in the subsequent litter. BF at farrowing had a significant (P<0.05) linear response on the subsequent litter size. Using the median of the BF at farrowing as differentiator, sows were classified FAT or LEAN. Results are presented separately for parity 2 and older parity sows due to an interaction. In total 137 sows had a subsequent litter and farrowing rates were similar (P>0.10) between LEAN and FAT sows within parity group. In parity 2 sows, total born in the subsequent litter was numerically higher in the FAT sows compared to the LEAN sows. In the older parity sows, total born and born alive were higher (P<0.05) in LEAN sows than in FAT sows. No differences were found in birth weight between FAT and LEAN sows. BF at farrowing could be related to feeding take capacity during lactation that could affect subsequent litter size. It is conclude that backfat thickness at farrowing affects litter size in the subsequent litter. (See table below.)

Key Words: backfat thickness, reproduction, sow

P015 (GS-MS) **Effects of immunological castration and distillers dried grains with solubles on belly slicing yields of male pigs slaughtered at two time points.** B. M. Bohrer[1,*], M. A. Tavarez[2], A. L. Schroeder[3], D. D. Boler[1], *[1]Animal Sciences, Ohio State University, Columbus, [2]Animal Sciences, University of Illinois, Urbana-Champaign, [3]Pfizer Animal Health, Kalamazoo, MI.*

The objectives were to determine cured belly characteristics and slice yields of immunologically castrated barrows (IC) fed 30% distillers grains (DDGS) when compared with physically castrated barrows (PC). Trimmed squared bellies from 193 pigs were cured, smoked, and sliced using commercial protocols. Data were analyzed as a 2 x 3 factorial in a split plot design. Sex, diet, and time of harvest post 2nd dose (5 or 7 wks) were fixed effects. Bellies from IC were thinner (3.70 vs. 3.93 cm; P < 0.01) and had narrower flop distances (15.00 vs. 17.62 cm; P = 0.01) than PC regardless of diet or time. There were no differences (P = 0.46) in brine uptake between IC and PC, but IC had a 1.37% unit lower (P < 0.01) cooked yield than PC. IC bellies were lighter, shorter (P < 0.05) and had fewer slices (4.89 vs. 5.17 kg ; 66.14 vs. 68.88 cm; 102.69 vs. 108.06) at 5 wk post 2nd dose and equal weight (5.91 vs. 5.92 kg), but longer at 7 wks (70.14 vs. 69.31 cm) yet produced fewer slices (109.81 vs. 111.88) than PC. Slice yield of IC was 5.64% units less (P < 0.01) than PC. Time of harvest post 2nd dose and fat % had a greater effect on bacon slicing yield than DDGS inclusion. Slices from IC had less (P < 0.01) fat (28.03%) than PC (32.80%). Slices from IC 5 wks post 2nd dose (24.28%) had less fat (P < 0.05) than 7 wks post 2nd dose (31.78%). Difference in slice yield in IC fed 0% DDGS and PC fed 0% DDGS was 7.47% units. When 30% DDGS was included in the diets the difference was 7.37% units, a change of 0.10% units. Conversely, when IC barrows were harvested at 5 wks post 2nd dose the magnitude of difference between PC were 6.10% units. The magnitude of the difference between PC and IC harvested at 7 wks post 2nd dose decreased to 5.18% units. Increasing time of harvest post 2nd dose of IC from 5 to 7 wks increased commercial slice yield by 1.96% units. Slice yield of PC only improved 1.04% units during the same time. Slice yields of IC were less than PC, but increasing the time of harvest post 2nd dose (to allow greater fat deposition in the belly) lead to greater improvements in bacon slice yields than reducing DDGS.

Key Words: bacon slicing yield, DDGS, Improvest

P014 Table

		Parity 2				Older Parity			
		LEAN		FAT		LEAN		FAT	
		Mean	stderr	Mean	stderr	Mean	stderr	Mean	stderr
Number of sows	#	21		18		47		68	
Previous lactation									
BF farrowing	mm	16.5	0.4	20.4	0.3	15.2	0.3	21.2	0.2
BF loss farrowing – mating	mm	4.2	0.3	4.2	0.4	3.7	0.2	4.2	0.2
BW farrowing	kg	197	3	200	3	244	3	260	3
BW loss farrowing – mating	kg	32.0	2.3	31.5	2.7	34.6	1.2	38.9	1.2
Subsequent litter									
Number of sows		19		14		44		60	
Parity Number	#	2.0	0.0	2.0	0.0	4.0	0.2	4.4	0.1
Total born	#	13.3	0.7	14.3	0.8	15.9[a]	0.4	14.3[b]	0.4
Born alive	#	12.5	0.6	13.3	0.7	14.3[a]	0.4	13.1[b]	0.4

Means without a common superscript letter differ (P<0.05)

P016 **Predicting belly fatty acid composition from jowl and backfat in swine.** Z. Rambo*, A. Schinckel, B. Richert, *Animal Science, Purdue University, West Lafayette.*

Sixty barrows (initial BW 63.8 ± 1.5 kg) were used to evaluate the effect of diet iodine value (IV) on fatty acid (FA) composition of jowl (J), belly (B) and 10th rib backfat (BF) after an 83 d feeding period. Pigs were allocated in randomized complete block design with 3 pigs/pen. Diets were fed in four phases and formulated to 10% total fat. Inclusion rates of fat sources were 8.1% beef tallow (BT), 6.7% choice white grease (CWG), and 5.6% canola oil (CAN), high oleic acid canola oil (HOC), or soybean oil (SBO) for wheat-rye (BT), corn-soy (CWG), and corn-soy-DDGS (CAN, HOC, and SBO) based diets, respectively. Average diet IV was 69.8, 83.9, 112.1, 107.9, and 124.0 for BT, CWG, CAN, HOC and SBO diets, respectively. Fat samples from J, B and BF were collected and analyzed for FA composition. Regression analysis was used to predict the IV, saturated fatty acids (SFA), polyunsaturated fatty acids (PUFA) and C18:2n6 in the B from J and BF using individual pigs and treatment means. The treatment residuals and residual standard deviations (RSD) were used as a measure of bias and error. The treatment sums of squares accounted for 78% of the total variance for B IV. The model B IV = J IV provided a R2 of 0.74, a slope of 1.10, and a RSD of 4.10. The model B IV = BF IV gave a R2 of 0.73, a slope of 0.67, and a RSD of 4.17. Prediction of B SFA using J or BF SFA yielded R2 values of 0.49 and 0.60 and RSDs of 1.82 and 1.82, respectively. The residuals were affected by treatment (P = 0.01) for J SFA with CO and HOC overestimating B SFA and CWG and BT underestimating B SFA. The model B PUFA = J PUFA or BF PUFA provided R2 values of 0.76, and RSDs of 3.12 and 3.15, respectively. Prediction of C18:2n6 in B from J or BF provided R2 values of 0.74 and 0.75 and RSDs of 2.97 and 2.91. Using treatment means to estimate B IV, SFA, PUFA, and C18:2n6 using mean values provided R2s ranging from 0.97 to 0.99 and RSDs ranging from 0.34 to 1.14. Prediction of individual pig IV, SFA, PUFA, and C18:2n6 from J and BF has relatively high errors while prediction of group B means using J and BF group means is of greater precision.

Key Words: fatty acid prediction, iodine value, swine

P017 **Industry productivity analysis—Seasonality in sow farm traits.** M. R. Bryan[1,*], C. E. Hostetler[2], M. T. Knauer[1], *[1]North Carolina State University, Raleigh, [2]National Pork Board, Des Moines.*

The objective of this study was to quantify seasonality in U.S. sow farm traits from a representative database. Data were provided by a data management company representing 1.8 million sows in North America. Production records were available from 2005 to 2010. Traits included piglets per mated female per year (PMFY), litters per mated female per year (LMFY), total number born (TNB), number born alive (NBA), number weaned (NW), preweaning mortality (PM), weaning weight per pig (WWT), lactation feed intake per d (LFI), gestation feed intake per d (GFI), replacement rate (RR), culling rate (CR) and sow mortality (SM). Data were analyzed in SAS using PROC MIXED. Models included year and month as fixed effects. Standard errors for PMFY, LMFY, TNB, NBA, NW, PM, WWT, LFI, GFI, RR, CR, and SM were 0.18, 0.015, 0.042, 0.047, 0.051, 0.39, 0.021, 0.072, 0.024, 2.06, 1.69 and 0.22, respectively. Seasonal means for U.S. sow farm traits are shown by month in Table 1. All traits, except RR, differed (P < 0.05) between months. Results showed seasonality in LMFY had the greatest impact on seasonality in PMFY. Producers and scientists can use these data to better understand seasonality in sow farm traits. (See Table 1 below.)

Key Words: reproduction, seasonality, sow

P018 **The impact of eradication of AD and PRRS on reproductive and growth performance on Japanese swine commercial farms.** Y. Sasaki*, R. Uemura, M. Sueyoshi, *Department of Veterinary Sciences, University of Miyazaki, Japan.*

In April 2010, foot-and-mouth disease (FMD) outbreak occurred in Miyazaki Prefecture, Japan. In the major affected area, ring vaccination and stamping out was performed to eradicate the outbreak. FMD was eradicated in August 2010 and swine producers start farming again in November 2010. After FMD eradication, swine producers in this area made control programs to keep Aujeszky's disease (AD) and porcine reproductive and respiratory syndrome (PRRS) virus free. This study compared reproductive and growth performance before and after AD/PRRS eradication. Data were obtained from three farrow-to-finish farms that had complete records of reproductive and growth performance before and after FMD outbreak. Data for before FMD outbreak (AD/PRRS Positive period) were collected from January 2008 to March 2010, and after FMD outbreak (AD/PRRS Negative period) were from January 2011 to July 2012. The reproductive data with 12,496 parity records of 3,757 sows and growth data with mean measurements of monthly records was used for the present study. All statistical analyses were performed in SAS. Average parity of sows in Positive and Negative periods were 3.8 (Range: 1 to 11) and 2.3 (Range: 1 to 4), respectively. Due to small number of records of parity 4, comparisons of reproductive

P017 Table 1. Seasonal means for U.S. sow farm traits from 2005 to 2010.

Trait	Month											
	J	F	M	A	M	J	J	A	S	O	N	D
PMFY	21.5	22.5	22.8	22.6	22.8	23.2	23.4	23.4	23.1	22.8	21.9	21.4
LMFY	2.28	2.37	2.38	2.33	2.32	2.36	2.39	2.40	2.37	2.34	2.26	2.24
TNB	12.28	12.41	12.38	12.40	12.41	12.44	12.46	12.50	12.50	12.46	12.32	12.35
NBA	11.09	11.21	11.20	11.24	11.29	11.31	11.32	11.34	11.37	11.33	11.22	11.20
NW	9.42	9.50	9.58	9.69	9.79	9.83	9.79	9.72	9.73	9.73	9.69	9.57
PM, %	15.1	15.2	14.4	13.8	13.4	13.1	13.5	14.3	14.4	14.1	13.7	14.5
WWT, kg	5.62	5.60	5.64	5.69	5.68	5.67	5.64	5.59	5.62	5.69	5.69	5.71
LFI, kg	6.55	6.45	6.51	6.47	6.39	6.15	6.12	6.05	6.30	6.60	6.87	6.83
GFI, kg	2.37	2.38	2.39	2.34	2.31	2.26	2.24	2.21	2.21	2.28	2.32	2.34
RR, %	57.9	54.3	53.5	56.1	53.6	56.0	53.2	53.4	54.1	54.1	54.9	53.7
CR, %	42.4	44.8	44.8	43.1	43.9	42.8	43.8	46.4	49.0	51.9	48.9	45.8
SM, %	10.8	10.8	10.4	10.1	9.8	10.4	11.2	11.4	10.5	10.1	9.8	10.1

performance were applied to parity 1 to 3. Number of total pigs born and pigs born alive was higher in Negative period than Positive period in parity 1 to 3 (P<0.05). Average piglet weight at weaning in Negative period at parity 1 to 3 was approximately 1 kg higher than those in Positive period (P<0.05). At parity 1 preweaning mortality in Negative period was higher than Positive period (P<0.05). No differences between period groups were found in number of pigs born dead, pigs weaned and farrowing rate. Regarding growth performance, postweaning mortality in Negative period was lower than those in Positive period (3.28 vs. 7.87%; P<0.05). Additionally, age at slaughter in Negative period was shorter than those in Positive period (166.5 vs. 186.7 days; P<0.05). In conclusion, AD/PRRS eradication could improve reproductive and growth performances.

Key Words: Aujeszky's disease, PRRS, reproductive performance

P019 (UGS) **The effects of immunological castration in mature boars.** C. Metzger [1, 2,*], M. Brubaker [2], M. Barker [2], W. Singleton [3], R. O. Bates [1], *[1]Michigan State University, East Lansing, [2]Whiteshire Hamroc, Albion, IN, [3]Purdue University, W. Lafayette, IN, United States.*

Improvest™ (IMP) is an anti-GnRF, two-dose, injectable product newly approved for immunological castration in growing male pigs. However its effectiveness in mature boars has not been ascertained. A study was conducted in a boar stud undergoing depopulation in summer of 2012, to determine changes in semen production and behavior among mature boars given IMP (n=25) compared to non-treated controls (C) (n=5). The second IMP injection (IMP2) was given 4 wk after the first (IMP1). Data collected included; paired testis width (mm) at IMP1 and 9 wk later and plasma testosterone (TESTOS; ng/ml) for 4 wk starting at IMP2. Weekly semen evaluation per collection included; vol (ml), semen concentration (sperm/ml), total sperm (billion), percent (%) motility and % progressive motility and behavior scores were collected from IMP1 through 9 wk. Behavior scores, ranged from 0-5. One point was given for each of 5 criteria expressed at each collection; chomping, vocalization, hairs bristling, challenging, and mounting the collection dummy. If a boar laid down in the warm up stall, one point was deducted. Boars treated with IMP had reduced testis width (163.6 vs 215.1, $P < 0.001$) 9 wk after IMP1 and lower TESTOS (0.302 vs 3.29, $P < 0.01$), at 3 wk post IMP2 compared to C boars, respectively. Semen vol was reduced in IMP treated boars compared to C boars (163.7 vs 286.0, $P<0.03$, respectively), but not concentration nor total sperm 5 wk after IMP2. Decreases were seen in % sperm motility and % progressive motility, and % normal sperm in IMP treated boars compared to C boars (61.2 vs 97.2, $P < 0.02$; 43.8 vs 82.6, P <0.01; 67.2 vs 92.9, $P <.03$, respectively) 5 wk after IMP2, while % abnormal heads, and % proximal droplets increased in IMP treated boars compared to C boars (1.89 vs 0.96, $P < 0.03$; 9.5 vs 2.2, $P <0.001$, respectively), 5 wk after IMP2. Behavior scores were not affected by treatment. This may have occurred due in part to previous learned behavior. Treatment of mature boars with IMP decreased testis size, plasma testosterone, and semen volume and caused semen quality to decline.

Key Words: immunological castration, pig, semen evaluation

P020 (GS-MS) **Pork quality: 2012 national retail benchmarking study.** B. T. Klinkner [1,*], D. S. Buchanan [1], C. C. Carr [2], R. B. A. Dahlen [1], R. J. Delmore [3], K. Grimshaw [4], W. R. Henning [5], R. K. Miller [4], S. J. Moeller [6], H. N. Zerby [6], D. J. Newman [1], *[1]Animal Sciences, North Dakota State University, Fargo, [2]Animal Sciences, University of Florida, Gainesville, [3]Animal Sciences, California Polytechnic State University, San Luis Obispo, [4]Animal Sciences, Texas A&M University, College Station, [5]Dairy and Animal Sciences, The Pennsylvania State University, University Park, [6]Animal Sciences, The Ohio State University, Columbus.*

The objective of this study was to benchmark values for fresh pork quality in the retail meat case. Nationally, 117 retail supermarkets, representing 32 market regions in 25 states were selected for sampling. Center-cut loin chop, sirloin chop, and blade steak were evaluated. The following measurements were taken in-store: pieces available per package, number of packages available per store, packaging type, package price per pound, product thickness, label temperature recommendations, enhancement type and percentage, and sell by date. Additionally, center-cut loin chops were assessed in-store for subjective color, marbling, firmness, enhancement type, and various quality defects. Moreover, after in-store analysis, ten packages of each brand and enhancement type were purchased when available of each of the three pork cuts for further objective analysis including pH, objective Minolta color (L*, a*, and b*), and tenderness (WBSF). Data were analyzed using means and ordinary least squares (PROC MEANS and GLM, SAS Institute, Cary, NY). Center-cut loin values (mean ± standard deviation) were: color (3.12±0.845), IMF (2.48±0.946), firmness (2.26±0.544), pH (5.87±0.300), L* (55.39±3.765), a* (6.36±2.631), b* (4.01±2.069), and WBSF (23.39±6.818). Sirloin chop values (mean ± standard deviation) were: pH (5.89±0.307), L* (51.89±3.258), a* (19.48±2.839), b* (10.11±2.739), and WBSF (18.71±5.172 N). Blade steak values (mean ± standard deviation) were: pH (6.22±0.272), L* (45.27±2.788), a* (19.72±2.220), b* (8.13±1.717), and WBSF (17.12±4.650 N). Least squares means for enhanced vs. non-enhanced center-cut loin chop were: color (3.22 vs. 3.16, SEM=0.014), IMF (2.38 vs. 2.44; SEM=0.019), firmness (2.24 vs. 2.22; SEM=0.007), pH (5.99 vs. 5.78; SEM=0.005), L* (54.32 vs. 56.19; SEM=0.086), a* (5.90 vs. 6.85; SEM=0.038), b* (3.71 vs. 4.09; SEM=0.054), and WBSF (20.88 vs. 25.30; SEM=0.173N); respectively. This research provides retailers, processors, and other pork industry stakeholders with benchmark values of pork quality, and provides the pork industry with necessary information to help address areas for improvement.

Key Words: benchmark , pork, quality

GROWTH, DEVELOPMENT, MUSCLE BIOLOGY AND MEAT SCIENCE

P021 **Lipid oxidation and color stability of processed pork from pigs fed varied levels of dried distillers grains.** C. Perkins*, Z. Callahan, C. Ballard, M. Shannon, B. Wiegand, *Division of Animal Sciences, University of Missouri, Columbia.*

Dietary fat source changes pork fatty acid profiles. This experiment evaluated varied levels of distillers dried grains with solubles (DDGS) on fat quality and shelf stability of processed pork. Picnic shoulders (n=39) were selected from individually-fed pigs randomly assigned one of five dietary treatments: 1) Corn/ soybean meal (SBM) in all phases, 2) +33.5% DDGS in all phases, 3) +33.5 % DDGS in Phase 1 and 2; Corn SBM in Phase 3, 4) +33.5% DDGS in Phase 1; 20% DDGS in Phase 2 and 11% DDGS in Phase 3, and 5) + 20% DDGS in all Phases. Diets were fed in three phases (phase 1: 27-59 kg,

phase 2: 59-91 kg, phase 3: 91-122 kg). Pig was the experimental unit. Pork shoulder trim was divided into two sections and assigned to processing treatments: A) Fresh bratwurst or B) Fresh ground pork patty. Samples were analyzed for fatty acid profiles, thiobarbituric acid reactive substances (TBARS), and Minolta objective color during a seven-day retail display at 4° C. Proximate analysis revealed no differences in fat ($P = 0.14$) or moisture ($P = 0.12$) percentage for the starting meat block. Saturated fatty acid (SFA) percentage was highest (39.4%) in diet 1 and lowest (36.8%) in diet 2 with all other diets being intermediate ($P = 0.04$). Monounsaturated fatty acid (MUFA) percentage was highest (48.9%) in diet 1 and lowest (43.4 %) in diet 2 with all other diets being intermediate ($P = 0.0001$). Polyunsaturated fatty acid (PUFA) percentage decreased ($P < 0.0001$) in similar proportion to the increases observed in SFA. Therefore, calculated iodine value (IV) was lowest (59.4) for diet 1 and highest (67.6) for diet 2 with all others being intermediate ($P < 0.0001$). Minolta L* values were greatest in diet 4 for fresh pork ($P = 0.01$) and fresh bratwurst ($P < 0.0001$) over the seven days of shelf storage compared to all other diets (d3=58.6, d5=59.8, d7=60.4 and d3=58.6, d5=62.5, d7=62.3, respectively). TBARS values did not differ for fresh pork ($P = 0.23$) or fresh bratwurst ($P = 0.43$) at any day of shelf storage. While inclusion of DDGS shifts pork fat to a more unsaturated product, levels below 33.5% or DDGS removal during finishing will result in lower IV in pork fat.

Key Words: dried distillers grains, pork, shelf life

P022 **Enhancement of mature camel-meat quality traits with calcium chloride injection.** A. N. Al-Owaimer*, *Animal Production, King Saud University, Riyadh, Saudi Arabia.*

This study was carried out to enhance mature camel meat tenderness with calcium chloride injection. Eight Somali male camels were used in this study. Their average weight and age were 500 kg and 5-6 years. The *Longissimus dorsi* muscles of each carcass were assigned randomly to either a control where no injection applied or 250 m*M* food-grade calcium chloride ($CaCl_2$) injection at 5% (wt/wt). Values of color components were not significantly ($P > 0.05$) affected by the treatments, although slight increase in redness (a^*) appeared in treated groups accompanied with observed decrease in lightness (L^*). Water-holding capacity (WHC), shear force and myofibril fragmentation index (MFI) showed significant differences between the treatments. Treated groups showed less shear values and high MFI indices that indicating an improvement in tenderness comparing to control group. It is also observed that MFI was highly ($P < 0.01$) correlated with drip loss and negatively ($P < 0.01$) correlated with WHC and shear force. This study came to a conclusion that using calcium chloride injection for Somali camel meat results in improved meat tenderness and enhanced quality traits.

Key Words: camel, meat, quality

P023 **Vein steak differences in strip loins of heifers due to the inactive myostatin allele.** M. Semler*, C. Calkins, L. Senaratne-Lenagala, K. Varnold, G. Erickson, *Animal Science, University of Nebraska, Lincoln.*

The objective of this study was to determine amount and musculature differences of strip loins from heifers of different genotypes (Angus, Angus × Piedmontese, and Piedmontese). The cattle genotypes were zero (0C), one (1C) and two (2C) copies of the inactive myostatin allele which causes muscle hyperplasiaand an increase in overall muscle mass (n = 19, 20, and 20). At 3 days post mortem samples were collected from the carcasses. Strip loins were then measured for fat thickness, loin weight, loin length, sirloin face width, rib face width, sirloin tail length, and rib tail length. Strip loins were then cut into 2.5-cm thick steaks and the following was recorded for each: total number of steaks, total number of vein steaks, total number of non-vein steaks, and weight of each individual steak were recorded for each strip loin. Vein steaks were defined as those steaks that contained the *Gluteus medius.* Data were analyzed in SAS (Version 9.2) using Proc GLM with a significance value of $P < 0.05$. Strip loins from 2C heifers were shorter *(*$P < 0.01$*;* 37.3 vs. 40.1 cm) and had a wider rib face *(*$P < 0.01$*;* 21.3 vs. 19.1 and 19.8 cm, respectively) when compared to 0C and 1C loins. Fat thickness measurements showed 2C strip loins were leaner ($P < 0.01$*;* 0.5 vs. 1.5 vs. 0.8 cm) than 0C and 1C samples. There were no difference shown for overall loin weight, sirloin face width, sirloin tail length, and rib tail length. When comparing 2C strip loins to 1C, 2C strip loins had a lower number of total steaks *(*$P < 0.03$; 12.4 vs. 13.1). The 1C strip loins had a greater number of non-vein steaks *(*$P < 0.01$; 9.4 vs. 8.5 and 8.6*)*, and a lower percentage of vein steaks ($P < 0.01$; 28.3 vs. 32.5 and 30.32%) compared to 0C and 2C samples. Overall mean steak weight, total weight of vein steaks, and percent weight of vein steaks within the strip loin did not differ among genotypes.

Key Words: beef, myostatin, vein steak

P024 **Background grazing, supplementation, finishing diet and aging affect biochemical constituents of beef bottom round steaks.** K. Varnold*, C. Calkins, B. Nuttelman, L. Seneratne-Lenagala, J. Stevenson, M. Semler, M. Chao, G. Erickson, *Animal Science, University of Nebraska, Lincoln.*

The objective of this study was to determine how biochemical constituents of meat are altered when diet and aging periods are varied. Crossbred steers (n = 48) were grazed on warm or cool-season grasses, without or with protein supplementation from wet distillers grains with solubles (WDGS), and were finished on corn or 35% WDGS. *Biceps femoris* muscles were collected and aged under vacuum 7 and 28 d. Samples were analyzed for proximal composition, pH, cooking loss, and heme and non-heme iron content, fatty acid content (neutral and phospholipid layers), amino acid, and minerals. Neither dietary treatment nor aging period had an effect on proximal analysis, pH, or cooking loss. Beef from cattle grazed on cool-season grass with supplementation and aged 28 d had higher ($P < 0.01$) non-heme iron content than 7 d. Warm-season grass grazing with no supplementation caused 28 d aged beef to have higher non-heme iron content. Beef from cattle grazed on warm-season grass with supplementation and finished on corn (versus WDGS) had higher ($P = 0.05$) glycine values. Beef that was aged 28 d had higher ($P < 0.01$) pH and heme iron (ppm) values than beef aged 7 d (5.65 vs 5.39 and 10.58 vs 9.54, respectively). Finishing cattle on corn increased ($P = 0.04$) histidine levels compared to WDGS. Cattle that are not supplemented while grazing had higher phosphorus (%) content ($P = 0.04$) in the meat when finished on WDGS as opposed to corn (0.23 vs 0.21). In the neutral layer, polyunsaturated fatty acid (%) content increased when cattle grazed on warm-season grass ($P < 0.01$) and decreased when finished on corn ($P < 0.01$) compared to WDGS (2.06 vs 1.74 and 1.61 vs 2.14, respectively). In the phospholipid layer, monounsaturated fatty acids (%) increased ($P < 0.01$) and polyunsaturated fatty acids (%) decreased ($P < 0.01$) if they were finished on corn rather than WDGS (22.57 vs 17.96 and 39.93 vs 45.81, respectively). Warm-season grasses caused the

most biochemical changes in meat, especially when paired with supplementation. Finishing diet had the most effect on fatty acid values, with corn tending to create a more saturated fatty acid profile.

Key Words: beef, biochemical constituents, diet

P025 **Relationship among EUROP carcass classification and retail production of Brazilian lambs.** H. A. Ricardo[1,*], R. O. Roça[2], S. A. Tavares[2], C. A. Surge[2], A. R. M. Fernandes[1], *[1]Grande Dourados Federal University, MS, [2]Sao Paulo State University (UNESP), Botucatu-SP, Brazil.*

The objective was to determine if exist correlation among EUROP carcass conformation and fatness classes and production of retail cuts from commercial Brazilian lambs. Were evaluated 194 lambs from a commercial slaughterhouse. On the day prior to slaughter, with 12 h of fast, the body weight (BW) and body condition (BC) were recorded. Lambs were humanely slaughtered, and hot carcass weight (HCW), and hot carcass dressing (HCD) were taken. Each carcass was evaluated by the EUROP sheep carcass classification scheme, for conformation and degree of fatness. The classification was done subjectively by a trained technician. Five conformation classes (CC) were used, represented by letters in an decrescent scale: S (Superior), E (Excellent), U (Very good), R (Good), O (Fair), and P (Poor). For fatness (FT) five classes were used, in a incremental scale: 1 (Low), 2 (Slight), 3 (Average), 4 (High), and 5 (Very high). After 24 h of chilling were obtained cold carcass weight (CCW), cold carcass dressing (CCD), and chilling losses (CL). Retail cuts were represented by eight trimmed cuts: neck bone-in (NK); shoulder banjo cut, bone-in (SB); breast and flap (BF); loin with *Longissimus* bone-in between first and last lumbar vertebra (LO); short cut leg, bone-in, chump-off (SL); rack, fully frenched (RF); shoulder rack (SR); boneless chump (BC). Each cut was weighted and the data was used to determine the loss percentage (LP). CC was positively correlated with BW ($r = 0.54$, $P < 0.0001$), HCW ($r = 0.48$, $P < 0.0001$), CCW ($r = 0.67$, $P < 0.0001$), CCD ($r = 0.49$, $P < 0.0001$), SB ($r = 0.46$, $P < 0.01$), BF ($r = 0.42$, $P < 0.05$), LO ($r = 0.61$, $P < 0.01$), SL ($r = 0.45$, $P < 0.05$), RF ($r = 0.40$, $P < 0.05$), and BC ($r = 0.57$, $P < 0.01$). CC also was correlated, but negatively, with CL ($r = 0.24$, $P < 0.05$). FT was not correlated with any characteristic evaluated. Only carcass conformation class showed relationship with retail cuts production from Brazilian lambs.

Key Words: conformation, fatness, lamb

P026 **Maternal nutrition during the second trimester of gestation alters gene transcription in the resultant offspring.** A. R. Taylor [1,*], T. Jennings [1], J. Koltes [2], M. Gonda [1], K. Underwood [1], J. Reecy [2], A. Wertz-Lutz [1], A. Weaver [1], *[1]Animal Science, South Dakota State University, Brookings, [2]Animal Science, Iowa State University, Ames.*

Altered maternal nutrition has been shown to influence adipose and muscle development in the resultant offspring. The mechanisms that facilitate altered development are yet to be determined. Therefore the objective was to evaluate the effects of maternal diet during the second trimester on gene expression in fetal tissues using microarray analysis. Twenty-two bred crossbred heifers of similar age and weight (BW = 527.73 ± 8.3 kg) were assigned randomly to one of three dietary treatments providing 146% (HIGH; n=7), 87% (INT; n=7), or 72% (LOW; n=8) of the energy requirements for growing pregnant heifers according to the Beef Cattle NRC from day 85 to 180 of gestation. Fetuses were removed via cesarean section at day 180 of gestation. Samples from the *longissimus dorsi* muscle (LD), brisket fat, subcutaneous fat and liver were collected from each fetus for evaluation of gene expression. Total RNA was isolated and gene expression differences were determined using the Affymetrix GeneChip microarray. To determine which genes were differentially expressed (DE) due to maternal diet, the limma package was used to analyze expression values. Within brisket fat tissue proprotein convertase subtilisin/kexin type 5 (PCSK5) was down regulated 1.78 fold ($q<0.11$) when HIGH diet was compared to LOW diet. Also gap junction protein (GJD4) was down regulated 1.69 fold ($q<0.11$) in the HIGH diet relative to the LOW diet. In LD samples TOE1 was 9.1 fold ($q<0.05$) down regulated when HIGH diet was compared to the LOW diet. Additionally, fetal growth traits were used as covariates to determine which genes were DE in response to fetal growth using the Mixed Procedure of SAS. Genes DE ($q<0.10$) in LD muscle included TRABD, MLF2, A2M, LOC514413, IL27RA, ERAP1. These findings are being confirmed via Real Time-PCR. These data suggest gene expression in brisket fat and LD muscle of fetal tissues can be influenced by maternal dietary treatment.

Key Words: cattle, fetal programming, gene expression

P027 **Effects of amino acid supplementation of reduced crude protein (RCP) diets on LM quality of growing-finishing swine.** A. N. Young[1,*], J. K. Apple[1], J. W. S. Yancey[1], J. J. Hollenbeck[1], T. M. Johnson[1], B. E. Bass[1], T. C. Tsai[1], C. V. Maxwell[1], M. D. Hanigan[2], J. S. Radcliffe [3], B. T. Richert [3], J. S. Popp [4], R. Ulrich [5], G. Thoma[5], *[1]Animal Science, University of Arkansas Division of Agriculture, Fayetteville, [2]Dairy Science, Virgina Polytechnic Institute and State University, Blacksburg, [3]Animal Science, Purdue University, West Lafayette, [4]Agricultural Economics & Agribusiness, University of Arkansas Division of Agriculture, [5]Chemical Engineering, University of Arkansas, Fayetteville.*

Barrows and gilts (n = 210/gender) were used to test the effects of crystalline AA supplementation of reduced CP diets on quality characteristics of the LM from growing-finishing swine. Pigs were blocked by BW, and pens (6 pigs/pen) within each block and gender were assigned randomly to either corn-SBM diets (**C**) devoid of crystalline LYS and formulated to 95% SID AA requirements or 1 of 4 RCP diets (CP and crystalline LYS levels for the dietary treatments during each feeding phase are presented in the accompanying table). During the last 3-wk feeding phase, 10 ppm of Paylean was included in all diets. A subsample of whole pork loins (2/pen) was captured during carcass fabrication and further processed into LM chops for quality data collection. LM ultimate pH and color scores were greater ($P \leq 0.04$) for barrows than gilts, but L* values and LM drip losses were greater ($P = 0.02$) in gilts than barrows. Redness (a*) values increased (cubic, $P = 0.01$) with decreasing dietary CP; yet, other color measures ($P \geq 0.06$) and percent drip loss ($P = 0.19$) were not affected by RCP treatment. The LM of barrows had greater ($P < 0.01$) marbling scores than that of gilts, and intramuscular fat (IMF) content increased almost 2 percentage points from C to RCP3 in barrows (5.8 vs. 7.7%) but decreased a full percentage point (6.2 vs. 5.2%) in gilts with decreasing CP (quadratic RCP × gender, $P = 0.03$). Shear force (WBSF) values increased 20.5% with decreasing CP in gilts, and WBSF values increased 0.6 kg from C to RCP2 but WBSF was similar among C, RCP3 and RCP4 (quadratic RCP × gender, $P = 0.03$). Results indicate that fresh pork quality, especially IMF, is improved by reducing dietary CP; however, the improvements associated with RCP appear to be gender specific. (See table on the next page.)

P027 Table

CP (added LYS) of experimental diets for each feeding phase (% as fed)

Phase	C	RCP1	RCP2	RCP3	RCP4
1	23.70	21.61 (0.19)	19.58 (0.37)	17.61 (0.56)	15.72 (0.75)
2	21.53	19.46 (0.18)	17.44 (0.36)	15.49 (0.54)	13.61 (0.71)
3	18.97	17.34 (0.15)	15.74 (0.29)	14.16 (0.44)	12.68 (0.59)
4	17.66	16.30 (0.13)	14.96 (0.24)	13.64 (0.36)	12.37 (0.48)
5	20.24	18.60 (0.15)	17.01 (0.30)	15.44 (0.45)	13.93 (0.60)

Key Words: intramuscular fat content, reduced CP, swine

P028 **Proteomic analysis of fetal ovine skeletal muscle as influenced by maternal metabolizable protein supplementation in isocaloric diets during late pregnancy.** C. A. Schwartz[1,*], K. A. Vonnahme[1], C. S. Schauer[2], S. M. Lonergan[3], K. J. Grubbs[3], J. B. Shabb[4], W. W. Muhonen[4], W. L. Keller[1], K. R. Maddock-Carlin[1], *[1]Department of Animal Sciences, North Dakota State University, Fargo, [2]Hettinger Research Extension Center, North Dakota State University, Hettinger, [3]Department of Animal Science, Iowa State University, Ames, [4]Department of Biochemistry and Molecular Biology, University of North Dakota, Grand Forks.*

The purpose of the study was to investigate the impact of contrasted protein levels in isocaloric diets of pregnant dams during late gestation on the proteome of offspring LM. Multiparous singleton pregnant ewes (n = 18) were randomized to receive 1 of 3 diets that were isocaloric and formulated to supply 60% (MP60), 100% (MP100), or 140% (MP140) of MP requirements during late gestation (d 100 to 130). Pregnant ewes and fetuses were necropsied on d 130 ± 1 of gestation and samples from the LM were immediately collected. Two-dimensional difference in-gel electrophoresis was used to compare the sarcoplasmic and myofibrillar protein fractions of fetal LM and data was analyzed using matrix-assisted laser desorption/ionization time-of-flight mass spectrometry techniques. Seven spots in the sarcoplasmic fraction corresponding to 5 proteins, and zero spots in the myofibrillar fraction differed in relative abundance ($P \leq 0.10$) among MP treatments. Upregulation of aldolase A in the LM of fetuses from MP140 and MP60 ewes vs. MP100 ewes was further validated ($P = 0.05$) by Western blot analysis. The main changes evidenced in the proteome of fetal LM were involved in AA metabolism and protein turnover. Creatine kinase was less ($P < 0.02$) abundant in fetal LM from MP140 ewes compared with MP100 ewes. Phosphoglucomutase 1 was more abundant ($P < 0.02$) in fetal LM of MP100 ewes compared with MP60 ewes. In conclusion, proteomics has allowed the identification of early changes in molecular pathways of fetal skeletal muscle development in response to maternal protein supply during late gestation.

Key Words: metabolizable protein, proteomics, sheep

P029 **Changes in within-pen variation in body weight and in individual pig body weight rank from weaning to finish in a commercial facility.** C. Shull [1,*], M. Ellis [1], B. Peterson [2], B. Wolter [2], B. Isaacson [2], *[1]University of Illinois, Urbana, [2]The Maschhoffs, Carlyle, IL.*

The objectives of this study were to: 1) Develop relationships between BW and within-pen variation in BW, and 2) Determine the extent to which the within-pen ranking of individual pigs for BW changed during the growth period. The study was conducted as a RCBD with a single treatment, namely Gender (barrows vs. gilts) over 2 periods. Periods 1 and 2 were from weaning to wk 10 post-weaning and from wk 10 post-weaning to a pen mean BW of 135.2 ± 0.76 kg, respectively. Period 1 involved a total of 1,882 pigs in 6 replicates (10 pens with 153 pigs and 2 pens with 175 pigs). Half of the replicates (3 pens of barrows and 3 pens of gilts) were used in Period 2 with each pen being split into 2 groups with a similar mean BW and variation in BW to result in 12 pens of 73 pigs (880 pigs in total). Pigs had ad libitum access to feed and water throughout the study. Floor space was 0.28 and 0.59 m^2/pig during Periods 1 and 2, respectively. A body weight rank was assigned to each pig based on its weight at each weighing time (birth, weaning, and every 2 wk from the start to end of study). During both periods, as BW increased, within-pen standard deviation of BW increased quadratically ($P \leq 0.05$); however, within-pen CV of BW decreased linearly ($P \leq 0.05$). Correlations between the within-pen BW rankings at birth and weaning and within-pen BW rankings at subsequent weighing times were from 0.5 and 0.6 ($P \leq 0.05$). The percentage of pigs in the same BW quartile at wk 22 post-weaning as they were in at birth, weaning, and wk 10 post-weaning was 39.0, 40.7, and 57.8%, respectively. These results suggest that the standard deviation of BW within a pen increases with increases in BW and that early weights are relatively poor predictors of subsequent weights of individual pigs within a pen.

Key Words: pigs, rank, variation

P030 **Development of growth curves for pigs reared to heavy weights in a commercial wean-to-finish facility.** C. Shull [1,*], M. Ellis [1], B. Peterson [2], B. Wolter [2], C. Peterson [2], *[1]University of Illinois, Urbana, [2]The Maschhoffs, Carlyle, IL.*

The objective of this research was to develop growth curves of live animal growth performance and ultrasound measures for entire pens of pigs reared to heavy BW in a commercial wean-to-finish facility. The study was conducted as a RCBD with a single treatment, namely gender (barrows vs. gilts) using 240 pigs in 12 pens of 20 pigs from weaning to a pen mean BW of 167.5 ± 3.30 kg. Pigs had ad libitum access to feed and water throughout the study and were provided a floor space of 1.06 m^2/pig. Group weights were collected every 2 wk from the start to end of study and individual pig weights and ultrasound measures were collected every 2 wk from wk 14 post-weaning to the end of study. Data were analyzed using the PROC MIXED procedure of SAS and regression equations were developed between pen mean BW and the pen mean growth performance and ultrasound measures. From start to end of study, barrows grew 3.7% faster ($P \leq 0.05$), consumed 5.4% more feed ($P \leq 0.05$), and tended to have a lower G:F ratio (1.9%; $P = 0.08$) than gilts. At the end of test, gilts had 9.6% less ultrasound backfat ($P \leq 0.05$) and 5.2% larger ultrasound *Longissimus* muscle area ($P \leq 0.05$). Instantaneous ADG was maximized at 78 and 77 kg BW for barrows and gilts, respectively, and decreased thereafter. Instantaneous ADFI was maximized at 115 and 121 kg BW for barrows and gilts, respectively, and decreased subsequently. Instantaneous G:F decreased ($P \leq 0.05$) quadratically across the range of BW evaluated for both barrows and gilts. As BW increased, there was a linear increase ($P \leq 0.05$) in backfat depth and a quadratic increase ($P \leq 0.05$) in *Longissimus* muscle area. This study provides estimates of the effect on growth and carcass traits of taking contemporary pigs to BW considerably above current US harvest weight.

Key Words: growth, heavy BW, pigs

P031 **Growth performance and carcass characteristics of pigs reared to heavy weights in a commercial facility.** C. Shull [1,*], M. Ellis [1], B. Peterson [2], B. Wolter [2], C. Peterson [2], *[1]University of Illinois, Urbana, [2]The Maschhoffs, Carlyle, IL.*

The effects of gender and final BW were evaluated in a study that used a RCBD with a 2 × 7 factorial arrangement of treatments: 1) Gender [barrows (B) vs. gilts (G)] and 2) Final BW of each individual pig within the pen (113, 125, 136, 147, 159, 170, and 181 kg). The study was carried out from weaning to the designated Final BW using 2,240 pigs in 112 pens of 20 pigs. Pigs had ad libitum access to feed and water and were provided a floor space of 1.06 m^2/pig. Pigs were ultrasonically scanned at the end of test and sent for harvest (in groups of 2 to 4 pigs/pen) at a commercial plant where carcass weight (with skin and feet removed) was collected. Compared to G, B had higher ($P \leq 0.05$) overall ADG (826 and 802 g for B and G, respectively; SEM 5.5) and ADFI (2.21 and 2.09 kg, respectively; SEM 0.010) and had greater ($P \leq 0.05$) backfat (28.3 and 24.8 mm, respectively; SEM 0.21), lower ($P < 0.001$) *Longissimus* muscle depth (5.62 and 5.74 cm, respectively; SEM 0.012) and area (49.5 and 51.1 cm^2, respectively; SEM 0.13), and similar ($P > 0.05$) carcass yield (68.2 and 68.1%, respectively; SEM 0.07). There was a Gender by Final BW interaction ($P \leq 0.05$) for overall G:F, with G having a higher ($P \leq 0.05$) G:F than B at every Final BW except for the 113 and 181 kg levels, where the genders had similar ($P > 0.05$) overall G:F. Overall ADG was highest ($P \leq 0.05$) for the intermediate Final BW levels and lowest ($P \leq 0.05$) for the lightest and heaviest 2 Final BW (810, 823, 831, 821, 822, 802, and 789 g for the 113, 125, 136, 147, 159, 170, and 181 kg Final BW, respectively; SEM 7.2). As Final BW increased, overall ADFI increased quadratically ($P \leq 0.05$), overall G:F decreased quadratically for B and linearly for G, backfat and *Longissimus* muscle area increased quadratically ($P \leq 0.05$), *Longissimus* muscle depth increased cubically ($P \leq 0.05$), and carcass yield increased quadratically ($P \leq 0.05$). The results of this study confirm that pigs can be reared to heavier live weights with relatively limited effects on performance.

Key Words: final BW, gender, pigs

P032 **Relationship between birth order and piglet pre-weaning mortality and other factors under commercial conditions.** L. M. Gesing[1,*], H. M. Rothe[1], M. Ellis[1], B. A. Peterson[2], A. M. Gaines[2], B. F. Wolter [2], C. M. Peterson [2], *[1]University of Illinois, Urbana, [2]The Maschhoffs, Carlyle, IL.*

The effect of birth order on BW, temperature, serum immunoglobulin G level (IgG), and pre-weaning mortality (PWM) was evaluated in a study involving 2,404 piglets from 191 litters. The study was carried out in a commercial farrowing facility using a split-plot design with 1 treatment (Birth Order) and 4 levels (Quartile 1, 2, 3, and 4). Litter was the whole plot and birth order was the sub-plot. At birth, all piglets born (alive and dead) within a litter were assigned to a Birth Order quartile. Rectal and body surface temperature were measured at birth and approximately 3 h after birth. At 24 h after birth, blood samples were taken for IgG analysis. Piglet BW was collected at birth and weaning (16-21 d of age). Piglets born in Quartile 4 were heavier ($P < 0.05$) at birth (1.4, 1.4, 1.4, 1.5 kg BW for Quartile 1, 2, 3, and 4, respectively; SEM 0.02), and weaning (5.8, 5.9, 5.9, 6.0 kg BW, respectively; SEM 0.05), and had a higher ($P < 0.05$) rectal and body surface temperature at birth than those in the other Birth Order quartiles. There was no effect of Birth Order on rectal or body surface temperature 3 h after birth. Piglets born in Quartile 1 had the highest ($P < 0.05$) serum IgG at 24 h, and those born in Quartile 4 had the lowest (13.7, 13.3, 13.1, and 12.4% blood serum, respectively; SEM 0.20). In addition, piglets born in Quartile 1 had higher ($P < 0.05$) PWM (3.5, 2.6, 2.8, and 2.6%, respectively) than the other Birth Order quartiles. In conclusion, the last 25% of piglets born within a litter (Quartile 4) had higher BW at birth and weaning but lower serum IgG levels 24 h after birth. Also, the first 25% of piglets born within a litter (Quartile 1) had the highest serum IgG levels 24 h after birth but also had the highest PWM.

Key Words: birth order, pigs, pre-weaning mortality

P033 **Carcass characteristics and beef tenderness differences in cattle qualified as kosher and non-kosher.** K. Sorensen [1,*], K. Maddock-Carlin [1], N. Hayes [1], W. Keller [1], K. Phelps [2], C. Schwartz [1], R. Maddock [1], *[1]North Dakota State University, Fargo, [2]Kansas State University, Manhattan.*

The objective was to determine if tenderness of beef from carcasses that qualified for kosher designation were different than cattle that did not qualify for kosher designation. Finished steers and heifers (n = 53) were slaughtered at a commercial facility according to kosher law. Carcass data were collected 24 h after chill, and samples were taken from the 13th rib. Steaks (2.5-cm thick) were fabricated from each sample, vacuum packaged, aged for 14 d, and then frozen until analysis of mechanical tenderness by Warner-Bratzler shear force (WBSF). Carcass data collected included ribeye area, HCW, 12th rib fat, marbling score, KPH, and final yield grade. Sarcomere length and Western blotting for troponin-T degradation was determined on samples collected at 24 h postmortem. The processing facility provided information indicating if the carcass had qualified as kosher. Of the 53 steers and heifers, 26 qualified as kosher. Data were analyzed using the GLM procedure of SAS, using kosher as the source of variation in the model. Carcasses qualified as kosher had a larger ($P = 0.04$) ribeye area than non-kosher carcasses. There were no differences ($P > 0.05$) in HCW, 12th rib fat, marbling score, or final yield grade. Kosher carcasses were less tender ($P < 0.001$) than non-kosher carcasses. Kosher carcasses tended ($P = 0.09$) to have shorter sarcomeres. Additionally, kosher carcasses had more ($P = 0.02$) intact troponin-T and less ($P = 0.003$) accumulation of a 30-kDa degradation product than non-kosher carcasses. Carcasses qualified as kosher were less tender and had less protein degradation than carcasses not qualified as kosher. Additional research is needed in order to maximize tenderness in kosher-qualified carcasses, thereby enhancing product quality and consumer satisfaction.

Key Words: kosher, proteolysis, tenderness

P034 **Lactate concentration at exsanguination is related to feedlot heifer temperament but not fresh beef color.** K. Wellnitz[*], J. Magolski, K. Carlin, V. Anderson, E. Berg, *Animal Sciences, North Dakota State University, Fargo.*

The objective was to investigate the relationship between feedlot measures of beef cattle temperament, abattoir vocalization, and exsanguination blood lactate concentration on ribeye Minolta color scores and 14d aged Warner/Bratzler tenderness. Measurements of feedlot temperament were obtained on 126 crossbred heifers prior to loading for slaughter on two consecutive Mondays. Measurements included exit velocity (meters/sec; EV) and subjective chute score

(CS) and capture score (CAPS) whereby 1 = calm/no movement and 5 = twisting of the body/struggling violently. Vocalization (VOC) scores (0 = no vocalization, 1 = little vocalization, 2 = extensive vocalization) were assigned while in the v-belt restrainer and blood lactate concentration (mmol/L; LAC) was measured approximately 40 s after exsanguination. Partial correlation coefficients (r) were calculated for LAC and CS (r = 0.27; P = 0.02), CAPS (r = 0.25; P = 0.03), EV (r = -0.21; P = 0.06), and VOC (r = 0.37; P < 0.01). Correlations between LAC and 24h Minolta color scores were not significant. Heifers were categorized by EV as SLOW = EV < 1.18 m/s, AVG = 1.95 ± 0.77 m/s, or FAST = EV > 2.72 m/s. The SLOW heifers had lower (P < 0.05) LAC (9.08 mmol/L) than FAST (11.82 mmol/L). Lactate concentration of the AVG heifers (10.18 mmol/L) did not differ from SLOW or FAST. Likewise, heifers that recorded an extensive VOC score (2) had higher LAC at exsanguination (12.99 mmol/L) than scores of 1 (10.06 mmol/L) or 0 (9.53 mmol/L). These data indicate that blood LAC at slaughter is related to market heifer temperament but not beef color.

Key Words: temperament, beef, quality

P035 **Carcass traits and shelf-life analysis of beef derived from steers in commercial feedlot settings administered Zilpaterol Hydrochloride with and without Hydro-Lac supplementation.** L. Hoffman [1,*], D. Kohls [2], H. Doering-Resch [2], G. Crawford[2], S. Scramlin [1], A. Weaver [1], K. Underwood [1], *[1]South Dakota State University, Brookings, [2]Form-A-Feed, Steward.*

An experiment was conducted to investigate the effects of extended Hydro-Lac®/Bovine Bluelite® Pellets use in conjunction with zilpaterol hydrochloride (Zilmax®) on carcass traits, ground beef shelf-life analysis, and tenderness of strip loin steaks. Hydro-Lac® (HL) is a timed-event nutrition product supplemented prior to slaughter that is formulated to provide essential nutrients, electrolytes, sugars, and other proprietary ingredients necessary to maintain homeostasis and performance in live cattle, particularly during periods of transport and heat stress. Cross-bred steers (n = 556) were randomly assigned to four pens at a commercial feedlot and fed 90 mg/(hd · d) Zilmax® for the last 20 d of the feeding period with a 3 d withdrawal prior to harvest. Two pens received no HL to serve as the control (CN), and two pens received HL (0.1135 kg · d) for 23 d prior to slaughter. There were no differences between treatments for HCW, yield grade (YG), LM area, marbling score, pH, 24 h drip loss, purge loss, and L*, a*, b*($P \geq 0.05$). There was a trend ($P=0.19$) for decreased Warner-Bratzler shear force with inclusion of HL. Carcasses from HL steers had increased 12th rib fat ($P \leq 0.01$) which accounted for the increased percentage of USDA YG 3 ($P=0.02$) carcasses. Also, HL carcasses had greater intramuscular fat content ($P=0.02$), which supports the reduction in the number of USDA Standard ($P \leq 0.01$) carcasses. Additionally, HL steaks had lower 48 h drip loss ($P=0.05$) and less cook loss ($P=0.04$) than CN steaks. There were no differences in a*, b*, or Hunter ratio in the ground beef shelf-life study ($P \geq 0.05$). Ground beef patties from CN carcasses had a greater L* value ($P \leq 0.01$) than HL indicating a brighter color of lean. There was also a trend for HL patties to have decreased TBARS values ($P=0.12$) by d 7 of retail display. These data indicate HL supplementation could increase fat content of meat products, increase shelf-life with reduced lipid oxidation, and lead to a greater water holding capacity for meat products.

Key Words: carcass characteristics, cattle, Zilpaterol hydrochloride

P036 **Effect of frequency of mixing during finishing on the growth rate, carcass characteristics, and morbidity and mortality levels of barrows and gilts reared in a commercial wean-to-finish facility.** L. Ochoa [1,*], M. Ellis [1], B. Isaacson [2], B. A. Peterson[2], *[1]Animal Sciences, University of Illinois, Urbana, [2]The Maschhoffs, Carlyle.*

The effect of frequency of mixing during finishing on the growth rate, carcass characteristics, and morbidity and mortality levels of barrows and gilts in a commercial wean-to-finish facility was investigated in a study involving 6,624 pigs (initial BW = 108.9 ± 2.01 kg). The study was carried out over a 5-wk period using a RCBD (blocking factor was day of start on test) with a 2 × 3 factorial arrangement of treatments: 1) Gender (Barrows vs. Gilts), and 2) Mixing frequency [Control (Not-mixed) vs. Pigs mixed at start of study (M1) vs. Pigs mixed at start and d 15 of study (M2)]. A total of 48 single-gender pens of 138 pigs were used. Start of test was immediately after the heaviest 10% of the pen had been removed from each pen. End of test was 5-wk later when the last group of pigs was sent for harvest (~20% of pigs from each pen were sent for harvest each week throughout the study period). The experimental unit was 2 pens of the same gender on the same mixing treatment between which pigs were exchanged. Mixing of pigs was carried out by randomly selecting 31 pigs from each pen and exchanging them between the 2 pens. Pigs were weighed at the start and end of study and every week during the study period. Pigs were harvested at a commercial plant and carcass measures were collected. There was no difference ($P > 0.05$) between genders for morbidity and mortality. Barrows had higher ADG (7.0%; $P < 0.05$), lower carcass yield (0.4 percentage units; $P < 0.05$), and lower predicted lean content (1.6 percentage units; $P < 0.05$) than gilts. Frequency of mixing had no effect ($P > 0.05$) on morbidity and mortality or carcass characteristics; however, overall ADG was lower ($P < 0.05$) for pigs mixed twice than for the other mixing frequencies (776, 753, and 703 g for Control, M1, and M2, respectively; SEM 36.7). The results of this study suggest mixing of pigs during finishing had no impact on the morbidity and mortality, however, the reduction in ADG in pigs mixed twice is of concern and needs to be verified.

Key Words: growth, mixing, pigs

P037 **Effect of live weight at mixing at the start of the finishing phase on growth rate and morbidity and mortality of barrows and gilts in a commercial wean-to-finish facility.** L. Ochoa [1,*], C. Shull [1], M. Ellis [1], B. Isaacson [2], B. A. Peterson [2], *[1]Animal Sciences, University of Illinois, Urbana, [2]The Maschhoffs, Carlyle.*

The effect of live weight at mixing at the start of the finishing phase on growth rate and morbidity and mortality of barrows and gilts in a commercial wean-to-finish facility was investigated in a study involving 6,618 pigs. The study was carried out from wk 16 (82.7 ± 10.8 kg BW) to wk 22 post-weaning (120.9 ± 11.8 kg BW) as a RCBD (blocking factor day of start on test) with a 2 × 2 × 3 factorial arrangement of treatments: 1) Gender (Barrows vs. Gilts), 2) Mixing [Control (Not-mixed) vs. Mixed at start of study], and 3) BW category (Heavy, Medium, and Light). Within pen, pigs were assigned to Heavy (heaviest 1/3 of the pen), Medium (middle 1/3 of the pen), and Light (lightest 1/3 of the pen) BW category. Within gender, mixing treatment was randomly assigned to 6 pens (3 Control and 3 Mixed). The 3 Control pens were kept intact (not-mixed) and contained all 3 BW categories. For the 3 Mixed treatment pens, pigs

of the same BW category from the 3 pens were moved into a new pen (i.e., 1 Mixed pen for each BW category). Individual pig BW was collected at the start and end of study and every 2 wk during the study period. Barrows had higher (9.6%; $P > 0.05$) overall ADG than gilts. Mixing reduced ADG (4.6%; $P < 0.05$). Overall ADG increased ($P < 0.05$) across BW category. Morbidity and mortality levels were not affected ($P > 0.05$) by Gender or Mixing; however, Light weight pigs had a higher ($P < 0.05$) incidence of morbidity and mortality than Medium or Heavy weight pigs (1.5, 1.2, and 2.9% for Heavy, Medium, and Light, respectively). These results suggest that mixing pigs in the finishing period reduced growth rates, and that Light pigs may have increased morbidity and mortality levels during the finishing period.

Key Words: live weight, mixing, pigs

P038 (GS-PHD) **Background grazing, supplementation, finishing diet and aging affect flavor in beef bottom round steaks.** K. Varnold [1,*], C. Calkins [1], R. Miller [2], G. Erickson [1], *[1]Animal Science, University of Nebraska, Lincoln, [2]Animal Science, Texas A & M University, College Station.*

The objective of this study was to determine diet and aging combinations that generate desirable beef flavor. Crossbred steers (n = 48) were grazed on warm or cool-season pastures, without or with protein supplementation from wet distillers grains with solubles (WDGS), and finished on corn diets with or without 35% WDGS (DM basis). *Biceps femoris* muscles from each carcass were aged under vacuum for 7 or 28 d. Steaks displayed under retail conditions for 7 d were used for consumer taste panels in Kansas City and Houston. Panelists (n=120 per city) rated cooked steaks for overall acceptability, overall flavor acceptability, and beefy flavor and intensity (1 = extremely dislike or extremely bland and 9 = extremely like or extremely intense). There were few differences with warm-season pasture. Beef from cattle grazed on cool-season grass without supplementation, and finished on corn (versus WDGS) had higher overall acceptability and overall flavor scores (4.96 vs 6.09 and 5.06 vs 6.01, respectively), after 7 d (but not 28 d) aging. After 28 d aging, beef from cattle grazed on cool-season grass with supplementation and fed corn (versus WDGS) had higher ($P \leq 0.01$) overall acceptability, overall flavor, and beef flavor intensity scores (6.26 vs 4.91, 6.36 vs 5.20, 6.48 vs 5.49, respectively). Beef from cattle that were grazed on cool-season grass and without supplementation had higher beef intensity scores if they were finished on WDGS rather than corn ($P = 0.05$) after 28 d aging. For cattle grazed on cool-season grass without supplementation, finishing on corn improves flavor desirability. Aging beef longer than 7 d tended to dissipate differences caused by finishing diet. When supplementing, finishing on corn instead of WDGS resulted in more desirable flavor after 28 d of aging.

Key Words: beef, diet, flavor

P039 (GS-PHD) **Investigation of protease activity in early postmortem muscle subjected to alternative chilling conditions.** D. Mohrhauser [1,*], S. Lonergan [2], E. Huff-Lonergan [2], K. Underwood[1], A. Weaver [1], *[1]Department of Animal Science, South Dakota State University, Brookings, [2]Department of Animal Science, Iowa State University, Ames.*

The objective of this study was two-fold: 1) determine the conditions (temperature, pH) that exist in early postmortem muscle of normally-chilled and delay-chilled beef carcasses to provide a model for in vitro work, and 2) determine the mechanism by which early postmortem temperature/pH conditions found in muscle influence the enzymes that regulate the aging process in vitro. For objective 1, seven market-ready calves were harvested with the right sides subjected to normal chilling (2.3°C) and the left sides subjected to ambient temperature (delay chilling; 22.6°C) for an additional 4.75 h and then allowed to normally chill. Delay-chilled carcasses had a more rapid pH decline and a slower rate of carcass cooling ($P<0.05$). No differences were observed for sarcomere length, total aerobic plate counts, or postmortem proteolysis of troponin T (TnT). WBSF was reduced in steaks from normally-chilled carcasses at 14 d ($P<0.05$), while results indicated a strong, negative correlation between 14 d WBSF and the change in pH from 6 to 12 h postmortem (r = -0.8105, $P<0.001$). These results were utilized to design the methodology for objective 2 where isolated myofibrils were subjected to µ-calpain digestion at 4 or 22°C with either a fast or slow initial pH decline. As expected, digestions with a fast initial pH decline had lower pH values in the early time points of the incubation ($P<0.05$). No differences were detected in µ-calpain activity or in the degradation of intact TnT between the fast and slow pH decline treatments; however, a temperature x time interaction was revealed in µ-calpain activity and in the degradation of intact TnT ($P<0.05$). Additionally, warmer digestions resulted in a tendency for increased activation of µ-calpain ($P<0.10$) and a significant reduction in intact TnT ($P<0.05$). Meat aging and µ-calpain activity are influenced by both temperature and pH, but more research is necessary to fully grasp their relationships.

Key Words: µ-Calpain, pH, temperature

P040 (GS-MS) **Effect of lactic acid enhancement pH on beef quality attributes of cull cow strip loins.** J. Hollenbeck*, J. Apple, J. Yancey, A. Young, C. Moon, T. Johnson, D. Galloway, *Division of Agriculture, University of Arkansas, Fayetteville.*

Strip loins from cull cows were used to test the effects of lactic acid (LA) enhancement solution pH (2.5, 3.0, 3.5) on fresh and cooked color and instrumental tenderness across the maturity scores of C, D, and E. Treatments included a non-enhanced USDA Select beef strip loin (Sel) control, non-enhanced cow (C0, D0, and E0) controls, and cow sections injected to 111% with pH 2.5 (C25, D25, and E25), 3.0 (C25, D25, and E25), or 3.5 (C35, D35, and E35) solutions made by buffering LA into 0.25% sodium bicarbonate and tap water. Post-injection, strip loin sections were vacuum-tumbled and vacuum-packaged overnight before fabrication into 3 2.5-cm-thick steaks: 1) aerobically packaged and placed into simulated retail display (4°C and 1,600 lux lighting) for 5 d; 2) vacuum-packaged and frozen (-20°C) for Warner-Bratzler shear force (WBSF) and cooked color measurement; and 3) vacuum-packaged and frozen (-20°C) for myofibril fragmentation index (MFI). Instrumental color was measured each day of display. Steaks were cooked to 71°C, evaluated for cooked color within 2 min of slicing, and cores from each steak were used to measure WBSF. Steaks enhanced at pH 2.5 had ($P < 0.01$) lower a* on d 1, 2, and 5 of display, with C25 similar to Sel. Steaks enhanced at pH 2.5 had ($P < 0.01$) lower b*, and C30, D25, D30, E25, and E30 were similar to Sel. Steaks enhanced at pH 2.5 combined ($P < 0.01$) lower cooked a* across maturities, greater ($P <0.01$) visual cooked color and greater internal doneness scores, and less calculated cooked oxymyoglobin content ($P < 0.01$; 630 nm-to-580 nm reflectance ratio), indicating a greater change from red to brown during the cooking process. There was no ($P \geq 0.16$) difference in WBSF among the treatments, but MFI values were lower

in E30 compared with C30, C35, D0, D30, D35, E0, and Sel. Results indicate that LA enhancement improved instrumental cooked color, visual cooked color, and visual internal doneness relative to cooking temperature, but only minimally effected cooked beef tenderness.

Key Words: cooked color, culls cows, post-rigor enhancement

NONRUMINANT NUTRITION: AMINO ACIDS

P041 **Effect of feeding reduced crude protein diets on nursery pig performance and feed costs.** G. Hosotani*, E. Kobashigawa, R. A. Murarolli, L. M. Gomes, M. C. Shannon, *Animal Sciences, University of Missouri, Columbia.*

Two 35-d experiments (Exp.) were conducted to investigate the effect of reducing crude protein by 2.5% and diet complexity with amino acid supplementation on performance and feed cost during the nursery phase. In Exp. 1 and 2, 32 barrows (initial wt = 7.28 ± 0.44 and 6.89 ± 0.77 kg, respectively) were weaned at 21 d and allotted to one of four dietary treatments in a completely randomized design with four replicates of each treatment with two pigs/pen. The four diets were: 1) corn-soybean meal based diet; 2) diet 1 with inclusion of fishmeal (FM) and spray-dried plasma (SDP) in Exp. 1 or soy protein concentrate (SPC) and spray-dried blood cells (SDBC) in Exp. 2; 3) low crude-protein diet (LCP) with 2.5% reduction; 4) LCP containing FM and SDP in Exp. 1 or SPC and SDBC in Exp. 2. In order to reduce CP by 2.5 %, diets were supplemented with synthetic lysine, methionine, threonine and tryptophan (Trp) in Exp. 1 and in Exp. 2, LCP diets were additionally fortified with synthetic valine (Val) and isoleucine (Ile). Blood samples were collected on d 14, 21, 28 and 35 for determining plasma urea N (PUN). Growth performance was determined weekly and by phase. Overall in Exp. 1, pigs fed corn-soybean meal based diet containing higher CP had greater ADG (P<0.01) than pigs fed LCP diet (0.51 kg/d vs 0.45 kg/d, respectively). During Phase 2 (7 to 21d), pigs fed diets containing FM and SDP had greater ADG (P<0.01) than pigs fed less complex diets (0.41 vs 0.36 kg/d, respectively). These data suggest that Val and Ile become the next limiting amino acids in LCP nursery diets. In Exp. 2, there was no effect on overall ADG, ADFI and G:F (P>0.05) when pigs were fed LCP diets. Pigs fed LCP diets had lower PUN concentrations (P<0.01) on d 14, 21, 28 and 35. In Exp. 1 and 2, pigs fed LCP diets had an average PUN concentration of 3.48 or 3.05 mg/dl, compared to pigs fed high CP diets had PUN concentration of 6.72 or 6.59 mg/dl, respectively. In Exp. 1 and 2, the nursery phase resulted in LCP diets averaging $0.03 or $0.04 more per lb/gain, respectively, compared to typical corn-soybean meal animal protein based diets. In conclusion, LCP diets can be fed to nursery pigs if Val and Ile requirements are met. However, the current cost of synthetic Trp, Val and Ile do not make these diets economical.

Key Words: crude protein, nursery pig, plasma urea nitrogen

P042 **Maximum replacement of CP with synthetic amino acids in nursery pigs.** B. E. Bass [1], T. Tsai [1,*], M. D. Hanigan [2], J. K. Apple[1], R. Ulrich [3], J. S. Radcliffe [4], B. T. Richert [4], G. Thoma [3], J. S. Popp [5], C. V. Maxwell [1], *[1]Animal Science, University of Arkansas, Fayetteville, [2]Dairy Science, Virginia Polytechnic Institute and State University, Blacksburg, [3]Chemical Engineering, University of Arkansas, Fayetteville, [4]Animal Science, Purdue University, West Lafayette, [5]Agriculture Economics & Agribusiness, University of Arkansas, Fayetteville.*

Weaned pigs (n=320) were blocked within gender by initial BW (6.51 ± 0.37 kg) and allotted to gender-balanced pens in a wean-to-finish facility (8 pigs/pen) to evaluate maximum replacement of CP with synthetic AA. Within blocks, pens were randomly assigned to 1 of 5 dietary treatments during nursery phases 1 (10 d), 2 (14 d) and 3 (14 d). Diets were formulated to maintain constant ME and SID Lys across treatments. For each phase, control (Ctrl) diets were devoid of synthetic AA, whereas Lys-HCl was added in equal increments (0.19, 0.38, 0.57, and 0.76% in phase1; 0.22, 0.44, 0.66, and 0.88% in phase 2; 0.25, 0.50, 0.75, and 1.00% in phase 3) at the expense of CP (SBM, fish meal [FM], and poultry meal [PM] in phase 1, FM and PM in phase 2, and SBM in phase 3). In phase 1, ADG, G:F, and BW were improved 27%, 12%, and 5% (quadratic, P<0.01) in pigs fed lower inclusions of Lys compared to Ctrl, but similar in pigs fed the 0.76% Lys. In phase 2, ADG, ADFI, and BW were increased 11%, 18%, and 8% (quadratic, P<0.01) in pigs fed lower inclusion levels of Lys than Ctrl-fed pigs, but similar in pigs fed the highest (0.88%) inclusion. Again, ADFI, ADG, and BW were 13%, 7%, and 7% better (quadratic, P<0.01) during phase 3 in pigs fed lower Lys inclusion levels compared to Ctrl, whereas ADG, and BW declined at 1.00% added Lys. Moreover, G:F decreased (linear, P<0.01) as Lys increased in phase 3 diets. Results suggest that 0.56 and 0.67% Lys can replace 19.0% CP in phase 1 and 24.5% CP in phase 2 nursery diets, respectively, without negatively impacting performance; however, ADG, ADFI, and BW were not affected in phase 3 at 0.75% Lys (29.6% reduction in CP), G:F decreased with increasing added Lys.

Key Words: CP, L-lysine HCL, nursery pigs

P043 **Amino acid digestibility by growing pigs in distillers dried grains with solubles with conventional, medium, or low concentrations of fat.** S. Curry*, D. Navarro, F. Almeida, H. Stein, *Animal Science, University of Illinois, Urbana.*

The objective of this experiment was to determine the standardized ileal digestibility of AA in 3 sources of DDGS with different concentrations of fat. Twelve growing barrows (initial BW: 76.1 ± 6.2 kg) were randomly allotted to a replicated 6 × 4 Youden square design with 6 diets and 4 periods. Three diets contained 60% DDGS with conventional (9.9%), medium (8.1%), or low (6.6%) concentrations of fat were formulated and contained 5.9, 4.9, and 4.0% fat, respectively. Two additional diets containing the low or the medium fat DDGS were also formulated, but corn oil was added to these diets to bring the concentration of fat in the diets to the same level as in the diet with the conventional DDGS (i.e., 5.9%). A N-free diet was also formulated to measure endogenous losses of AA in the pigs. Pigs were fed experimental diets for four 7-d periods and ileal digesta were collected on d 6 and 7 of each period. The standardized ileal digestibility (**SID**) of CP and all indispensable AA, except Trp, was greater (P < 0.01) in conventional DDGS than in the medium fat and low fat DDGS (Table 1). Adding oil to the diets containing the medium fat and low fat DDGS did not consistently increase the SID of AA. In conclusion, conventional DDGS has greater SID values for most AA compared with medium fat and low fat DDGS and addition of oil to diets containing medium fat or low fat DDGS does not ameliorate this reduction. (See table on the next page.)

Table 1. Standardized ileal digestibility of amino acids (%) in DDGS with conventional (9.9%), medium (8.1%), or low (6.6%) concentration of fat

Item	DDGS source					SEM	P-value
	Conventional	Medium fat	Low fat	Medium fat	Low fat		
Diet fat, %	5.9	4.9	4.0	5.9	5.9		
Ile	79.8^{a}	72.9^{bc}	73.1^{bc}	75.2^{b}	71.9^{c}	0.94	<0.01
Lys	67.9^{a}	56.4^{c}	61.7^{b}	62.6^{b}	57.3^{c}	1.90	<0.01
Met	88.1^{a}	84.8^{bc}	83.6^{c}	85.8^{b}	85.0^{bc}	0.67	<0.01
Cys	76.0^{a}	67.3^{c}	68.8^{bc}	70.9^{b}	67.3^{c}	1.59	<0.01
Thr	73.4^{a}	66.9^{c}	68.2^{bc}	70.4^{b}	68.2^{bc}	1.29	<0.01
Trp	83.1^{a}	77.8^{c}	81.1^{ab}	81.0^{abc}	78.0^{bc}	1.21	<0.05
Val	80.5^{a}	74.2^{bc}	74.6^{bc}	75.9^{b}	73.0^{c}	0.95	<0.01

Key Words: amino acid digestibility, distillers dried grains with solubles, pigs

P044 **Amino acid and organic matter digestibility in six distillers dried grains with solubles samples fed to growing pigs.** K. de Ridder[1,*], P. McEwen[1], C. de Lange[1], I. Mandell[1], R. Lackey[2], *[1]Animal and Poultry Science, University of Guelph, [2]Ontario Ministry of Agriculture Food and Rural Affairs, Stratford, Canada.*

Distillers dried grains with solubles (DDGS) has variable nutritional value for pigs. A digestibility study was conducted to determine standardized ileal digestibility (SID) of amino acids (AA), as well as apparent fecal and ileal digestibility of organic matter (OM), in 6 different DDGS samples that were selected based on colour (Minolta L-value 47.7 to 62.3). Eleven pigs (initial BW 31±3.3 kg) were surgically fitted with a T-cannula in the distal ileum and used during 4 subsequent periods. In periods 1 and 2, samples 1 to 3 were evaluated; in periods 3 and 4, samples 4 to 6 were evaluated. Samples were assigned to pigs based on two consecutive crossover designs with 4 or 5 observations per sample. DDGS diets contained 65.7% DDGS, starch, sugar, vitamins and minerals. An N-free diet was used in all periods (n=9) to determine basal endogenous ileal AA losses for calculating AA SID. Each period included 6 d adaptation followed by 3 d fecal collection periods; ileal digesta was then collected 8 h on each of 2 consecutive days. Titanium was used as marker to determine nutrient digestibility. Across samples there was considerable variation in AA SID (mean ± SD across sample means, %): CP 77.0±5.2, lysine 69.8±7.0, threonine 74.8±5.4, methionine 85.4±3.2, and tryptophan 70.5±6.1. Similarly, fecal and ileal OM digestibility were 81.4±2.9 and 62.6±4.7, respectively. Diets with DDGS contained 1.18 to 3.45 ppm deoxynivalenol, which appeared positively correlated with SID of Lys (R^2=0.71). There was no correlation between color and AA or OM digestibility (P>0.10). In these DDGS samples colour was not a good predictor of AA and OM digestibility. Alternative quality control measures are needed to routinely asses the nutritional value of DDGS samples.

Key Words: amino acids, DDGS, ileal digestibility

P045 **Predicting standardized ileal digestibility of dietary amino acids in pigs: A meta-analysis.** F. Messad[1,*], E. Charbonneau[1], M.-P. Létourneau-Montminy[2], F. Guay[1], *[1]Department of Animal Science, Laval University, Quebec, [2]Agriculture and Agri-Food Canada, Dairy and Swine Research and Development Centre, Sherbrooke, Canada.*

Meals, an important source of amino acids (AA), constitute the second class of the most important ingredient in swine feeding after cereals. However, the accurate use of these ingredients requires a precise knowledge of the standardized ileal digestibility (SID) of AA, which may vary depending on its origin. A meta-analysis was performed to propose prediction models of the SID of dietary AA, taking into account major chemical composition such as their crude protein, total AA, gross energy and, fiber (NDF, ADF) concentrations. A database of 47 references (224 treatments) was built. The type of meals (soybean, cotton, colza and sunflower), surgical procedures (T-canula, anastomosis), animal gender, meals processing (eg.. solvent extraction, extrusion, roasting and expeller extraction) and physiological stage (piglets early post weaning: 5-10 kg BW, piglets post weaning: 10-25 kg BW, growing pigs: 25-60 kg BW, finishing pigs: > 60kg BW, gestating or lactating sows) were included in each model. For each AA, a particular attention was given to the relationship between independent variables to avoid colinearity. Then, between and within experiment responses of SID AA to the main covariates were performed to choose the right statistical model. For this project, studies were considered as fixed factors in the models. Several models have been developed to predict the SID of dietary Lys, Met, Thr, Trp and Val. Results showed that neither the gender, nor meals processing, nor physiological stage seems to modify SID. After analysis, it was found that the NDF was the best predictor of SID [Lys:R^2 adj =92.14, Met:R^2 adj = 83.87, Thr:R^2 adj = 75.52,Trp:R^2 adj = 85.47 and Val:R^2 adj = 87.77]. This study is the first step of a large program to develop a predictive tool to improve feed formulation in pigs.

Key Words: meta-analysis, amino acids, pigs, standardized ileal digestibility

P046 **Evaluation of three models of digestible lysine requirements applied to two genetic populations of pigs.** M. S. S. Ferreira[1, 2,*], A. P. Schinckel[3], [1]CAP*ES Foundation scholar process n° 8944-11-3, Brazilia, [2]Veterinary Medicine, Federal University of Lavras, Brazil, [3]Animal Science, Purdue University, West Lafayette.*

Swine growth models are used to predict the nutrient requirements, feed costs and economic returns of different genetic populations of pigs. Pigs selected for increased carcass lean percentage and feed efficiency have increased daily lysine requirements. The objectives of this study were to compare predicted lysine requirements of three different models, and to evaluate if relative differences in predicted lysine requirements for each model are similar for barrows and gilts of two genetic populations of pigs, high-lean (HLG) and low-lean gain (LLG). Data from a previous study (Wiseman et al., 2007; JAS 85:1825-1835), which 2 genetic populations of barrows and gilts were used to estimate chemical compositional growth from 25 to 125 kg of BW, were used to predict daily digestible lysine requirements. Two models, SCH03 (Schinckel et al., 2003. JAS 81:1106-1119) and NRC 1998 (NRC98), use constant estimates of the lysine utilization efficiency (EFF) for protein deposition, meanwhile NRC 2012 (NRC12) model predicted that the EFF values decreased with increased BW. Also, the NRC12 model predicted greater digestible lysine required for maintenance based on recent research results. The models predicted that HLG pigs had similar greater overall predicted lysine:NE ratios than LLG pigs. The greatest differences between the models predicted digestible lysine requirements were after 75 Kg BW. The differences increased at 100 kg (17.17 vs. 15.43 and 14.11 g/d) and 125 kg BW (18.69 vs. 16.16 and 14.78 g/d for the NRC12, NRC98, and SCH03 models, respectively). The NRC12 model predicted 6.5 and 16.7 % greater total SID lysine was required from 25 to 125 kg BW than the NRC98

and SCH03, respectively. The models predicted similar differences in lysine requirements for the four groups of pigs. The NRC12 model predicted greater daily lysine requirements than the previous models after 75 kg BW. Additional research on the change in EFF above 75 kg BW and the relationship of population wide EFF to the magnitude of between-pig variation should be considered.

Key Words: growth models, lysine requirements, pigs

NONRUMINANT NUTRITION: INGREDIENTS AND FEED ADDITIVES

P047 **The effects of phytogenics on the growth performance, nutrient digestibility, blood profiles, intestinal microflora, meat color and relative organ weight after oral challenge with Clostridium perfringens in broilers.** H. L. Li [1], S. Eng Kian [2], I. H. Kim [1,*], [1]*Department of Animal Resource & Science, Dankook University, Cheonan, Republic of Korea,* [2]*Delacon Biotechnik Ges.m.b.H., Steyregg, Austria.*

A total of 405 ROSS 308 broilers with a BW of 42 ± 1g (1 d of age) were used in a 35-day trial to investigate the effects of phytogenics containing essential oils of thyme and star anise as lead active components on growth performance, nutrient digestibility, blood profiles, intestinal microflora, meat color and relative organ weight after oral challenge with *Clostridium perfringens*. Broilers were randomly assigned to 1 of 3 treatments (9 replicate pens per treatment with 15 broilers per pen). Dietary treatments were: CON, control diet; ANT, CON + 10 mg/kg avilamycin; PFA, CON + 250 mg/kg phytogenics. Broilers were oral challenged with 5 ml *Clostridium perfringens* (10^7cfu/ml) culture suspensions on d 21, 22 and 23. The PFA treatment improved (P<0.05) body weight gain (BWG) and F/G than CON and ANT treatments during d 22 to 35 and overall period (1 to 35 d). The mortality was lower (P<0.05) in PFA and ANT treatments than CON treatment. The broilers fed PFA diet had higher (P<0.05) apparent total tract digestibility of DM, N, energy, crude fat, and calcium at 21 d, and higher (P<0.05) calcium digestibility at 35 d than those fed CON and ANT diets, respectively. At d 35, PFA treatment reduced (P<0.05) the total serum cholesterol content and increased (P<0.05) high density cholesterol concentration compared with CON and ANT treatments. Populations of (P<0.05) *Clostridium perfringens* and *Escherichia coli* (*E. coli*) in small and large intestine were reduced in PFA treatment compared with CON treatment. The lesion score of small intestine was also lowered (P<0.05) by ANT and PFA treatments than CON treatment. In conclusion, dietary supplementation with 250 mg/kg phytogenics could improve growth performance, reduce mortality and blood cholesterol, and inhibit *Clostridium perfringens* and *E. coli* proliferation in small and large intestines in broilers after oral *Clostridium perfringens* challenge.

Key Words: broilers, *clostridium perfringens*, growth performance

P048 **The effect of phytogenics on the growth performance, nutrient digestibility, noxious gas emission, meat grade and quality in growing-finishing pigs fed with different energy density diets.** H. Y. Baek [1], S. Eng Kian [2], I. H. Kim [1,*], [1]*Department of Animal Resource & Science, Dankook University, Cheonan, Republic of Korea,* [2]*Delacon Biotechnik Ges.m.b.H., Steyregg, Austria.*

A total of 144 crossbred pigs [(Yorkshire × Landrace) × Duroc)] with an initial BW of 29.69 ± 2.57 kg were used in a 16-wk trial to evaluate the effects of phytogenics supplementation in different energy density diets on growth performance, nutrient digestibility, fecal noxious gas emission, meat quality and carcass grade. Pigs were randomly distributed into 1 of 4 dietary treatments on the basis of BW and gender. Each treatment had 9 replicate pens with 4 pigs per pen. Treatments were as follows: LE, low energy basal diet (Grower: 3341; finisher: 3350 kcal ME/kg); LEA, LE + 100 ppm phytogenics; HE, high energy basal diet (Grower: 3446; finisher: 3440 kcal ME/kg); HEA, HE + 100 ppm phytogenics. The constituents of phytogenics are a blend of thyme, rosemary, oreganum extracts and a special combination of saponins. During 1 to 6 wk, pigs fed the LE and LEA diets had greater (P<0.05) ADFI than those fed the HEA diet. HEA treatment had higher (P<0.05) G:F ratio than those in LE and LEA treatments. During 7 to 12 wk, pigs fed the HEA diet had a lower (P<0.05) ADFI than those fed the LE diet. During 13 to 16 wk, HEA treatment had a higher (P<0.05) ADG than that in LE treatment. Overall, the ADFI was decreased (P<0.05) in HEA treatment compared with LE and HE treatments. The G/F was higher (P<0.05) in HEA than that in LE treatment. The ATTD of energy and N was increased (P<0.05) in HEA treatment compared with LE treatment at wk 6 and wk 12, respectively. The ATTD of N in LEA treatment was higher (P<0.05) than that in LE treatment at wk 16. Meat pH values of pigs fed the LEA and HEA diets were higher (P<0.05) than those fed the LE diet. The a* value in HEA and LE treatments was higher P<0.05) than that in LEA treatment. In conclusion, dietary inclusion of 100 ppm phytogenics in high energy level diet improved the feed efficiency, the nutrient digestibility and meat quality in growing-finishing pigs.

Key Words: growing-finishing pigs, growth performance, phytogenics

P049 **The effects of phytogenics on growth performance, fecal score, blood profiles, fecal noxious gas emission, nutrient digestibility, intestinal morphology in weanling pigs challenged with Escherichia coli K88.** J. W. Park [1], S. Eng Kian [2], I. H. Kim [1,*], [1]*Department of Animal Resource & Science, Dankook University, Cheonan, Republic of Korea,* [2]*Delacon Biotechnik Ges.m.b.H., Steyregg, Austria.*

A total of 120 crossbred pigs [(Yorkshire × Landrace) × Duroc)] with an initial BW of 6.09 ± 0.96 kg (21 d of age) were used in a 6-wk trial to evaluate the effects of phytogenics on growth performance, fecal score, blood profiles, fecal noxious gas emission and intestinal morphology in weanling pigs challenged with *Escherichia coli (E. coli)* K88. Pigs were randomly distributed into 1 of 4 dietary treatments. Treatments were as follows: T1, negative control (without antibiotics); T2, T1 + antibiotic (150 ppm apramycin at Phase 1, 39 ppm tiamulin at Phase 2 and Phase 3); T3, T1 + 0.05% phytogenics; T4, T1 + 0.2% commercial mix of organic acids. Phytogenics is based on a combination of essential oils and high value herbal substances. Each treatment had 6 replicate pens with 5 pigs per pen. Overall, pigs fed the T3 diet had greater (P<0.05) ADG than those fed the T1 and T4 diets. The apparent total tract digestibility (ATTD) of DM was increased (P<0.05) in T4 treatment compared with that in T1 treatment at wk 1 and 3. The ATTD of ash in T3 and T4 treatments was greater (P<0.05) than that in T2 treatment at wk 1. The ATTD of ash and Ca was increased (P<0.05) in T4 treatment compared with T1 treatment at wk 3. Pigs fed the T3 diet had a higher (P<0.05) ATTD of P than those fed the T1 and T4 diets. No difference (P>0.05) was observed in blood profiles throughout the experimental period. The fecal NH_3, total mercaptans, H_2S and acetic

acid emission were not affected (P>0.05) by dietary phytogenics. The duodenum villi height, crypt depth and villi/crypt ratio did not differ (P>0.05) among treatment groups after *E.coli* K88 challenge. Results indicated that 0.05% phytogenics could improve the ADG and might be used as an alternative to antibiotic in weanling pigs.

Key Words: growth performance, phytogenics, weanling pigs

P050 **The effects of phytogenics on egg production, egg quality, excreta microbiota, noxious gas emission, and nutrient digestibility in laying hens with different nutrient density diets.** J. P. Lee [1], S. Eng Kian [2], I. H. Kim [1,*], *[1]Department of Animal Resource & Science, Dankook University, Cheonan, Republic of Korea [2]Delacon Biotechnik Ges.m.b.H., Steyregg, Austria.*

A total of 240 50-week-old Hy-line laying hens were used to evaluate the effects of phytogenics inclusion in different nutrient density diets on performance. Layers were randomly assigned to 1 of 4 treatments for 20 weeks (12 birds/cage, 5 cages/treatment). Dietary treatments were: 1) T1, basal diet; 2) T2, T1 (beef tallow from 7.28% to 7.265%) + 150 ppm phytogenics (blending Quillaja 30%, Anise 20% and Thyme 17%); 3) T3, T1 (Ca from 3.790% to 3.718%, P from 0.800% to 0.732%) + 150 ppm phytogenics; 4) T4, T1 (Ca from 3.790% to 3.718%, P from 0.800% to 0.732%, protein from 16.20% to 15.73%, energy from 2780 kcal/kg to 2748 kcal/kg) + 150 ppm phytogenics. Thirty eggs except soft and broken eggs were selected for analyzing egg quality. Excreta microbiota and gas emission were measured at the beginning and end of experiment. Nutrient digestibility was measured every 5 weeks following the procedures by the AOAC (2000). Overall, ADFI was higher (P<0.05) in T3 and T4 than T1 and T2 (112 vs. 115 vs. 108 vs. 108 g). Egg weight in T2 and T3 was higher (P<0.05) than T1 (63.12 vs. 62.95 vs.61.02 g) through the experiment. Yolk color in T2 and T4 was higher (P<0.05) than that in T3 (8.95 vs. 9.00 vs.8.65) at wk 15. Yolk height in T4 was higher (P<0.05) than that in T1 (8.38 vs. 7.67) at wk 20. Fecal NH_3 emission was decreased (P<0.05) in T3 and T4 compared with T1 and T2 (14.2 vs. 16.4 vs. 64.6 vs. 39.2 ppm) at wk 20. The apparent total tract digestibility (ATTD) of DM in T1 and T3 was higher (P<0.05) than that in T2 (74.24 vs. 73.97 vs. 72.93%) at wk 10, and the ATTD of Ca in T4 was higher (P<0.05) than that in T1 (58.45 vs. 52.86%). T2 and T4 had greater (P<0.05) ATTD of P compared with T1 and T3 (47.59 vs. 48.53 vs. 42.05 vs. 43.12%) at wk 15. At the end of 20th wk, T3 had the highest (P<0.05) ATTD of P than that in T1, T2 and t4 (48.90 vs. 46.08 vs. 41.08 vs. 44.12%). In conclusion, dietary supplementation of 150 ppm phytogenics increased egg production, feed intake and reduced NH_3 emission. There were no negative effects under lowered nutrient density condition with phytogenics in laying hens.

Key Words: egg quality, laying hens, phytogenics

P051 **Effects of 25-hydroxycholecalciferol on growth performance, skeletal integrity, and intestinal transporter gene expression in growing pigs.** A. Regassa*, R. Adhikari, J.-M. Heo, M. Nyachoti, W. K. Kim, *Animal Science, University of Manitoba, Winnipeg, Canada.*

A study was conducted to examine the effects of 25-(OH) vitamin D3 on performance, skeletal integrity and expression of intestinal transporter genes. A total of 24 sixty-day-old gilts with an average initial BW of 23.13 ± 1.39 kg were randomly allocated to one of three treatments: 1) Control (C) , 2) C+50 µg/kg of 25-(OH) vitamin D3, and 3) C+100 µg/kg 25-(OH) vitamin D3. The control diet contained 0.6% Ca and 0.23% available P. The experiment was conducted for 42 days and body weight gain and feed intake were measured weekly. At the end of the experimental period, animals were slaughtered to collect bone and intestinal samples for analysis of skeletal integrity and expression of calcium and phosphate transporter genes using Dual Energy X-Ray Absortiometry (DEXA) and real-time polymerase chain reaction (RT-PCR), respectively. Dietary inclusion of 25-(OH) vitamin D3 had no effect on average daily feed intake, average daily gain, and feed efficiency. Similarly, measures of bone strength such as bone mineral content, bone mineral density, and bone area were not affected by dietary treatments. However, the mRNA expressions of calcium binding protein (CaBP), intestinal calcium channel (TRVP6) and sodium dependent phosphate transporter 2 (SLC34A2) were improved by 78, 55 and 59%, respectively, in the 100 µg/kg of 25-(OH) vitamin D3 group and by 37, 33 and 69% in the 50 µg/kg 25-(OH) vitamin D3 group compared to the control group. The expression of SLC34A2 mRNA in the 50 and 100 µg/kg of 25-(OH) vitamin D3 treatments was significantly higher than in the control (P=0.486). In conclusion, supplementation of two levels of 25-(OH) vitamin D3 improved the expression of Ca and P transporter genes without affecting the measures of skeletal integrity and growth performance in growing pig fed diet with adequate levels of Ca and P. Thus, further research is essential to investigate the effects of different levels of 25-(OH) vitamin D3 in low Ca and P diets on growth performance, bone development, skeletal integrity, and intestinal nutrient transporter gene expression in different ages and genders of pigs.

Key Words: 25-hydroxycholecalciferol, skeletal integrity, calcium binding protein, intestinal calcium channel, sodium dependent phosphate transporter, dual energy X-ray absortiometry, gilts

P052 **Dietary plant extracts altered gene expression profile in alveolar macrophages of weaned pigs experimentally infected with PRRSv.** Y. Liu [1,*], J. J. Lee [1], M. Song [1], T. M. Che [1], J. A. S. Almeida [1], D. Bravo [2], W. G. Van Alstine [3], J. E. Pettigrew [1], *[1]Animal Sciences, University of Illinois, Urbana, [2]Pancosma SA, Geneva, Switzerland, [3]Purdue University, West Lafayette.*

This study was conducted to characterize the effects of 3 plant extracts on gene expression of alveolar macrophages (AM) in weaned pigs experimentally infected with PRRSv. Weaned pigs (n = 32, 7.8 kg BW) were housed in individual pens for 28 d: 14 d before and after the inoculation (d 0). Treatments were in a 2 × 4 factorial arrangement: with or without a PRRSv challenge (intranasal, 10^5 50% tissue culture infective dose) and 4 diets (control diet (CON), 10 ppm of garlicon (GAR), capsicum (CAP) or turmeric oleoresin (TUR)). Total RNA (n = 4) was extracted from AM of pigs at d 14. Double-stranded cDNA was amplified, labeled, and further hybridized to the Affymetrix GeneChip Genome Array. Microarray data were analyzed in R using packages from the Bioconductor project and in DAVID Bioinformatics Resources. Pairwise comparisons were analyzed for the 4 different comparisons of interest. Quantitative real time PCR was applied to verify the expression detected by microarray. With fold-change cutoff of 0.5, PRRSv infection altered (P < 0.05) the expression of 1352 genes in pigs fed the CON (755 up, 597 down). Compared with the infected CON, feeding CAP, GAR, or TUR altered the expression of 46 genes (24 up, 22 down), 134 genes (59 up, 75 down), or 98 genes (55 up, 43 down), respectively. The PRRSv infection up-regulated (P < 0.05) the expression of genes related to immune system process, response to stimulus, cell cycle, cytokine activity and chemokine activity, but down-regulated (P < 0.05) the expression of genes involved in signal transduction and innate immune

responses. Compared with the infected CON, feeding CAP increased ($P < 0.05$) the expression of genes related to antigen processing and presentation, but decreased ($P < 0.05$) the expression of genes related to apoptosis, feeding GAR up-regulated ($P < 0.05$) the expression of genes involved in cell cycle and DNA repair, and feeding GAR and TUR down-regulated ($P < 0.05$) the expression of genes in immune response and antigen processing and presentation. In conclusion, plant extracts regulated the expression of genes in AM of PRRSv-infected pigs, especially altering the immune system.

Key Words: plant extracts, PRRSv, weaned pigs

P053 **Effects of plant extracts on gene expression profiles of alveolar macrophages of weaned pigs.** Y. Liu [1,*], J. J. Lee [1], M. Song[1], T. M. Che [1], J. A. S. Almeida [1], D. Bravo [2], W. G. Van Alstine [3], J. E. Pettigrew [1], *[1]Animal Sciences, University of Illinois, Urbana, [2]Pancosma SA., Geneva, Switzerland, [3]Purdue University, West Lafayette.*

This study was conducted to characterize the effects of 3 plant extracts on gene expression of alveolar macrophages (AM) in weaned pigs. Weaned pigs (n = 16, 7.8 kg BW) were housed in individual pens for 28 d and fed 4 diets: a nursery basal diet (CON), 10 ppm of garlicon (GAR), capsicum (CAP) or turmeric (TUR) oleoresin. Total RNA (n = 4) was extracted from AM of pigs at d 28. Double-stranded cDNA was amplified, labeled, and further hybridized to the Affymetrix GeneChip Genome Array. Microarray data were analyzed in R using packages from the Bioconductor project. Differential gene expression was tested by fitting a mixed linear model equivalent to a ANOVA using the limma package. Bioinformatics analysis was conducted by DAVID Bioinformatics Resources. Pairwise comparisons were analyzed for 3 comparisons of interest. Quantitative real time PCR was applied to verify the expression detected by microarray and showed similar patterns when compared with the original microarray data. The modulated genes were defined by 1.5 fold change and a cut-off of $P < 0.05$ by parameter tests. Compared with the CON, feeding CAP, GAR, and TUR altered the expression of 47 genes (19 up, 28 down), 36 (15 up, 21 down), and 85 (13 up, and 72 down), respectively. The supplementation of CAP up-regulated ($P < 0.05$) the expression of genes related to the cytokine-cytokine receptor interaction and cell surface receptor linked signal transduction, but down-regulated ($P < 0.05$) protein catabolic process, macromolecule metabolic process, GnRH signaling pathway, and ubiquitin mediated proteolysis. Feeding GAR increased ($P < 0.05$) the expression of genes involved in transport and localization, but decreased ($P < 0.05$) the expression of genes involved in zinc ion binding, protein metabolic process, and TGF-beta signaling pathway. Feeding TUR enhanced ($P < 0.05$) the expression level of genes associated with active transmembrane transporter activity, but reduced ($P < 0.05$) the expression of genes related to transition metal ion binding, viral myocarditis, and antigen processing and presentation of peptide antigen via MHC I. In conclusion, plant extracts regulated the expression of genes in AM of pigs.

Key Words: gene expression, plant extracts, weaned pigs

P054 **Effects of fructan supplementation on growth performance, nutrient digestibility, blood profiles, fecal noxious gas content, and fecal microflora in growing pigs.** J. H. Jung, S. M. Hong, I. H. Kim*, *Department of Animal Resource & Science, Dankook University, Cheonan, Republic of Korea.*

A total of 80 growing pigs [(Landrace × Yorkshire) × Duroc, BW = 27.11 ± 0.97 kg] were used in a 42-d trial to evaluate the effects of fructan on growth performance, nutrient digestibility, blood profiles, fecal noxious gas content, and fecal microflora. Pigs were randomly distributed into 1 of 4 dietary treatments, and each treatment had 5 replicate pens with 4 pigs per pen (two barrows and two gilts). Dietary treatments were: CON, control diet; FR1, CON + 0.05% fructan; FR2, CON + 0.10% fructan; FR3, CON + 0.20% fructan. At the end of experiment, nutrient digestibility was measured following the procedures by the AOAC (2000), IgG, WBC, RBC and lymphocyte levels were assessed using an automatic biochemistry analyzer (HITACHI 747, Japan), and fecal *Lactobacillus* and *E. coli* shedding were measured by using MacConkey agar plates and *lactobacilli* medium III agar plates. Pigs fed FR2 diet had a higher ($P<0.05$) ADG than those fed CON diet (612 vs. 552 g). The G/F ratio was decreased ($P<0.05$) in FR3 treatment compared with other treatments (0.362 vs. 0.379 or 0.376 or 0.391). No effect ($P>0.05$) was observed in ADFI among dietary treatments. The apparent total tract digestibility (ATTD) of dry matter (DM) (67.65 vs. 76.38 or 75.13 or 79.10%) and energy (65.95 vs. 78.86 or 74.51 or 77.97%) was decreased ($P<0.05$) in FR1 treatment compared with CON, FR2 and FR3, while pigs fed the FR2 and FR3 diets had higher (75.91 or 77.28 vs. 69.14%; $P<0.05$) ATTD of nitrogen (N) than those fed the FR1 diet. No differences ($P>0.05$) were observed in red blood cell (RBC), white blood cell (WBC), immunoglobulin G (IgG) concentrations, and lymphocyte percentage among treatments at the end of the experiment. FR1 and FR3 treatments had higher (7.26 or 7.30 vs. 6.93, $\log_{10}$cfu/g; $P<0.05$) fecal *Lactobacillus* counts than that in CON treatment. Fecal *E.coli* counts were unaffected ($P>0.05$) by dietary treatments. In conclusion, results indicated that inclusion of 0.10% fructan improved ADG (10.9%), inclusion of 0.05% fructan decreased nutrient digestibility and increased fecal *Lactobacillus* number (4.8%), and inclusion of 0.20% fructan decreased G/F ratio (4.5%) and increased fecal *lactobacillus* number (5.3%).

Key Words: fructan, growing pig, growth performance

P055 **The effects of a novel *Lactobacillus acidophilus* fermentation product on growth performance and fecal bacteria in 5 to 14 kg pigs.** E. D. Frugé[1,*], E. L. Hansen[1], S. A. Hansen[1], K. A. Frerichs[1], C. W. Hastad[2], M. Scott[3], J. W. Frank[3], A. Brainard[3], *[1]Hubbard Feeds, Mankato, [2]New Fashion Pork, Jackson, [3]Diamond V, Cedar Rapids.*

An experiment was conducted to determine the effects of lactobacillus acidophilus fermentation product (LAFP) and four other dietary gut modifiers on growth performance and fecal concentrations of *Bifidobacteria* (BB) and *Lactobacillus* (LB). Pigs (N = 1008) were allotted to 6 dietary treatments (TRT) with 6 replicates and 28 pigs/pen in a randomized complete block design. Experimental TRT were: 1) Negative control (NC); 2) NC + yeast cell wall/hydrolyzed whole yeast; 3) NC + live *Saccharomyces cerevisiae*; 4) NC + Inulin; 5) NC + *Saccharomyces cerevisiae* fermentation product; 6) NC + LAFP. The NC diet contained 3000 ppm Zn, 200 ppm Cu, dried *Bacillus subtillis/lichenformis* fermentation product, dietary acidifier and an antibiotic. Pig weights and feed disappearance were measured on d 0, 8, 15, and 22. Fresh fecal samples were collected on d 8 and 15 from each pen for PCR analysis of BB and LB. Overall (d 0 to d 22), there were no significant differences between TRT for ADG, ADFI, and total BW gain. Pigs fed TRT 2, 3, 4, 5, and 6 had improved G:F compared to pigs fed TRT 1 ($P < 0.05$). Fecal BB and LB was highest for pigs fed TRT 6 compared with TRT 1, 2, and 5, with TRT 3 and 4 intermediate on d 15. Greater concentrations of BB and LB indicate a more favorable enteric environment for pigs fed LAFP. (See table on the next page.)

Table. 1. Growth performance and fecal PCR analysis.[1]

TRT	1	2	3	4	5	6	SEM	P <
d 0 BW, kg	5.5	5.5	5.5	5.5	5.5	5.5	0.03	1.0
ADG, g	387	405	408	404	402	423	11.73	0.47
ADFI, g	436	441	443	437	439	459	13.45	0.85
G:F	0.89[b]	0.92[a]	0.92[a]	0.93[a]	0.92[a]	0.92[a]	0.009	0.05
d 22 BW, kg	14.2	14.6	14.7	14.6	14.6	15.0	0.27	0.50
Fecal bacteria[2]								
d 8								
BB	1	2.20	1.24	2.08	0.81	1.01	.0012	0.80
LB	1	3.31	1.07	2.14	2.79	1.44	.0004	0.78
d 15								
BB	1[b]	1.23[b]	3.61[ab]	2.91[ab]	1.39[b]	10.05[a]	.0018	0.02
LB	1[b]	0.77[b]	0.69[b]	2.27[ab]	1.20[b]	4.93[a]	.0001	0.01

[1ab] Within a row, means without common superscript differ (P < 0.05).
[2]Means expressed as fold change vs. TRT 1.

Key Words: lactobacillus, nursery, pigs

P056 **The interactive effects of a non-starch polysaccharide enzyme and phytase in diets with high-fiber co-products on growth performance of nursery pigs.** *A. B. Graham*, J. M. DeRouchey, M. D. Tokach, R. D. Goodband, S. S. Dritz, S. Nitikanchana, J. L. Nelssen, Kansas State University, Manhattan.*

Two experiments were conducted to determine the effects of a dietary non-starch polysaccharide enzyme (NSP; Easyzyme, ADM, Decatur, IL) and/or phytase (Phyzyme, Danisco Animal Nutrition, St. Louis, MO) addition in corn-soybean meal or high-fiber diets on nursery pig performance. In Exp. 1, 192 pigs (9.9 kg BW) were allotted to 1 of 4 dietary treatments arranged in a 2×2 factorial. Main effects were diet type (corn-soybean meal; CS, or corn-soybean meal plus 30% wheat middlings; CSM) with or without 0.05% NSP enzyme. From d 0 to 21, pigs fed CS diets had greater (P<0.001) ADG than those fed CSM diets (546 vs. 503 g/d). Added NSP enzyme had no effect on ADG (525 vs. 525 g/d). In CS diets, NSP enzyme had no effect on ADFI or G:F, whereas in CSM diets, NSP enzyme increased ADFI and decreased G:F (interaction P<0.03). In Exp. 2 (see table), 350 pigs (11.6 kg BW) were allotted to 1 of 7 dietary treatments arranged in a 2×3 factorial plus control. Pigs were fed either a CS diet with no NSP enzyme or phytase or 1 of 6 diets containing 10% wheat midds, 10% hominy, and 10% corn germ meal with or without NSP enzyme and 0, 500, or 1,200 FTU/kg phytase. Available P was formulated to the pig's requirement before adding phytase to determine if phytase affected the digestibility of other nutrients that might enhance growth performance. Pigs fed the CS diet had greater ADG, and G:F than pigs fed co-product-based diets. Added NSP enzyme had no effect on ADG and ADFI, but decreased G:F. Increasing phytase had no effect on ADG, ADFI, or G:F. These results suggest that adding high-fiber co-products to diets decreased ADG and G:F compared with CS diets. Added NSP enzyme or high concentrations of phytase in diets adequate in P had no positive effects on growth performance.

Exp. 2

	Corn-soy diet	Co- product diet						
NSP enzyme:	-	-	+	-	+	-	+	
Phytase, FTU/kg	-	-	-	500	500	1200	1200	SEM
d 0 to 21								
ADG, g[a]	553	512	509	499	504	529	497	14.92
ADFI, g	867	849	859	817	863	841	846	28.83
G:F[ab]	0.64	0.60	0.59	0.61	0.59	0.63	0.59	0.01

[a] Diet type: P < 0.01.

[b] NSP enzyme: P < 0.01.

Key Words: co-products, enzyme, phytase

P057 **Effect of xylanase supplementation both with and without phytase on apparent total tract digestibility (ATTD) in growing and finishing pigs.** Y. D. Jang [1,*], M. D. Lindemann [1], R. A. Cabrera [2], *[1]Animal and Food Sciences, University of Kentucky, Lexington, [2]Huvepharma, Inc., Peachtree City, GA.*

The effect of xylanase supplementation both with and without phytase in diets was evaluated for growing and finishing pigs. A total of 16 barrows were allotted to 4 treatments in 4 replicates for Group 1 (initial BW: 41.7 ± 8.7 kg) and this process was repeated for Group 2 (initial BW: 86.5 ± 10.3 kg). Dietary treatments supplemented xylanase (Hostazym X, 15,000 EPU/g; Huvepharma, Inc. Peachtree City, GA) and phytase (Optiphos, 2000 FTU/g; JBS United, Inc. Sheridan, IN) as follow: 1) positive control [PC]: corn-SBM based diet, 2) negative control [NC; ME was reduced by 79 and 100 kcal/kg from the PC diet for Groups 1 and 2, respectively], 3) NXP: NC + xylanase [1,500 EPU/kg diet] + phytase [800 FTU/kg diet], and 4) NX: NC + xylanase [1,500 EPU/kg diet]. A 5-d fecal collection was performed after a 7 d adaptation period for determining ATTD. The ATTDs of Groups 1 and 2 were pooled to calculate mean ATTD. The highest ATTDs of dry matter (87.09, 84.82, 85.55, and 85.84%, P<0.05), gross energy (86.58, 84.24, 84.96, and 85.08%, P<0.01), ether extract (EE; 86.74, 76.74, 82.89, and 77.94%, P<0.01), acid detergent fiber (ADF; 68.60, 58.38, 60.86, and 63.59%, P<0.01), neutral detergent fiber (NDF; 73.67, 62.58, 65.18, and 68.32%, P<0.01), and hemicellulose (75.47, 63.84, 66.31, and 69.76%, P<0.01) were observed in PC group. The phytase and xylanase supplementation (NXP) showed the highest ATTD of P among treatments (47.41, 43.87, 53.06, and 43.28%, P<0.01) and the increased ATTD of EE compared with NC and NX groups (76.74, 82.89, and 77.94% for NC, NXP and NX, respectively, P<0.01). In contrast between NC and NX groups, the single supplementation of xylanase (NX) increased ATTDs of ADF (58.38 and 63.59%, P=0.051), NDF (62.58, and 68.32%, P=0.052) and hemicellulose (63.84, and 69.76%, P=0.055). This experiment demonstrated that the phytase and xylanase supplementation improved ATTDs of P and EE whereas the improvements in ATTD of fibrous components were observed in the diet supplemented with xylanase only for pigs.

Key Words: phytase, xylanase, pigs, apparent total tract digestibility

P058 **Effect of supplemental xylanase on apparent digestibility and blood parameters in growing pigs fed wheat/wheat bran or corn/corn DDGS based diets.** J. M. Heo [1,*], E. Kiarie [2], A. K. Agyekum [1], M. Nyachoti [1], *[1]Animal Science Department, University of Manitoba, Winnipeg, Canada, [2]DuPont Industrial Biosciences-Danisco Animal Nutrition, Marlborough, Wiltshire, United Kingdom.*

The effect of xylanase on apparent digestibility and blood profiles was tested in growing pigs. Four diets in a 2 (diet type; wheat/wheat bran or corn/corn DDGS) × 2 (xylanase; with 2000 U/kg of feed or without) factorial arrangement were fed to 4 ileal cannulated barrows (28.2 ± 0.92 BW) in a 4 × 4 Latin Square design with 2 added columns (n = 6). All diets contained supplemental microbial phytase (500 FTU/kg) and TiO_2 (3 g/kg) as indigestible marker. Enzymes were provided by Danisco UK Ltd. Pigs were fed their respective diets in two equal portions at 0830 and 1630. Daily feed allowance was based on the BW at the beginning of each period and was calculated to supply 2.6 times the estimated maintenance requirements. Each period lasted for 12 d. Pigs were adapted to experimental diets for 7 d. On d 8 and 9, grab fecal samples were collected and on d 10 and 11, ileal digesta was collected continuously from each pig from 0800 to 2000 daily for digestibility measurements. Blood samples

were collected via jugular vein on d 12. Pigs fed corn/corn DDGS increased ($P < 0.05$) AID of Ca, P, arabinoxylans and total NSP and ATTD of Ca, P, fat and total NSP digestibility compared with pigs fed wheat/wheat bran. Apparent ileal digestibility (AID, %) of DM (65.8 vs. 62.1), CP (79.4 vs. 75.9), Ca (62.8 vs. 51.7) and P (52.0 vs. 40.3) were greater ($P < 0.05$) in pigs fed their respective diets with xylanase supplementation than their counterparts, respectively, independent of wheat/wheat bran or corn/corn DDGS. Apparent total tract digestibility (ATTD, %) of energy, DM, Ca and P improved ($P < 0.05$) with xylanase supplementation (i.e., 64.8, 65.8, 62.8 and 52.0 vs. 61.4, 62.1, 51.7 and 40.3, respectively). Glucose, plasma urea N content and AID of starch did not differ ($P > 0.10$) among treatments. No interactions were observed ($P > 0.10$) between diet type and xylanase supplementation. The study demonstrated that effectiveness of xylanase in improving nutrients and energy utilization across different feed types. These benefits were related to the breakdown of both soluble and insoluble arabinoxylans fractions from corn and wheat.

Key Words: digestibility, pigs, xylanase

P059 **The effect of adding β-mannanase in corn-soybean meal based diets on individually housed nursery pig performance.** Z. Rambo [1], J. Ferrel [2], D. Kelly [1], B. Richert [1,*], *[1]Animal Sciences, Purdue University, West Lafayette, [2]ChemGen Corp, Gaithersburg, MD.*

Individual barrows (BW=6.34±0.43kg; 26d age) were used to evaluate the effect of adding β-mannanase (M) in corn-soybean meal based diets on pig performance during the nursery period. Pigs were allocated in a randomized block design into individual pens, stratified by litter and initial BW to 3 dietary treatments, with 7 (PC) or 8 (NC, T2) pens per treatment. Dietary treatments were: Negative Control (NC; 3309 and 3314 kcal/kg ME phase 2 and 3, respectively); T2, NC+M (0.10 MU/kg); and Positive Control (PC, 3389 and 3394 kcal/kg ME phase 2 and 3, respectively) for 25d. Pigs were fed 3 dietary phases, a common phase 1 (d 0 to 7), phase 2 (d 7 to 17), phase 3 (d 17 to 32). Individual body weight and feed disappearance were recorded on d 7, 17, and 32. Phase 2 ADG was numerically improved for PC and T2 compared to NC (433, 465, 480 g/d, T1-T3, respectively). G:F during Phase 2 was also numerically improved for PC and T2 compared to NC (0.770, 0.812, 0.827, T1-T3, respectively). On d 17 BW was significantly higher ($P<0.05$) for T2 compared to NC while PC was intermediate (13.89, 14.86, 14.69 kg, T1-T3, respectively). Phase 3 ADG tended ($P<0.10$) to increase for T2 over PC with NC being intermediate (573, 618, 557 g/d, T1-T3, respectively) while G:F numerically improved for T2 and PC over NC (0.599, 0.619, 0.611, T1-T3, respectively). Overall, T2 ADG and ADFI numerically improved over both NC and PC (517, 557, 526 g/d, T1-T3, respectively), (803, 840, 779 g/d, T1-T3, respectively). Overall G:F for PC was numerically higher than NC with T2 being intermediate (0.646, 0.672, 0.686, T1-T3, respectively). Final BW for experimental treatments were 19.25, 20.25, 19.52 kg, T1-T3, respectively. The supplementation of a corn-soybean meal based diet with the exogenous enzyme β-mannanase can improve overall nursery pig ADG, ADFI, and G:F performance.

Key Words: enzyme, swine, β-mannanase

P060 **Effects of added zinc on growth performance and carcass characteristics of finishing pigs fed ractopamine HCl.** C. Paulk [1,*], M. Tokach [1], J. Nelssen [1], J. Gonzalez [1], J. DeRouchey [1], R. Goodband [1], S. Dritz [2], *[1]Animal Science and Industry, [2]Diagnostic Medicine/Pathobiology, Kansas State University, Manhattan.*

Two experiments were conducted to determine the effects of added Zn on growth performance and carcass characteristics of finishing pigs fed ractopamine HCL (RAC; Elanco Animal Health, Greenfield, IN). In Exp. 1, 1,234 pigs (PIC 337 × 1050, 102 kg BW) were used in a 28-d study with 26 pigs per pen and 24 pens per treatment. Pens randomly assigned to 1 of 2 diets with and without 50 ppm added Zn from ZnO. All diets (0.92% SID Lys) contained 5 ppm RAC and80 ppm Zn supplied from the premix. Addition of 50 ppm Zn did not influence ($P>0.20$) growth performance or carcass characteristics. In Exp. 2, 312 pigs (PIC 327 × 1050, 94 kg BW) were used in a 27-d study. Pens were randomly allotted to diets with 2 pigs per pen and 26 pens per treatment. Treatments were a corn-soybean meal diet (0.66% SID Lys), a diet (0.92% SID Lys) with 10 ppm RAC, the RAC diet plus 50, 100, and 150 ppm added Zn from ZnO, or 50 ppm added Zn from Availa-Zn (Zinpro, Eden Prairie, MN). The premix used in all diets provided 83 ppm Zn from $ZnSO_4$. Pigs fed the RAC diet had increased ($P<0.05$) ADG, G:F, HCW, yield, loin weight compared with pigs fed the control diet. Increasing Zn from ZnO in diets containing RAC tended to increase G:F (linear, $P<0.09$) and loin weights (quadratic, $P<0.06$). Pigs fed diets with 50 ppm added Zn from Availa-Zn tended to have increased ($P<0.06$) ADG compared with pigs fed the RAC diet. No differences between sources of 50 ppm added Zn were observed. The trends for improved performance with the addition of Zn indicate that further research is needed with Zn in pigs fed RAC.

Key Words: Availa-Zn, ractopamine HCl, zinc oxide

P061 **The effects of microsource S and diet-type on pig performance, fecal consistency, pen cleaning time and microbial load of growing-finishing pigs.** S. Nitikanchana [1,*], S. Dritz [1], M. Tokach [1], R. Goodband [1], J. DeRouchey [1], J. Nelssen [1], J. Bergstrom [2], *[1]Kansas State University, Manhattan, [2]DSM, Nutritional Products, Parsippany, NJ.*

A total of 1,245 pigs (PIC 1050×337, initially 48 kg) were used in a 90-d study to determine the effects of MicroSource S (DSM Nutritional Products Inc., Parsippany, NJ) and diet type on growth performance, carcass traits, fecal consistency, pen cleaning time, and post-cleaning microbial load as measured by ATP concentration in growing-finishing pigs raised under commercial conditions. Pens were allotted in a completely randomized design with 25 to 26 pigs per pen and 8 replications per treatment. Treatments were arranged as a 3×2 factorial with main effects of MicroSource S (0, 1×, or 1.3×) and diet type (corn-soybean meal- or a by-product–based diet with 30% dried distillers grains with solubles and 15% bakery by-product). The MicroSource S dose in the diet was 73.5 million cfu/kg feed for the 1× level and 95.5 million cfu/kg feed for the 1.3× level. Overall (d 0 to 90), increasing MicroSource S had no effect ($P>0.12$) on growth performance, carcass characteristics, ATP concentration, manure score, or wash time. Pigs fed the by-product diet had greater ($P<0.01$) ADFI and poorer ($P<0.01$) G:F compared with those fed the corn-soybean meal diet with no difference in ADG. Pens of pigs fed the by-product diets required more ($P<0.01$) time to wash, which appeared to be the result of an increase ($P<0.01$) in manure buildup.

P061 Table

Exp. 1				Exp. 2							
							Availa-Zn, ZnO, ppm Zn		ppm Zn		
	Control	Added Zn	SEM		Control	RAC	50	100	150	50	SEM
ADG, kg	1072	1079	9	ADG, g	1036	1204	1237	1228	1236	1265	22
G:F	0.350	0.355	0.3	G:F	0.314	0.383	0.389	0.391	0.397	0.395	0.005
HCW, kg	96.3	96.8	0.6	HCW, kg	89.5	93.8	94.9	94.0	94.2	95.3	0.70
Carcass yield, %	75.6	75.6	0.2	Carcass yield, %	73.9	74.4	74.8	74.5	74.4	74.7	0.2
Backfat depth, mm[1]	15.8	15.7	0.2	Backfat depth, mm[1]	24.7	23.6	23.7	23.1	22.3	22.8	0.9
Loin depth, mm[1]	70.3	70.9	0.4	Loin wt, kg[1]	3.86	4.05	3.97	4.05	4.13	4.00	0.06
Lean, %[1]	51.3	51.4	0.1	Lean, %[1]	51.7	52.2	52.1	52.3	52.6	52.5	0.4

[1]Adjusted to a common HCW.

In summary, the 1× or 1.3× level of MicroSource S did not improve growth performance or alter fecal consistency, post-cleaning microbial load, or barn wash time. (See table above.)

Key Words: by-products, MicroSource S, pig

P062 **Evaluating indicators of bone metabolism and turnover in geriatric, ovariectomized rats fed varied sources of conjugated linoleic acid.** K. Kanosky*, E. Benavides, D. Keisler, B. Wiegand, *Division of Animal Sciences, University of Missouri, Columbia.*

Dietary fat alters characteristics of bone metabolism in rats. CLA has been shown to decrease arachidonic acid and PGE_2, thus improving bone density. We sought to determine if varied sources of 0.6% CLA altered rat tissue fatty acid compositions, femur and spine bone mineral content (BMC), femur and spine BMD, and osteoclast activity in aged ovariectomized female rats. Retired breeder (365 ± 28 d of age and 4.5 ± 0.5 parity), Sprague Dawley, female rats (n=86) were randomly assigned to ovariectomy (OVX) or sham (SHAM) surgeries. Rats were fed 4% soy oil (CON) for 14 d. For an additional 70 d, within surgery groups, rats were randomly allotted to dietary treatments: CON, 0.6% CLA + 3% soy oil (CLA), 0.6% CLA from cheddar cheese powder + 3% soy oil (CC), or 0.3% CLA + 0.3% CLA from cheddar cheese powder + 3% soy oil (CCCLA). Total fatty acids from liver, peritoneal fat, thigh muscle, and femoral bone marrow were extracted and detected by gas chromatography. Dual-energy X-ray absorptiometry (DEXA) scans measured BMC and BMD of femora and spines (L1-L4). Activity of rat serum band 5 tartrate-resistant acid phosphatase (TRAcP5b) was detected by ELISA. Additionally, serum estradiol concentrations were measured by RIA. The fatty acid composition of liver was not altered by the dietary treatments. When given CLA, the percentage of 20:4n6 (P<0.01) and total n3 (P<0.01) decreased in peritoneal fat. In thigh muscle, a reduction in total PUFA (P<0.01), PUFA:SFA (P<0.01), total n6 (P=0.01), total n3 (P<0.01), and 20:4n6 (P<0.01) was observed. Rats that were given CLA had lower amounts of 18:2n6c (P<0.05), total PUFA (P<0.01), PUFA:SFA (P<0.01), total n3 (P<0.01), and total n6 (P<0.05) in rat femoral bone marrow. No differences were detected for treatment or surgery effects on femur BMC, spine BMC, or spine BMD. Rats fed CC and CCCLA tended to have less dense femurs (P=0.08) when compared to CON- and CLA-fed rats. TRAcP5b and estradiol were not affected by treatment or surgery. In conclusion, rats fed CLA had lower amounts of PUFA, therefore indicating a possible reduction in PGE_2 by affecting bone remodeling.

Key Words: bone, linoleic acid, rat

P063 **The effect of Tempeh supplementation on growth performance, nutrient digestibility, blood profiles, fecal microflora, and fecal score in weanling pigs.** J. H. Cho, D. Jung, I. H. Kim*, *Department of Animal Resource & Science, Dankook University, Cheonan, Republic of Korea.*

Tempeh is fermented soybean food in Indonesia, and contains high protein, saponin, essential amino acids, vitamins and fiber. A total of 125 weanling pigs [(Landrace × Yorkshire) × Duroc, BW = 7.51 ± 0.73 kg] were used for a 35-d trial to evaluate the effect of Tempeh supplementation on growth performance, nutrient digestibility, blood profiles, fecal microflora, and fecal score. Pigs were allocated to 1 of 5 treatments by BW and sex (2 gilts and 3 barrows/pen; 5 pens/treatment). Treatments included: CON, control diet; KT1, CON + 0.15% Tempeh from Korea (produced by Sunbio); KT2, CON + 0.30% Tempeh from Korea (produced by Sunbio); IT1, CON + 0.15% Tempeh from Indonesia; IT2, CON + 0.30% Tempeh from Indonesia. All diets were formulated to meet or exceed the NRC (2012) nutrient requirements of weanling pigs. In this study, pigs fed IT1 diet had the higher (409 vs. 361 g; P<0.05) ADFI than pigs fed ST2 diet during d 1 to d 14. Pigs fed the KT1 diet had higher (P<0.05) ADG than those fed the CON and IT2 diets during d 15 to d 35 (655 vs. 619 or 596 g) and during d 1 to d 35 (526 vs. 495 or 479 g). The ADG in IT1 was higher (P<0.05) than that in IT2 during d 15 to d 35 (637 vs. 596 g) and during d 1 to d 35 (510 vs. 479 g). Dietary treatments had no effect (P>0.05) on G/F ratio throughout the experimental periods. Apparent total tract digestibility (ATTD) of N was increased (P<0.05) in KT1, KT2 and IT1 compared with CON (P<0.05) on d 14 (86.94 or 85.93 or 85.83 vs. 82.17%) and d 35 (85.29 or 84.98 or 84.40 vs. 80.80%). The ATTD of energy was higher (P<0.05) in pigs fed KT1 and KT2 diets than those fed CON and IT2 diets (82.72 or 82.11 vs. 78.86 or 79.29%) on d 35. The blood IgG concentration was increased (P<0.05) in pigs fed the KT1 diet compared with pigs fed the CON diet (325.8 vs. 301.0 mg/dL) on d 35. No effect (P>0.05) was observed on the RBC, WBC concentration and lymphocyte percentage, fecal *lactobacillus* and *E. coli* counts among treatments at the end of the experiment. No effect (P>0.05) was observed on the fecal score among treatments. In conclusion, dietary supplementation with 0.15% Korea Tempeh improved the growth performance, nutrient digestibility, and IgG concentration in weanling pigs.

Key Words: growth performance, Tempeh, weanling pig

P064 **Disappearance of butyrate in the digestive tract of weanling and growing pigs fed diets containing different sources of butyrate.** K. Sotak [1,*], M. Song [1], H. Stein [1], S. Moreland [2], *[1]University of Illinois, Urbana-Champaign, [2]Nutriad Inc., Elgin.*

In this study, disappearance kinetics of different sources of butyrate in diets fed to weanling and growing pigs was investigated. Weanling pigs (n = 24; 8.0 ± 0.5 kg BW) and growing pigs (n = 24; 96.8 ± 4.3 kg BW) were randomly allotted to 4 dietary treatments (6 pigs per treatment): 1) a control diet, 2) the control diet + 0.4% uncoated butyrate (UCB), 3) the control diet + 0.4% coated butyrate A (CBA), and 4) the control diet + 0.4% coated butyrate B (CBB). The dietary treatments were provided to pigs daily for 7 d at 3 times the estimated energy requirement for maintenance. On the last d of the experiment, all pigs were euthanized to collect samples from the stomach, duodenum, jejunum, ileum, cecum, and proximal and distal colon. Concentrations of DM and butyrate were analyzed in all samples. There was a similar pattern of the concentration of butyrate in the digestive tract of weanling and growing pigs, indicating that the concentration of butyrate was greater in the stomach than in the duodenum and jejunum, and gradually increased in the ileum. However, butyrate concentration was markedly increased in the cecum through the proximal colon and decreased in the distal colon. The concentrations of butyrate were greater in the small intestines of growing pigs than in weanling pigs. Weanling pigs fed the CBA and CBB diets had greater ($P < 0.05$) concentrations of butyrate in the jejunum (405 and 446 vs. 213 μg butyrate/g digesta DM) and ileum (1840 and 1915 vs. 979 μg butyrate/g digesta DM) compared with weanling pigs fed the control diet. Likewise, growing pigs fed the CBA and CBB diets had greater ($P < 0.05$) concentrations of butyrate in the stomach than pigs fed the control diet (779 and 779 vs. 441 μg butyrate/g digesta DM) than growing pigs fed the control diet. However, no differences were observed in the concentrations of butyrate in the other sections of the digestive tract of weanling and growing pigs among dietary treatments. In conclusion, the coated butyrate increased the concentrations of butyrate in gastric and intestinal contents of pigs, but the uncoated butyrate did not.

Key Words: absorption, butyrate, pigs

P065 (GS-PHD) **Amino acid digestibility in heat damaged distillers dried grains with solubles fed to pigs.** F. N. Almeida [1,*], J. K. Htoo [2], J. Thomson [3], H. H. Stein [1], *[1]Animal Sciences, University of Illinois, Urbana, [2]Evonik Industries AG, Hanau, Germany, [3]Evonik Degussa Corporation, Kennesaw.*

The primary objective of this experiment was to determine the effects of heat treatment on the standardized ileal digestibility (SID) of AA in corn distillers dried grains with solubles (DDGS) fed to growing pigs. The second objective was to develop regression equations that may be used to predict the concentration of SID AA in corn DDGS. A source of corn DDGS was divided into 4 batches that were either not additionally heated or autoclaved at 130˚C for 10, 20, or 30 min. Four diets containing DDGS from each of the 4 batches were formulated with DDGS being the only source of AA and CP in the diets. A N-free diet also was formulated and used to determine the basal endogenous losses of CP and AA in the pigs. Ten growing pigs (initial BW: 53.5 ± 3.9 kg) were surgically equipped with a T-cannula in the distal ileum and allotted to a replicated 5 × 4 Youden square design with 5 diets and 4 periods in each square. Regression equations to predict the concentration of SID AA were developed using the forward selection method. The SID of CP decreased linearly ($P< 0.05$) from 77.9% in the unheated DDGS to 72.1, 66.1, and 68.5% in the DDGS samples that were autoclaved for 10, 20, or 30 min, respectively. The SID of Lys was quadratically reduced ($P< 0.05$) from 66.8% in the unheated DDGS to 54.9, 55.3, and 51.9% in the DDGS that was autoclaved for 10, 20, or 30 min, respectively. The concentrations of SID Arg, His, Leu, Lys, Met, Phe, and Thr may be best predicted by equations that include the concentration of acid detergent insoluble N in the model ($r^2 = 0.76$, 0.68, 0.68, 0.84, 0.76, 0.73, and 0.53, respectively). The concentrations of SID Ile and Val were predicted ($r^2= 0.58$ and 0.54, respectively) by the Lys:CP ratio, whereas the concentration of SID Trp was predicted ($r^2 = 0.70$) by the analyzed concentration of Trp. In conclusion, the SID of AA is decreased as a result of heat damage and the concentration of SID AA in heat damaged DDGS may be predicted by regression equations developed in this experiment.

Key Words: amino acids, distillers dried grains with solubles, heat damage

P066 (GS-MS) **Effect of spray dried plasma protein compared to spray dried chicken egg protein on growth performance of nursery pig.** E. K. Pegg [1,*], P. M. Walker [1], R. L. Atkinson [2], B. G. Harmon [3], P. J. Lammers [1], *[1]Agriculture, Illinois State University, Normal, IL, [2]Animal Science, Food and Nurtition, Southern Illinois University , Carbondale, [3]Railsplitter Feed Technology Inc., Wildwood, MO.*

Immunoglobulin is typically supplied by the inclusion of spray dried plasma protein (SDP) in nursery pig diets. More recently, spray dried chicken egg (SDE) has been used as an alternative to plasma protein. A study involving 372 weanling pigs from two farrowing groups were utilized in two trials to evaluate SDE on nursery growth performance, feed efficiency (G:F), and mortality/morbidity. In each trial, pigs were weaned at 24.5 ± 3.4 d, eartagged and blocked by weight (4 blocks). Pigs were randomly allotted within block, disregarding sex or litter, to six pens containing seven or eight pigs/pen. Three diets containing SDP, SDE or a commercial control diet (CNTL) were randomly assigned to each of two pens within each block. All diets were medicated with 50g/909.9kg of carbadox and each of the two temperature controlled nursery rooms were sanitized once each week with a commercial product (Disrupt™) containing Fe, Cu, and Zn. The three diets were fed in three phases changing nutrient composition such that Phase 1 was 7d, Phase 2 was 14d (Trial 1) or 15d (Trial 2) and Phase 3 was 12d (Trial 1) or 11d (Trial 2). Immunoglobulin levels were uniformly reduced in going from Phase 1 to Phase 2 to Phase 3. All data were analyzed using the MIXED procedures of SAS for a randomized block design. Pen was the experimental unit with model including treatment, phase, and treatment x phase interaction. Pen DMI and weight gain were adjusted to and compared on an 8 pig/pen basis. No significant treatment x replicate interaction was observed. No differences ($P> 0.05$) were found for DMI, weight gain, or G:F between the three dietary treatments. Significant increases in DMI and weight gain were observed between Phase 1, 2, and 3 as pigs increased in age. No significant differences in measures of pig morbidity were observed between treatments. One pig died during the study due to Mulberry Heart Disease. Similar responses in DMI, weight gain, and G:F were observed with SDP and SDE supplemented diets. Therefore, spray dried chicken egg can be substituted for spray dried plasma protein as a less expensive source of immunoglobulin.

Partial Funding: Brookside Agra, LLC

Key Words: nursery pig performance , porcine plasma , spray dried chicken egg

P067 (GS-PHD) **Impact of an acute water and feed deprivation event on performance, histology, and stress markers in weaned pigs.** N. Horn [1,*], F. Ruch [2], K. Ajuwon [1], G. Miller [3], O. Adeola [1], *[1]Animal Sciences, Purdue University, West Lafayette, [2]Enzyvia, LLC, Sheridan, [3]Biomatrix, Princeton.*

The impact of acute stressors on performance, histological parameters, and serum stress markers in weaned nursery pigs were evaluated. Pigs (6.21 ± 0.29 kg) were allotted in a randomized complete block design to 4 post-weaning treatments on the basis of body weight at the time of weaning. There were 8 pigs per pen and 12 replicate mixed-sex pens per treatment. The post-weaning treatments were arranged in a 2 x 2 factorial of 0 or 24-h feed deprivation period and 0 or 24-h water deprivation period after which the piglets were returned to normal management procedures. Growth performance was measured the day following the stressor, 7, 14, and 28 d post weaning. Serum and intestinal samples were taken d 2 and 7 post weaning. Serum was analyzed for cortisol and corticotrophin releasing factor, and villus height and crypt depth were measured in the jejunum and the ileum. There was a decrease in ADG with the water stressor ($P < 0.01$) immediately following the stressor although there was a significant improvement in ADG and feed efficiency ($P < 0.01$) at d 7 post weaning. Furthermore, there was a reduction in ADFI during the last 14 d of the trial and cumulatively ($P < 0.05$) in the water stress group. On d 7 post weaning, there was a reduction ($P < 0.05$) in jejunal crypt depth with the water stressor and a reduction ($P = 0.05$) in ileal villus height with the feed stressor. With administration of the water stressor there was an increase ($P < 0.05$) in serum cortisol and corticotrophin releasing factor on d 2 post weaning and an increase in serum cortisol but not corticotrophin releasing factor 7 post weaning. There was no impact of the feed stressor or a feed x water stressor interaction on growth performance or any of the serum measurements. The results from the current trial show that an acute water stressor at the time of weaning has negative impacts on growth performance, histological measurements, and serum stress indicators not only immediately following the stress event but throughout the nursery period.

Key Words: acute stressors, nursery pig

NONRUMINANT NUTRITION: NURSERY AND GROW-FINISH NUTRITION

P068 **An evaluation of dietary natural zeolite or humic acid substances and high sulfate water on nursery pig performance.** J. R. Flohr*, M. D. Tokach, J. L. Nelssen, S. S. Dritz, J. M. DeRouchey, R. D. Goodband,*Kansas State University, Manhattan.*

A total of 350 nursery pigs (PIC 1050 barrows, initially 21 d of age) were used in a 21-d study to determine the effects of high-sulfate water, and natural zeolite and humic substances on growth and fecal consistency of nursery pigs. Treatments were arranged in a 2 × 5 factorial with 2 water treatments (control or water with 2,000 ppm Na_2SO_4) and 5 dietary treatments (control, 1 or 2% zeolite, 1% humic acid [HA], or 1% humic and fulvic acid [HFB]). There were 7 replications/treatment and 5 barrows/pen. Water treatments remained the same from d 0 to 21, and all diets were fed in 2 phases, with the same treatment inclusion rates in both phases. Phase 1 diets were fed in a pellet form (d 0 to 8) and Phase 2 diets were fed in meal form (d 8 to 21). Fecal samples were collected on d 5, 8, 15, and 21, visually scored for consistency (1= firm, 5= watery), and analyzed for DM. Overall (d 0 to 21), a water source × diet interaction ($P < 0.03$) occurred for ADG and G:F, because pigs fed 1% HA had poorer ($P < 0.01$) ADG and G:F than other treatments when drinking 2,000 ppm Na_2SO_4 water but improved ADG and G:F when drinking control water. Pigs drinking 2,000 ppm Na_2SO_4 water had poorer ($P < 0.01$) ADG and G:F; and tended ($P = 0.08$) to have lower ADFI than pigs drinking control water. Pigs drinking 2,000 ppm Na_2SO_4 water had more fluid fecal samples ($P < 0.01$) and lower ($P < 0.01$) fecal DM on d 5 and 8 compared to pigs drinking control water. In conclusion, pigs drinking water with 2,000 ppm Na_2SO_4 had decreased ADG, G:F, and tended to have lower ADFI, also they had more watery feces on d 5 and 8 as measured by fecal DM compared to pigs drinking control water. The zeolite or humic acid products tested did not improve pig growth or alter fecal DM for pigs drinking high sulfate water.

	Dietary Treatment					
Item	Control	1% Zeolite	1% HA	1% HFB	2% zeolite	SEM
Control water						
ADG, g	268	274	300	274	248	13.4
G:F	0.72	0.74	0.78	0.73	0.71	0.021
d 8 fecal score	3.3	2.8	3.1	3.0	2.7	0.15
d 8 fecal DM, %	23.1	26.7	25.6	26.5	28.7	1.70
2,000 ppm Na_2SO_4						
ADG, g	264	249	229	255	262	13.4
G:F	0.71	0.70	0.67	0.70	0.74	0.021
d 8 fecal score	3.3	3.7	3.3	3.5	3.4	0.15
d 8 fecal DM, %	22.3	18.8	22.7	22.0	22.1	1.70

Key Words: non-nutritive feed additives, nursery pig, sulfate water

P069 **Effects of varying ingredient particle size and diet form on nursery pig growth performance and caloric efficiency.** J. A. De Jong*, J. M. DeRouchey, M. D. Tokach, R. D. Goodband, S. S. Dritz, J. L. Nelssen, *Animal Science, Kansas State University, Manhattan.*

A total of 675 pigs (initial BW 11.1 kg) were used in a 21-d study to determine the effects of varying ingredient particle size and diet form on nursery pig growth performance and caloric efficiency. Pens of pigs were balanced by initial BW and randomly allotted to 1 of 8 dietary treatments (17 pens/treatment). The 8 diets included 3 corn-soybean meal–based diets consisting of: 1) corn ground to 620 µ and fed in meal form, 2) corn ground to 352 µ and fed in meal form, and 3) diet 2 pelleted. The remaining 5 diets contained 20% wheat middlings (midds) and 30% dried distillers grains with solubles (DDGS). Diets 4 to 8 consisted of: 4) corn ground to 620 µ, midds and DDGS unground (534 and 701 µ), and fed in meal form; 5) diet 4 but corn also ground to 352 µ and fed in meal form; 6) diet 5 fed in pellet form; 7) corn, soybean meal, DDGS, and midds finely ground (352, 421, 377, and 357 µ), and fed in meal form; and 8) diet 7 fed in pellet form. Diets were not isocaloric. Overall (d 0 to 21), pelleting improved ($P<0.03$) ADG, G:F, and caloric efficiency on a ME or NE basis. Reducing corn particle size did not influence G:F or caloric efficiency, but tended ($P<0.08$) to reduce ADFI, which led to a reduction ($P<0.02$) in ADG. High-by-product diets reduced ($P<0.01$) ADG, ADFI, final BW, and ($P<0.01$) G:F, but caloric efficiency was similar to pigs fed the corn-soybean meal–based diet. Grinding the by-products to a smaller particle size further reduced ($P<0.05$) ADG, ADFI, and final BW, but did not influence

P069 Table

Treatment:	1	2	3	4	5	6	7	8	
Diet[a]:	C	C	C	H	H	H	H	H	
Portion Ground:		Corn	Corn		Corn	Corn	Diet	Diet	
Item Diet form:	Meal	Meal	Pellet	Meal	Meal	Pellet	Meal	Pellet	SEM
ADG, g	648	621	618	585	564	599	548	573	24.8
ADFI, g	1001	963	948	935	917	909	861	890	41.1
G:F	0.648	0.647	0.652	0.626	0.615	0.659	0.637	0.644	0.01
Caloric efficiency, mcal/kg									
ME	5.12	5.14	5.09	5.20	5.31	4.95	5.11	5.07	0.08
NE	3.66	3.67	3.63	3.65	3.73	3.48	3.59	3.56	0.05
Final wt, kg	24.8	24.2	24.7	23.4	23.3	23.8	22.4	23.1	0.58

G:F. Pelleting improved performance; however, fine grinding corn or other components of the high-by-product diet did not further improve nursery pig performance. (See table above.)

Key Words: DDGS, feed processing, wheat middlings

P070 **The effects of feeder design (conventional dry vs. wet-dry) on growth performance of 20- to12-kg pigs.** S. Nitikanchana*, S. Dritz, M. Tokach, R. Goodband, J. DeRouchey, J. Nelssen, *Kansas State University, Manhattan.*

A total of 1,253 pigs (PIC 1050 × 337; initially 20.4 kg) were used in a 104-d study to evaluate the effects of using a wet-dry (WD) or conventional dry (CD) feeder on growth performance of growing-finishing pigs. There were 25 to 27 pigs per pen and 24 pens per feeder type. At the start of the trial, pens of pigs were weighed and randomly allotted to 1 of the 2 feeder types. The CD feeder was a single-sided, 1.42 m wide, stainless steel feeder (Thorp Equipment, Inc., Thorp, WI) with 4 feeding spaces that were 35.6 cm wide and a 10.8 cm deep trough. A cup waterer in the pen using CD feeders ensured ad libitum access to water. The WD feeder was double-sided (38.1 cm wide feeder opening on each side) with a single nipple waterer (Crystal Springs, GroMaster, Inc., Omaha, NE) where water in the feeder was the only source of water. All pigs were fed the same corn-soybean meal diets containing 30% bakery meal and 10 to 45% dried distillers grains with solubles during 5 dietary phases. For the overall period, pigs fed with WD feeders had greater ADG (P<0.01) and ADFI (P=0.01) with no differences in G:F (P=0.51) compared with pigs fed using the CD feeder. This study confirms previous results where pigs fed using a WD feeder have greater ADG and ADFI than those fed with a CD feeder.

Effects of feeder design (conventional dry vs. wet-dry) in 20- to 112-kg pigs

Feeder type	Conventional dry	Wet-dry	SEM	Probability, P <
d 0 to 104				
ADG, g	863	891	4.58	0.01
ADFI, g	2153	2235	21.9	0.01
G:F	0.402	0.399	0.003	0.51

Key Words: feeder design, growth, pigs

P071 **The effects of increasing levels of pellet fines on growth performance of 14 to 34 kg nursery pigs.** E. D. Frugé [1,*], E. L. Hansen [1], S. A. Hansen [1], K. A. Frerichs [1], C. W. Hastad [2], *[1]Hubbard Feeds, Mankato, [2]New Fashion Pork, Jackson.*

An experiment was conducted to determine the effects of increasing levels of pellet fines (0 to 100% fines) on growth performance compared to pigs fed meal diets. Pigs (N=1000, 14.5 kg) were allotted to 6 dietary treatments (TRT) with 6 replicates and 27 or 28 pigs per pen in a randomized complete block design. The experimental TRT were; 1) Meal diet; 2) pellet (screened); 3) Pellet with 25% fines; 4) Pellet with 50% fines; 5) Pellet with 75% fines; 6) Pellet with 100% fines. Percentage fines were achieved by roller grinding pellets and blending back to screened pellets. All diets were identical in ingredient and nutrient composition. Pig weights and feed disappearance were measured on d 0, 7, 14, 21, and 28. A summary of the overall (d 0 to 28) results is presented in Table 1. Pigs fed TRT 2 had improved ADG compared with pigs fed TRT 1, 5 and 6 with pigs fed TRT 3 and 4 intermediary. Pigs fed TRT 2 had improved G:F compared with all other TRT. Pigs fed TRT 3 and 4 had improved G:F compared to pigs fed TRT 1, whereas pigs fed TRT 5 and 6 had similar G:F with pigs fed TRT 1. There were no TRT differences for ADFI. Final BW of pigs fed TRT 2 was heavier than pigs fed TRT 1, 5 and 6 with those fed TRT 3 and 4 intermediary. Pigs fed TRT 6 had lighter final BW compared to those fed TRT 1. Regression curves were fitted for TRT 2 - 6 for ADG (y = -0.6677x + 749.81, R^2 = 0.91), ADFI (y = -0.0088x2 + 0 .05019x + 1121.4 R^2 = 0.89) and G:F (y = -0.0004x + 0.6587, R^2 = 0.95). These data allow for performance and financial analysis on the effects of diet form and pellet fines of 14 to 34 kg pigs.

Table. 1 The effects of increasing levels of fines.[1]

TRT[2]	1	2	3	4	5	6	SEM	P <
Initial BW, kg	14.6	14.5	14.7	14.4	14.5	14.5	0.10	0.50
ADG, g	705[b]	742[a]	721[ab]	723[ab]	699[bc]	677[c]	9.50	0.05
ADFI, g	1130	1126	1130	1131	1105	1089	15.71	0.33
G:F	0.62[c]	0.66[a]	0.64[b]	0.64[b]	0.63[bc]	0.62[c]	0.004	0.05
Final BW, kg	34.4[b]	35.3[a]	34.9[ab]	34.7[ab]	34.1[bc]	33.4[c]	0.31	0.05

[1 abc] Within a row, means without common superscript differ (P <0.05).

[2] Actual fines: meal, 5, 43, 59, 73, & 100%

Key Words: fines, nursery pigs, pellet

P072 **Effects of increasing dietary bakery meal on growing-finishing pig growth performance and carcass quality.** C. Paulk[1,*], S. Nitikanchana [2], S. Dritz [2], M. Tokach [1], J. Nelssen [1], J. DeRouchey [1], R. Goodband [1], K. Prusa [3], *[1]Animal Science and Industry, [2]Diagnostic Medicine Pathobiology, Kansas State University, Manhattan, [3]Animal Science, Iowa State University, Ames.*

A total of 1,263 pigs (PIC 337 × 1050; initially 35.3 kg BW) were used in a 102-d study to determine the effects of dietary bakery meal on growth performance and carcass quality. Pens were randomly allotted to 1 of 3 dietary treatments while balancing for initial BW and gender. There were 16 pens per treatment with 25 to 28 pigs per pen. Dietary treatments included 0, 7.5, and 15% bakery meal. Analyzed bakery meal contained 14.0% CP, 8.1% ADF, 19.0% NDF, 6.4% fat, and 5.3% ash (as-fed basis). On d 84, the 5 heaviest

P073 Table

	Bakery meal,%					Bakery meal,%			
Item	0	7.5	15	SEM	Item	0	7.5	15	SEM
ADG, g	933	916	928	7	HCW, kg	97.0	96.3	96.8	0.7
G:F	0.381	0.374	0.371	0.003	Yield, %	75.6	75.8	75.4	0.2
Caloric efficiency, mcal/kg					Backfat thickness, mm[1]	15.8	15.9	15.6	0.2
ME	8.93	9.17	9.30	0.08	Loin depth, mm[1]	70.6	70.6	70.8	0.4
NE	6.70	6.79	6.81	0.06	Lean, %[1]	51.4	51.3	51.5	0.1
Final BW, kg	128.4	127.0	128.4	1.0	Belly IV				
					d 84	78.7	78.6	80.2	0.6
					d 102	75.2	76.0	81.1	1.0

[1]Adjusted to a common HCW.

pigs from each pen (determined visually) were sold. On d 102, the remaining pigs were sent to harvest for carcass data collection. On d 84 and d 102, the median weight market pig from every pen was selected (determined visually) for collection of carcass quality measurements. Pigs fed diets containing 7.5% bakery meal tended to have the lowest (quadratic, $P<0.07$) ADG. Increasing bakery meal worsened (linear, $P<0.02$) G:F and caloric efficiency on a ME basis. This suggests that ME values overestimated the energy value of bakery meal (3,700 ME kcal/kg; 2,415 NE kcal/kg). There were no differences ($P>0.21$) in carcass weight, yield, backfat, or loin depth. For pigs subsampled on d 84, belly fat iodine value (IV) tended to increase (linear, $P<0.09$) as bakery meal increased. Pigs subsampled on d 102 had decreased (linear, $P<0.04$) middle and edge belly thickness, increased (linear, $P<0.001$) belly IV, and tended to lower (linear, $P<0.09$) belly weight with increased bakery meal. In conclusion, adding this bakery meal source negatively affected growth performance and carcass fat quality with most of the negative effects on fat IV when feeding 15% bakery meal. (See table above.)

Key Words: bakery meal, carcass quality, growing-finishing pigs

P073 **The effects of soybean hulls and their particle size on growth performance and carcass characteristics of finishing pigs.** D. Goehring*, J. M. DeRouchey, S. S. Dritz, M. D. Tokach, R. D. Goodband, J. L. Nelssen, *Kansas State University, Manhattan.*

A total of 1,215 pigs (initial BW 31.1 kg) were used in a 118-d study to determine the effects of 7.5 and 15% soybean hulls (unground or ground) on growth performance and carcass characteristics of finishing pigs raised in a commercial environment. Pens were balanced by initial BW and gender (28 pigs/pen) with 9 replications per treatment. Treatments were arranged in a 2 × 2 + 1 factorial with main effects of soybean hull particle size (unground or ground, 787 and 370 µ, respectively) and soybean hull level (7.5 or 15%) in corn-soybean meal–based diets. The fifth treatment was a positive control, corn-soybean meal–based diet. All diets were fed in meal form. No particle size × soybean hull interactions ($P>0.18$) were observed. Increasing soybean hulls, regardless of particle size, did not affect ADG but numerically increased ($P=0.11$) ADFI, resulting in poorer (linear, $P<0.02$) G:F. Increasing soybean hulls improved (linear, $P<0.002$) caloric efficiency on an ME and NE basis, indicating published energy values undervalue the energy content of soybean hulls. Grinding soybean hulls to a fine particle size worsened G:F ($P<0.05$) and caloric efficiencies ($P<0.03$). Carcass yield and HCW decreased (linear, $P<0.03$) with increasing soybean hulls. Increasing soybean hulls decreased (linear, $P<0.001$) backfat depth and increased ($P<0.01$) percentage lean. Grinding soybean hulls to a fine particle size prior to diet manufacturing increased backfat depth ($P<0.002$) and decreased ($P<0.004$) percent lean and FFLI. In summary, increasing dietary soybean hulls to 7.5 or 15% did not affect ADG, ADFI, or final BW in growing and finishing pigs; however, G:F became poorer and carcass yield and HCW decreased.

Soybean hulls, %:	0	7.5	7.5	15	15	
Item Particle size :	-	Ground	Unground	Ground	Unground	SEM
ADG, g	835	841	837	820	843	9.8
G:F	0.391	0.381	0.387	0.375	0.384	0.004
Caloric efficiency, Mcal/kg						
ME	8.54	8.49	8.32	8.29	8.08	0.09
NE	6.33	6.20	6.07	5.95	5.80	0.06
Final BW, kg	128.3	128.8	127.7	126.5	128.9	1.39
Carcass yield, %	76.6	75.2	75.4	75.2	75.0	0.36
Lean, %[a]	57.4	57.5	58.1	57.8	58.4	0.19
Loin depth, mm[a]	66.7	65.0	66.1	66.2	65.4	0.67
Backfat depth, mm[a]	15.4	14.9	14.3	14.7	13.7	0.26

[a] HCW used as covariate

Key Words: finishing pig, particle size, soybean hulls

P074 **Effect of replacing soybean meal with low oligosaccharide soybean meal in the diets of early weaned pigs.** D. Pangeni[1,*], J. A. Jendza[2], L. Anil[2], S. K. Baidoo[2], *[1]Department of Animal Science, University of Minnesota, Saint Paul, [2]Southern Research and Outreach Center, University of Minnesota, Waseca*.

An experiment was conducted to determine the effect of replacing conventional soybean meal (cSBM, 46.55 % CP) with low oligosaccharide soybean meal (LOSBM, 53.16 % CP) on growth performance, blood urea nitrogen (BUN), intestinal morphology and digesta viscosity of early-weaned pigs. Thirty-two 19-d old pigs (6.9 ± 0.4 kg BW) were assigned to individual pens based on a randomized complete block design, with 8 blocks (wt. group) of 4 dietary treatments. Four iso-nitrogenous nursery diets were formulated and used in 2 × 2 factorial arrangement with factors consisting of soybean meal type (cSBM vs. LOSBM) and FM/SDPP (with or without). Pigs were fed ad libitum through the entire experimental period of 14 d. Pigs were weighed; blood was collected via jugular vena puncture and were euthanized by overdose of sodium pentobarbital for organ (intestine, pancreas, liver, heart, kidney and spleen) harvest. No interaction of FM/SDPP and the source of soybean meal were observed for the response criteria studied. Average daily gain and average daily feed intake were not affected by dietary treatments. However, inclusion of FM/SDPP improved ($P = 0.03$) gain to feed ratio. Treatments had no effect on organ weights and intestinal length. No effect of dietary treatment was observed for

ileal and jejunal crypt depths, and ileal villi height. However, jejunal villi height was greater (P = 0.01) in cSBM diet. Concentration of BUN was higher (P = 0.01) in pigs fed LOSBM diet than in pigs fed diets containing SBM. Replacing cSBM with LOSBM reduced (P = 0.01) the viscosity of intestinal content. In conclusion, LOSBM was shown to be a suitable substitute for cSBM, with no negative effects and improved digesta viscosity.

Key Words: blood urea nitrogen, low oligosaccharide soybean meal, swine, viscosity

P075 **The effects of dietary soybean hulls, particle size, and diet form on nursery pig performance.** D. Goehring [1,*], J. M. DeRouchey [1], M. D. Tokach [1], S. S. Dritz [1], R. D. Goodband [1], J. L. Nelssen [1], B. W. James [2], *[1]Kansas State University, Manhattan, [2]Kalmbach Feeds, Inc., Upper Sandusky.*

A total of 1,100 nursery pigs (6.8 kg BW) were used in a 42-d study to determine the effect of increasing soybean hulls (10 or 20%) and soybean hull particle size (unground = 671 µ or ground = 398 µ) in nursery pig diets fed in both meal and pelleted form. Pens of pigs (5 barrows and 5 gilts) were balanced by initial BW and randomly allotted to treatments with 11 replicates per treatment. Treatments were arranged in a 2×2×2 factorial with main effects of 10 or 20% unground or finely ground soybean hulls with diets in pelleted or meal form. No 3-way or particle size × soybean hull interactions (P>0.37 and P>0.17) were observed. Diet form × particle size interactions were observed for G:F (P<0.05) and a tendency for ADFI (P<0.10). Grinding soybean hulls improved G:F and reduced ADFI in meal diets but did not change G:F and had less effect on ADFI when pelleted. There were diet form × particle size interactions (P<0.05) for caloric efficiency on an ME and NE basis. Grinding soybean hulls slightly improved caloric efficiency in meal diets, but not in pelleted diets. There was a tendency for diet form × soybean hull level interactions (P<0.06) for ADFI, G:F, and caloric efficiency. Increasing soybean hulls from 10 to 20% increased ADFI and worsened G:F in meal diets but were not changed in pelleted diets leading to a greater improvement in caloric efficiency in pelleted diets than meal. For main effects, grinding soybean hulls below 617 µ decreased (P<0.01 and P<0.08) ADG and ADFI and tended (P<0.08) to reduce final weight. Pelleting provided the expected improvement in ADG and eliminated the negative effect of increasing soybean hulls on G:F. Regrinding soybean hulls below 617 µ reduced growth performance. (See table below.)

Key Words: nursery pig, particle size, soybean hulls

P076 **Energy value of a low oligosaccharide soybean meal in pigs.** V. Perez [1,*], N. Bajjalieh [2], T. Radke [1], D. Holzgraefe [1], *[1]ADM Alliance Nutrition, Quincy, IL, [2]Integrative Nutrition, Inc., Decatur, IL.*

The objective was to measure DE and ME in a soybean meal (SBM) low in oligosaccharides (SBM-LO), and compare it against a conventional SBM (SBM-C). The following concentrations were measured in SBM-C vs. SBM-LO (DM basis): GE, 4,564 vs. 4,639 kcal/kg; sucrose, 8.02 vs. 15.73%; raffinose, 1.01 vs. 0.35%; stachyose, 5.16 vs. 0.40%, respectively. The DE and ME were measured in grower (51±0.6 kg BW) and finisher (95±0.4 kg BW) barrows; the same procedures were followed in each period. The experiment had a randomized complete block design; blocks were categories of BW. The 3 treatments were a basal diet (97.28% corn), and the basal diet with 30% of either SBM-C or SBM-LO added at expense of corn. Each treatment had 8 block replicates. All diets included a phytase (500 FTU/kg of diet) without consideration of energy or nutrient contribution. Feed offer was set to provide 2.5 times their energy maintenance requirement; that calculation assumed SBM-LO to have 10% more energy than SBM-C, reducing feed offer by 3% as compared to pigs fed SBM-C. Pigs were placed in metabolic cages and allowed 14 d of adaptation, followed by 4 d of total collection of feces and urine. The DE and ME values in ingredients were calculated by the difference procedure. Both DE and ME values measured in corn (Table 1) were less than 3% smaller than book values (Nutrient Requirements of Swine, 2012). The ME measured value in SBM-C was 13 and 6% less in grower and finisher pigs, respectively, than its book value (Nutrient Requirements of Swine, 2012). In grower pigs, SBM-LO had 550 kcal of either DE or ME/kg of DM more (P<0.05) than SBM-C. In finisher pigs, SBM-LO had 399 kcal of DE and 293 kcal of ME/kg of DM more (P<0.05) than SBM-C. In conclusion, SBM-LO had about 16.5% more energy in grower pigs and about 9.6% more energy in finisher pigs than SBM-C.

Table 1. Energy value (kcal/kg DM) of corn and soybean meals conventional (SBM-C) or low oligosaccharides (SBM-LO) in pigs

Item	Corn	SBM-C	SBM-LO	SEM
DE in growers	3,889[b]	3,436[c]	3,986[a]	12
ME in growers	3,799[a]	3,250[b]	3,800[a]	17
DE in finishers	3,849[b]	3,685[c]	4,084[a]	9
ME in finishers	3,739[a]	3,454[b]	3,747[a]	14

[a,b,c] Within rows, means with different superscript differ (P<0.05)

Key Words: energy, pigs, soybean meal

P075 Table

Diet Form:		Meal				Pellet				
	Grind type:	Unground		Ground		Unground		Ground		
Item	Soybean hulls, %:	10%	20%	10%	20%	10%	20%	10%	20%	SEM
ADG, g		475	477	460	467	502	494	478	490	17.8
ADFI, g		708	735	677	708	746	736	722	743	29
G:F		0.672	0.649	0.679	0.66	0.673	0.672	0.662	0.661	0.007
Caloric efficiency, Mcal/kg										
ME		4.7	4.64	4.65	4.56	4.69	4.47	4.77	4.56	0.05
NE		3.29	3.17	3.26	3.12	3.29	3.06	3.34	3.12	0.04

P077 **Grain distillers dry yeast on nursery pig performance.** V. Perez[1,*], J. Less[2], T. Radke[1], D. Holzgraefe[1], *[1]ADM Alliance Nutrition, Quincy, IL, [2]ADM, Specialty Feed Ingredients, Decatur, IL.*

A total of 192 newly weaned pigs (5.8±0.2 kg BW and ~21 d of age) were used to measure the effect of increasing the concentration of a dietary grain distillers dry yeast (DY) on their performance. The DY is a *Saccharomyces cerevisiae* used in corn ethanol production. The experiment had a randomized complete block design; blocks were 4 BW categories × 2 nursery rooms. The experimental unit was a pen with 2 barrows and 2 gilts. Each treatment had 8 block replicates. Dietary treatments were the inclusion of DY at 0, 0.5, 1, 2, 4, and 8% of the diet. As the dietary inclusion of DY increased across treatments from 0 to 8% DY, fish meal was gradually replaced from 3.85 to 0% in diets for d 0 to 7, and from 2.5 to 0% in diets for d 7 to 14. Dietary treatments were fed from d 0 to 42, and then a common diet without DY was fed to all pigs from d 42 to 56. All diets were formulated to provide the same energy and nutrient concentrations among treatments. Amino acids were provided on a standardized ileal digestibility basis. The ADG and ADFI were calculated per pen on a pig-day basis. Data were analyzed using the MIXED procedures of SAS; block was used as a random effect in the model. Linear and quadratic polynomials were estimated for the inclusion of DY. No differences were detected in ADG and ADFI among treatments. During d 0 to 14, G:F in pigs fed 0.5% DY was lower (P<0.05) than that in pigs fed 1 or 8% DY (Table 1). The reason for that effect is unknown. The G:F from d 0 to 56 increased as more DY was included in the diet (DY linear effect, P=0.060). In conclusion, DY replaced fish meal without affecting pig performance. Adding up to 8% DY in the diet during the first 6 wk post-weaning was not detrimental for pig performance. Overall, feed efficiency improved with increasing levels of DY.

Table 1. Increasing concentrations of dietary grain distillers dry yeast (DY) on nursery pig performance.

Response	DY 0%	DY 0.5%	DY 1%	DY 2%	DY 4%	DY 8%	SEM
ADG d 0-14, g/d	321	313	306	316	308	312	14
G:F d 0-14, g/kg	920	883	946	901	896	948	22
ADG d 0-42, g/d	560	562	543	551	539	544	14
G:F d 0-42, g/kg	693	695	700	680	688	700	10
ADG d 0-56, g/d	653	656	631	635	637	653	14
G:F d 0-56, g/kg*	640	647	645	631	653	660	9

* Linear effect, P=0.060.

Key Words: nursery, pigs, yeast

P078 **Inclusion of fermented soybean meal, chicken meal, or poultry by-product meal in phase 1, phase 2, and phase 3 diets fed to weanling pigs.** O. J. Rojas Martinez*, H. H. Stein, *Animal Sciences, University of Illinois , Urbana.*

Three experiments were conducted to test the hypothesis that fermented soybean meal (FSBM), chicken meal (CM), or poultry by-product meal (PBM) can replace fish meal (FM) in diets fed to weanling pigs during the initial 28 d post-weaning. In all experiments, newly weaned pigs (21 d) were randomly allotted to a randomized complete block design. In Exp 1, 192 pigs (initial BW: 6.88 ± 2.48 kg) were allotted to 4 dietary treatments with 2 phases. In phase 1, a positive control diet contained FM, whey powder (WP), and protein plasma (PP). A negative control diet (without animal protein) and 2 additional diets in which FSBM replaced FM or FM and PP were also formulated. In phase 2 diets, a positive control, a negative control diet, and 2 diets in which FSBM replaced FM or FM and WP were formulated. In Exp 2, 175 pigs (initial BW: 6.86 ± 2.86 kg) were allotted to 5 dietary treatments with 3 phases. The positive control diet contained FM, WP, and PP in phase 1 and 2, and FM and WP in phase 3, but no animal ingredients were included in the negative control diets. Three additional diets were formulated within each phase in which FSBM replaced FM, FM and PP, or FM, PP, and WP. In Exp. 3, 175 pigs (initial BW: 6.97 ± 2.1 kg) were allotted to 5 dietary treatments with 3 phases. The positive control diets contained FM, whereas no FM was included in the negative control diets. Three additional diets were formulated within each phase in which FM was replaced by CM, PBM, or FSBM. The final BW of the pigs in each experiment was not different among treatments. Likewise, the G:F ratio for the overall experiment were not different among treatments in Exp. 1 and Exp. 2. However, in Exp. 3, G:F was greater for pigs fed the positive control diets than for pigs on the other treatments, but it was not different among pigs fed CM, PBM, and FSBM. In conclusion, FSBM may replace FM, CM, and PBM in diets fed to pigs during the initial 28 d post-weaning without affecting pig growth performance except that G:F may be reduced.

Key Words: Fermented soybean meal, chicken meal, poultry by-product meal, pigs

P079 **Effects of feeding low or high peroxidized distillers dried grains with solubles (DDGS) to sows and their progeny on growth performance and carcass characteristics of progeny.** X. Li[1], G. C. Shurson[1], S. K. Baidoo[2], D. D. Gallaher[3], J. E. Anderson[4], L. J. Johnston[5,*], *[1]Department of Animal Science, University of Minnesota, Saint Paul, [2]Southern Research and Outreach Center, University of Minnesota, Waseca, [3]Department of Food Science and Nutrition, University of Minnesota, Saint Paul, [4]Division of Science and Math, [5]West Central Research and Outreach Center, University of Minnesota, Morris.*

An experiment was conducted to evaluate the effects of feeding sows (gestation = 40%; lactation = 20%) and progeny (nursery and growing-finishing = 30%) DDGS containing low (LOD) or high (HOD) peroxidized lipid on growth performance and carcass characteristics of progeny. Mixed parity sows (n = 48; mean parity = 3.2) were assigned to 1 of 3 dietary treatments [corn-soybean meal control diets (CON), LOD, or HOD] in a completely randomized design. Concentrations of ME and AA were similar between diets within phase and exceeded NRC (1998) recommendations. Malondialdehyde (MDA) concentrations in gestation and lactation diets were: 2.32, 3.70, 4.08, 2.89, 3.24, and 3.36 ng/mg oil, respectively. Pre-suckling pigs were sorted by individual birth weight into Small (≥ one SD below avg birth weight of the litter) and Large (≥ one SD above avg birth weight of the litter). At weaning, 182 mixed sex piglets (2 to 3 from each birth weight group) were allotted to 1 of 6 treatments (3 diets with 2 birth weight groups nested in each diet). Each pen housed 7 or 8 pigs and there were 4 pens per treatment. Pigs were assigned to diets from weaning to harvest that contained the same sources of DDGS as their dams consumed. Pigs fed LOD or HOD had lighter (P < 0.05) final BW than pigs fed CON (114.8 or 113.7 vs. 118.4 kg; SE = 1.12). Pigs fed LOD had lower ADFI than pigs fed CON or HOD from weaning to harvest (1.79 vs. 1.90 or 1.94 kg; SE = 2.01). Feeding LOD tended to improve (P = 0.08) G:F compared with feeding CON or HOD throughout the study (0.52 vs. 0.50 or 0.49; SE = 0.01). Large pigs fed HOD had greater (P < 0.05) ADG and ADFI compared with Small pigs fed the same diet. Feeding HOD decreased (P < 0.05) backfat depth (26.8 vs. 28.4 mm; SE = 1.24) and loin eye area at the 10th rib (43.9 vs. 40.4 cm^2; SE = 1.28) compared with feeding CON. Small pigs fed LOD or CON

had lighter ($P < 0.05$) HCW than Large pigs fed the same diet. In conclusion, continuously feeding HOD to sows and offspring did not affect post-weaning growth but compromised carcass characteristics of finishing pigs. Small pigs had slower growth rate and lighter carcass weight compared with Large pigs fed the same diets.

Key Words: Peroxidized DDGS, growth performance, carcass quality, swine

P080 **Effect of dietary iodine value on tissue fatty acids and iodine value in market pigs.** Z. Rambo [1,*], A. Jones [1], A. Schinckel [1], D. Kelly [1], B. Richert [1], M. Latour [2], *[1]Animal Science, Purdue University, West Lafayette, [2]Animal Science, Southern Illinois University, Carbondale.*

Sixty barrows (initial BW 63.8 ± 1.5 kg) were used to evaluate the effect of diet iodine value (IV) on fatty acid (FA) composition of jowl (J), belly (B) and 10th rib backfat (BF) after an 83 d feeding period. Pigs were allocated in a randomized complete block design with 4 blocks, 3 pigs/pen. Diets were fed in four phases and formulated to 10% total fat. Inclusion rates of fat sources were 8.1% beef tallow (BT), 6.7% choice white grease (CWG), and 5.6% canola oil (CAN), high oleic acid canola oil (HOC), or soybean oil (SBO) for wheat-rye (BT), corn-soy (CWG), and corn-soy-DDGS (CAN, HOC, and SBO) based diets, respectively. Average diet IV of the four phases was 69.8, 83.9, 112.1, 107.9, and 124.0 for BT, CWG, CAN, HOC and SBO diets, respectively, as determined by the modified Folch procedure (1957). Fat samples from the J, B, and BF from each pig were collected and analyzed for FA composition using gas chromatography and tissue IV was determined (AOAC 1990). Diet main effects were analyzed using the GLM procedure of SAS and Duncans mean separation test. Overall (d 0 - 83) ADG, ADFI, and G:F was not affected by diet ($P > 0.10$). The main effect of diet was significant ($P < 0.01$) for all reported FA and IV data. Means with different superscripts differ at $\alpha = 0.05$. Jowl IV was 66.5^{a}, 70.1^{a}, 77.5^{b}, 76.5^{b}, and 83.4^{c} for BT, CWG, CO, HOC, and SBO diets, respectively. Belly IV was 63.1^{a}, 66.5^{a}, 76.9^{b}, 73.7^{b}, and 82.9^{c} for BT, CWG, CO, HOC, and SBO diets, respectively. Backfat IV was 64.0^{a}, 69.8^{b}, 80.7^{c}, 80.1^{c} and 92.3^{d} for BT, CWG, CO, HOC, and SBO diets, respectively. Pigs fed the BT diet consumed 20% more C18:0 (32.65 vs. 27.21 g/d) than pigs fed CWG, however percent C18:0 in the J (8.94 and 8.13%) and B (9.39 and 9.09%) was not different between BT and CWG, respectively. Intake of C18:1n9 was 95.5^{b}, 97.8^{b}, 127.1^{c}, 139.8^{d}, and 70.2^{a} g/d for BT, CWG, CO, HOC, and SBO diets, respectively. Pigs fed HOC had the highest C18:1n9 in the B; but, C18:1n9 was not different between pigs fed BT, CWG, CO, or SBO in B. These results indicate that diet IV can significantly alter tissue IV, however the magnitude of change of C18:0 and C18:1n9 in fat tissue is less influenced by feeding high SFA and MUFA diets as a result of de-novo fat synthesis and conversion.

Key Words: diet fatty acid, iodine value, swine

P081 **Validation of the net energy content of canola meal and efficacy of a multi-enzyme product in 15 to 34 kg nursery pigs.** E. L. Hansen [1,*], E. D. Frugé [1], S. A. Hansen [1], K. A. Frerichs [1], C. W. Hastad [2], *[1]Hubbard Feeds, Mankato, [2]New Fashion Pork, Jackson.*

An experiment was conducted to validate the net energy (NE) content of canola meal (CM) and the potential improvement in CM net energy through the use of a multi-enzyme product (MEP). Pigs (N=999, 15.4 kg) were allotted to 6 dietary treatments (TRT) with 6 replicates and 26 to 28 pigs per pen in a randomized complete block design. The experimental TRT were; 1) Control (C), 0% CM with 1.25% added pork fat; 2) C + 10% CM; 3) C + 20% CM; 4) C + 30% CM; 5) As 3, + 425 ppm MEP; 6) As 3, iso-caloric to TRT 1 (3.35% added pork fat). All diets contained 15% DDGS and 1000 FYT/kg phytase (DSM, Ronozyme Hi-Phos). The NE matrix values for corn, soybean meal, DDGS, pork fat, and CM were obtained from NRC (2012). Pig weights and feed disappearance were measured on d 0, 7, 14, 21, and 27. A summary of the overall results is presented in Table 1. Pigs fed increasing CM tended to have reduced ADG (Q, $P < 0.09$) at 20% or greater. Pigs fed increasing CM had increased ADFI (Q, $P < 0.03$) at 10 and 20% then reduced ADFI at 30%. Pigs fed increasing CM had decreased G:F (L, $P < 0.01$) starting at 10% CM. There was no improvement in performance for pigs fed TRT 5 (MEP) compared to those fed TRT 3. Pigs fed TRT 6 had improved G:F compared to those fed TRT 3 and similar to those fed TRT 1. Dietary NE of TRT 1 was calculated at 2489 kcal/kg with caloric efficiency calculated at 3999 kcal NE/kg gain. Basis this caloric efficiency, CM was calculated to contain 1918, 1918, 2017, 1962 and 1907 kcal NE/kg for TRT 2 to 6, respectively, all of which are higher than NRC 2012 at 1889 kcal/kg. (See table below.)

Key Words: canola meal, net energy, pigs

P082 **Energy concentration and phosphorus digestibility in canola, cottonseed, and sunflower products fed to growing pigs.** D. A. Rodríguez, R. C. Sulabo, J. C. González-Vega*, H. H. Stein, *Animal Sciences, University of Illinois, Urbana-Champaign.*

Two experiments were conducted to determine the concentration of ME (Exp. 1) and the standardized total tract digestibility (STTD) of P (Exp. 2) in canola-, cottonseed-, and sunflower-products fed to growing pigs. Canola products included canola seeds (CS) and canola meal (CM), and cottonseed meal (CSM) was also used. Sunflower seeds (SFS), sunflower meal (SFM), and de-hulled sunflower meal (SFM-DH) were the sunflower products included, and de-hulled soybean meal (SBM) was also used. In Exp. 1, 48 growing barrows (BW: 44.8 ± 3.9 kg) were randomly allotted to 8 diets with 6 pigs per diet. A basal diet containing 97.15% corn and 7 diets containing corn and CS, CM, CSM, SFS, SFM, SFM-DH, or SBM were formulated. In Exp. 2, 84 growing barrows (BW: 13.7 ± 1.5 kg) were randomly allotted to 14 diets with 6 pigs per diet. Fourteen diets containing CS, CM, CSM, SFS, SFM, SFM-DH, or SBM without or with microbial

P081 **Table 1** The effects of increasing levels of CM.[1]

TRT[2]	1	2	3	4	5	6	SEM	P <	Lin	Quad
Initial BW, kg	15.2	15.5	15.4	15.5	15.5	15.4	0.11	0.39	0.26	0.45
ADG, g	704^{a}	708^{a}	697^{a}	670^{b}	700^{a}	698^{a}	8.68	0.07	0.01	0.09
ADFI, g	1130	1157	1162	1122	1157	1119	14.71	0.15	0.84	0.03
G:F	0.62^{a}	0.61^{ab}	0.60^{c}	0.60^{c}	0.61^{bc}	0.62^{a}	0.004	0.01	0.01	0.31
Final BW, kg	34.2	34.6	34.2	33.6	34.4	34.2	0.28	0.21	0.06	0.09

[1abc] Within a row, means without common superscript differ (P <0.05). [2]Lin and Quad (TRT 1 to 4).

phytase (500 phytase units per kg) were formulated. Results of Exp. 1 indicated that the ME in SFS and CS is greater than that of all other oilseed meals, but CM, CSM, SFM, and SFM-DH contain less ME than SBM. Results of Exp. 2 indicate that the STTD of P in CM is not different from the STTD of P in SBM and SFS, but greater than in CS, CSM, SFM, and SFM-DH. Microbial phytase increased the STTD of P in all ingredients.

Table 1. Concentrations of ME and STTD of P in ingredients[1]

Item	CS	CM	CSM	SFS	SFM	SFM-DH	SBM	SEM
ME, kcal/kg DM	5,098^{b}	3,306^{d}	2,700^{e}	5,739^{a}	2,998^{de}	2,860^{e}	4,035^{c}	110
STTD of P, %, -phytase[2]	45.6^{ef}	58.0^{cd}	45.6^{ef}	51.7^{cde}	37.4^{f}	50.0^{de}	62.0^{bc}	3.7
STTD of P, %, +phytase[2]	70.7^{ab}	74.6^{a}	60.0^{bcd}	73.8^{a}	59.8^{cd}	54.9^{cde}	78.0^{a}	

[1] $^{a-e}$Values within a row lacking a common superscript letter are different ($P < 0.01$)
[2] The STTD of P was greater ($P < 0.01$) for all ingredients if phytase was used, but no interactions between ingredient and phytase were observed.

Key Words: energy, oilseed meals, phosphorus

P083 **Effects of molasses supplementation on growth performance, nutrient digestibility, blood characteristics, fecal moisture, fecal noxious gas emission, and meat quality in finishing pigs.** S. C. Kim, L. Yan, I. H. Kim*, *Department of Animal Resource & Science, Dankook University, Cheonan, Republic of Korea.*

A total of 120 finishing pigs [(Landrace × Yorkshire) × Duroc, BW = 54.21 ± 2.62 kg] were used in a 10-week feeding trial to evaluate the effect of molasses inclusion on performance. Pigs were randomly assigned to 1 of 3 dietary treatments by BW and sex (2 gilts and 2 barrows/pen; 10 pens/treatment). Dietary treatments were: CON, basal diet (corn, 50.72%; rice bran, 4.31%; soybean meal 15.29%; limestone 0.78%); T1, basal diet (corn, 47.99%; rice bran, 4.47%; soybean meal, 15.42%; limestone, 0.73%) + 2.5% molasses; T2, basal diet (corn, 45.25%; rice bran, 4.62%; soybean meal, 15.55%; limestone, 0.68%) + 5.0% molasses. All diets were formulated to meet or exceed the NRC (1998) requirements for finishing pigs. Pigs were allowed ad libitum access to feed and water throughout the experimental period. Individual pig BW and feed consumption was recorded every 5 weeks to calculate growth performance. ATTD was measured following the procedures by the AOAC (2000). The whole blood samples were analyzed for RBC, WBC, and lymphocyte counts using an automatic blood analyzer (ADVIA 120, Bayer, Tarrytown, NY). Fecal *Lactobacillus* and *E. coli* shedding were measured by using MacConkey agar plates and *lactobacilli* medium III agar plates. At the end of the experiment, pigs were slaughtered for measuring meat color, WHC, pH, LMA, cooking loss and drip loss. There were no differences (P>0.05) in ADG, ADFI, and G/F among dietary treatments. The ATTD of DM, N, and energy were unaffected (P>0.05) by dietary treatments. The lymphocyte percentage in blood in T1 treatment was higher (P<0.05) (69.78% vs. 63.15%) than that in CON treatment at 10 week, but no differences (P>0.05) were observed in the concentrations of RBC and WBC. No difference (P>0.05) was observed in meat quality by application of molasses. The supplementation of molasses did not affect (P>0.05) the fecal noxious gas emission. The fecal moisture was also unaffected (P>0.05) by dietary treatments. In conclusion, results indicated that supplementation of 2.5% molasses increased (10.5%) blood lymphocyte percentage, but had no effect on growth performance, fecal gas emissions, and meat quality in finishing pigs.

Key Words: finishing pigs, growth performance, molasses

P084 **Effect of rate of daily gain on nutrient and energy digestibility in growing-finishing pigs.** N. W. Jaworski [1,*], A. Owusu-Asiedu [2], D. Petri [3], H. H. Stein [1], *[1]Animal Science, University of Illinois, Urbana, [2]Danisco Animal Nutrition, DuPont Industrial Biosciences, [3]Animal and Environmental Applications, DuPont Nutrition and Health, Waukesha.*

An experiment was conducted to test the hypothesis that slow-growing pigs have reduced digestibility of energy and nutrients compared with faster-growing pigs if fed a diet based on corn, soybean meal, and distillers dried grains with solubles. Two experimental diets were used. The phase 1 diet was fed from 25 to 50 kg and the phase 2 diet was fed from 50 to 90 kg. Titanium dioxide (0.4%) was included in the diets as an inert marker. One hundred pigs (initial BW: 24.1 ± 2.0 kg) were randomly allotted to 2 pens by initial BW and sex. Each pen had 25 barrows and 25 gilts and had 6 feeders and 12 nipple drinkers to allow ad libitum feed and water consumption. Pigs were weighed individually at the start of the experiment, every fortnight, and at the end of each phase. Daily allotments of feed and feed left in feeders were recorded every fortnight and at the end of each phase. When pigs had an average BW of approximately 50 and 90 kg, 3 fast-growing pigs and 3 slow-growing pigs within each pen were selected, sacrificed, and immediately processed to collect digesta samples from the stomach, duodenum, jejunum, ileum, cecum, colon, and rectum. The ADG for these pigs were within 2 SD of the mean of the pen average. Data were analyzed with SAS Proc Mixed as a 2 X 2 factorial with 2 growth rates and 2 phases. There were no interactions between growth rate and phase and no differences in digestibility of energy and nutrients between fast- and slow-growing pigs. Phase 1 pigs had greater ($P < 0.05$) apparent total tract digestibility of DM, Ca, and P than phase 2 pigs, but phase 2 pigs had a greater ($P < 0.05$) apparent jejunal digestibility of DM, GE, crude fiber, ADF, and NDF than phase 1 pigs, but for all other measurements, no differences between phase 1 and phase 2 were observed. In conclusion, the digestibility of energy and nutrients is not different between fast- and slow-growing pigs and differences in energy or nutrient digestibility is not the reason for differences in pig growth rates within a pen.

Key Words: digestibility, growth rate, variation

P085 **Effect of levan supplementation on the immune response of growing pig challenged with lipopolysaccharide.** Z. F. Zhang, H. Y. Baek, I. H. Kim*, *Department of Animal Resource & Science, Dankook University, Cheonan, Republic of Korea.*

A total of 20 growing pigs (26.22 ± 0.55 kg) were used to evaluate the effect of levan on immunological responses and rectum temperature after lipopolysaccharide (LPS) challenge. Pigs were randomly allotted to 1 of 2 treatments for a 42-d trial. Dietary treatments included: 1) CON, control diet; 2) LV, CON + 0.05% levan. Levan consists of beta-(2, 6) linked fructose units with average molecular weight of 700 kDa. At the end of the experiment, 5 pigs in each treatment were intraperitoneal injected with *E. coli* LPS at a concentration of 100 μg/kg of BW, and the other half were injected with sterile saline solution. After LPS injection, blood samples were taken at 0, 2, 4, 6, 8 hours (h) for the determination of RBC, WBC concentration, lymphocyte percentage, and blood inflammatory response, and the rectum temperature was measured at the same time. LPS challenge increased (169.5%, 140.1%, 155.3%, 97.4%; P<0.01) cortisol concentration at 2, 4, 6 and 8 h. Serum cortisol concentration was decreased (30.5%; P<0.05) in LV compared that

in CON after at 2 and 8 h. WBC concentration was increased (25.4%, $P<0.05$) by levan supplementation at 6 h. Levan supplementation after LPS and saline challenge increased (22.53 or 20.97 vs. 18.02 or 17.52 × $10^3/\mu\ell$, $P<0.01$) WBC concentration compared CON after LPS and saline challenge at 8 h. LV treatment gave higher (25.6%, $P<0.05$) lymphocyte percentage compared with CON at 8 h. TNF-α concentration in CON was increased (38.0%, 29.6%, 39.3%; $P<0.05$) compared with that in LV at 4, 6 and 8 h. Serum IL-6 concentration was decreased ($P<0.05$) in LV compared with that in CON at 6 h (39.8%) and 8 h (27.4%). In conclusion, data from this study suggested that 0.05% levan supplementation decreased serum cortisol, TNF-α and IL-6 concentration, increased WBC concentration and lymphocyte percentage after LPS challenge in growing pigs, and may offer benefit effects on immune function post LPS challenge.

Key Words: growing pigs, levan, LPS challenge

P086 **Interaction of Grobiotic-s and antibiotics on growth performance of nursery pigs raised under substandard conditions.** H. Tran*, J. W. Bundy, Y. S. Li, T. E. Burkey, P. S. Miller, *Animal Science, University of Nebraska, Lincoln.*

A 5-wk feeding study was conducted to evaluate the efficacy of Grobiotic-s (GRO; International Ingredient Corp., St. Louis MO) in ameliorating the deleterious effects of substandard environmental housing conditions on growth performance of nursery pigs. Ninety-six weaned pigs (age, 20 ± 1 d; initial BW, 5.04 ± 0.5 kg) were randomly assigned into 16 pens. Dietary treatments included: 1) control (no GRO or antibiotics, AB); 2) GRO (2.5%); 3) AB (phase 1, 0.18% Tiamulin and 0.4% Chlortetracycline; phase 2, 0.18% Tiamulin); and 4) GRO + AB. Treatments were fed throughout phase 1 (wk 1 and 2) and phase 2 (wk 3). A common diet devoid of GRO or AB was fed to all pigs in phase 3 (wk 4 and 5). Substandard environmental conditions were created by incomplete cleansing of pens and feeders without disinfection following a previous trial (20 d apart). Room temperature was maintained at 23.3 to 24.4°C. Diets were formulated to meet or exceed nutrient requirements (NRC, 1998). Pigs were weighed and fecal samples were scored at d 0 and weekly thereafter. Pigs fed AB had greater ($P < 0.01$) BW on d 14, 21, and 28 compared to non-AB fed pigs. Pigs fed GRO tended to have greater ($P < 0.10$) BW compared to control pigs on d 21 and 28. Greater ($P < 0.01$) ADG (phase 1; 148 vs 85 g), ADFI (phase 1; 231 vs 196 g; phase 2, 491 vs 394 g), and GF (phase 1; 635 vs 434 g/kg) were observed in pigs fed AB compared to non-AB pigs. Overall, pigs fed AB had greater ADFI (496 vs 461 g; $P = 0.01$) compared to non-AB fed pigs. Pigs fed GRO tended to have greater (476 vs 446 g; $P = 0.08$) ADFI compared to control pigs. With respect to fecal scores, AB-fed pigs had decreased scores on d 7 (0.7 vs 1 and 1.1; $P = 0.07$) and d 21 (0.1 vs 0.5; $P = 0.001$) compared to non-AB fed pigs. There were no effects of GRO ($P > 0.10$) on fecal scores. Given the substandard environmental conditions, feeding AB improves growth performance and fecal score of pigs in the early nursery period and inclusion of GRO tends to increase feed consumption when compared to control pigs.

Key Words: antibiotics, Grobiotic-s, pigs

P087 **Effect of dietary addition of tiamulin and chlortetracycline on pig performance immediately after placement in the finishing barn.** S. Nitikanchana*, S. Dritz, M. Tokach, R. Goodband, J. DeRouchey, J. Nelssen, *Kansas State University, Manhattan.*

A total of 1,313 pigs (PIC 1050 × 337; initially 22 kg) were used in a 35-d study to determine the effects of adding tiamulin and chlortetracycline (CTC) to feed on pig performance immediately after the move from the nursery to the finisher barn (placement). There were 31 to 33 pigs per pen and 10 pens per treatment. Immediately after placement, pens were randomly allotted to 1 of 4 treatments arranged in a 2×2 factorial with main effects of tiamulin (0 and 38.5 ppm) or CTC (0 and 440 ppm). Diets were corn-soybean meal–based and contained 20% bakery meal and 35% dried distiller's grains with solubles. Treatment diets were fed from d 0 to 15 with a non-medicated diet fed to all pigs from d 15 to 35. An interaction ($P<0.01$) was observed for ADFI from d 0 to 15 and for the overall period, with pigs fed the diet without medication and the combination of tiamulin and CTC having greater ADFI than those fed either medication alone. Adding antibiotics to the diets improved G:F from d 0 to 15, with no differences among pigs fed tiamulin, CTC, or their combination (interaction, $P<0.01$). Adding tiamulin or CTC to diets improved ($P<0.01$) ADG and G:F from d 0 to 15. However, when the in-feed antibiotics were removed from the diet (d 15 to 35), ADG of pigs previously fed any of the medicated diets decreased (tiamulin $P<0.01$; CTC $P<0.06$) compared with pigs previously fed the non-medicated diet. Because the advantages in performance from d 0 to 15 were lost during the period from d 15 to 35, there were no overall differences ($P>0.15$) in ADG or G:F. Adding tiamulin and/or CTC to diets immediately after pig placement in the finishing barn can improve growth performance, but the performance was not maintained in the subsequent period when pigs were fed non-medicated diets.

Effects of tiamulin and CTC fed immediately after placement on growing pig performance

Item	No medication	Denagard	CTC	Denagard + CTC	SEM
d 0 to 15					
ADG, g	648	677	687	723	7.607
G:F	0.551	0.641	0.626	0.621	0.009
d 15 to 35					
ADG, g	921	870	887	855	12.74
G:F	0.491	0.458	0.477	0.454	0.009
d 0 to 35					
ADG, g	804	787	801	798	7.231
G:F	0.509	0.512	0.522	0.507	0.006

Key Words: chlortetracycline, pigs, tiamulin

P088 **Cytokine gene expression and secretion by alveolar macrophages derived from pigs fed spray dried porcine plasma.** H. Tran*, J. W. Bundy, P. S. Miller, T. E. Burkey, *Animal Science, University of Nebraska, Lincoln.*

An ex vivo experiment was conducted to evaluate the effects of spray dried porcine plasma (SDPP) on gene expression and secretion of tumor necrosis factor-alpha (TNFα) and interleukin-10 (IL10) by porcine alveolar macrophages (PAM) derived from pigs fed a control diet or diet containing 5% SDPP. On d 14 postweaning, 3 pigs per dietary treatment were selected and euthanized for PAM collection. The PAM cells from each pig were counted and seeded into the culture plates for 24 h before being washed and assigned to 2 treatments: control (no lipopolysaccharide; LPS) and LPS (10 ng/mL). Thus, 4 treatments included: 1) control diet, no LPS (CTL-); 2) control diet + LPS (10 ng/mL; CTL+); 3) SDPP diet, no LPS (SDPP-); 4) SDPP diet+ LPS (10 ng/mL; SDPP+). Total cellular RNA and culture media were harvested at 3, 6, and 24 h after the

LPS challenge. With respect to TNFα gene expression, no dietary effect ($P > 0.10$) was observed; however, LPS-treated PAM cells had greater (77.35 vs 1.23; $P < 0.001$) relative abundance of TNFα mRNA compared to non-LPS treated cells. The relative abundance of TNFα mRNA was greatest (85.9 vs 18.0 and 14.0; $P = 0.01$) at 3 h compared to 6 and 24 h after LPS addition. With respect to IL10 gene expression, there was a diet × LPS interaction ($P = 0.01$) where CTL+ had greater (10.6 vs 1.0; 1.8; and 1.2) IL10 mRNA relative abundance compared to CTL-, SDPP-, or SDPP+ treatments. The expression of IL10 in PAM cells was time independent ($P > 0.10$). With respect to TNFα concentration in culture media, there was a LPS × time interaction ($P = 0.01$) where CTL+ and SDPP+ cells secreted greater (54.29 and 80.91 vs 0.05 and 1.47 ng/mL) TNFα compared to CTL- or SDPP- at 24 h; however, no dietary effect on TNFα secretion was observed. In conclusion, LPS upregulates the expression (TNFα and IL10 mRNA) and secretion (TNFα) of pro- and anti-inflammatory cytokines by PAM cells; however, feeding SDPP had no effect on the expression and secretion of these cytokines upon secondary stimulation with LPS.

Key Words: cytokines, porcine alveolar macrophages, spray dried porcine plasma

P089 **Long term effects of spray-dried plasma in nursery diets on intestinal immune response to subsequent stress.** A. Moeser [1], J. Campbell [2,*], J. Crenshaw [2], J. Polo [2], *[1]North Carolina State University, Raleigh, [2]APC, Inc., Ankeny.*

The objective was to test the effects of level and duration of feeding spray-dried plasma (SDP) post-weaning (PW) on support of intestinal mucosa against subsequent moving stress and infection during transition from the nursery to the grower at 50 d of age. A total of 44 pigs (15-18 d of age) were fed 0%, 2.5% (1 wk PW), or 5% (2 wk PW) SDP in nursery diets. At approximately 32 d PW, pigs were subjected to mixing and transport stress and challenged with *Salmonella typhimurium* (ST). Pigs were inoculated intra-gastrically with doses of 3 x 10^9 cfu ST. A control group was fed 0% SDP and not challenged (NC). At 2 d post-infection villi height was reduced and ileal crypt depth was increased ($P<0.05$) as a result of challenge compared to NC pigs. Ileal crypt depth of pigs fed 5% SDP (250 μm) for 2 wk PW was greater ($P<0.05$) compared to all other treatments (132, 197, and 180 μm for NC, ST, and 2.5%, respectively) which might indicate a more robust recovery of the intestinal epithelia. Dextran flux increased ($P<0.05$) in challenged pigs fed diets with either 0 or 2.5% SDP (for 1 wk PW) compared to control NC pigs. Pigs fed the diet with 5% SDP (for 2 wk PW) did not exhibit increased permeability in response to challenge and stress. Ileal tissue concentration of TNF-α was increased ($P< 0.05$) in challenged pigs (209 and 186 pg/mL for ST and 2.5%, respectively) regardless of dietary SDP compared to control NC pigs (69 pg/mL) and was greatest for 5% SDP (313 pg/mL) which may indicate an enhanced immune response against ST. In summary, transportation stress combined with ST challenge induced clinical disease and intestinal barrier dysfunction. Pigs fed the enhanced nutrition supplied by the diet with 5% SDP during the initial 14 d PW were more resilient to gut injury caused by subsequent transport stress and ST. Results suggest 5% SDP supplemented in diets and fed for 2 wk PW enabled the pig to better cope with subsequent stress and enteric challenge later in life.

Key Words: stress, spray-dried plasma, salmonella, pigs

NONRUMINANT NUTRITION: SOW NUTRITION AND MANAGEMENT

P090 **Effects of dietary L-carnitine and chromium picolinate on sow reproductive performance.** N. W. Shelton [1,*], J. L. Nelssen[1], M. D. Tokach [1], S. S. Dritz [1], R. D. Goodband [1], J. M. DeRouchey[1], L. L. Greiner [2], J. Connor [2], J. C. Woodworth [3], *[1]Kansas State University, Manhattan, [2]Innovative Swine Solutions, Carthage, [3]Lonza, Allendale.*

A total of 211 sows and litters (PIC) were used to compare the effects of dietary L-carnitine and chromium on sow reproductive performance. Two dietary treatments were used including a control with no added L-carnitine or chromium and a test diet with 25 ppm L-carnitine and 200 ppb chromium from chromium picolinate (CC). Treatments were allotted in a generalized block design with parity serving as the blocking factor. Gilts and sows received treatment diets for at least 24-d prior to breeding, during gestation, lactation, and up until breeding for the subsequent parity. During gestation, sow feedings levels were based on parity and body condition. During lactation, sows were fed once daily and limited to 6.1 kg. Pigs were individually weighed at birth and d 18 of lactation. Adding CC to sow diets did not increase ($P>0.07$) the number of pigs born (14.1 vs. 13.9) or live born (12.9 vs. 13.0), BW of total (136 vs. 137 g) or live born (138 vs. 140 g) piglets, and litter weight for total (18.5 vs. 18.8 kg) or live born (17.4 vs. 17.9 kg) compared with sows fed the control diet. Adding CC to sow diets did not ($P>0.07$) impact the amount of variation in pig birth weight. Gilts and parity 2 sows fed CC nursed larger and heavier litters on d 7 of lactation compared to those not receiving CC (11.9 vs. 10.8; 30.5 vs. 28.4 kg); however, parity 3 and older sows fed CC nursed smaller and lighter litters compared to those not receiving CC (9.8 vs. 10.2; 25.0 vs. 27.4 kg; Parity × Treatment, $P<0.04$). Adding CC to sow diets did not impact ($P>0.07$) pig number (10.2 vs. 10.1), pig BW (544 vs. 556 g), or litter weight (61 vs. 62 kg) on d 18 of lactation. Sows fed diets containing CC also had increased ($P<0.02$) lactation feed intake (5.4 vs. 5.2 kg) and decreased ($P<0.01$) lactation BW loss (7 vs. 13 kg) compared with sow consuming diets without CC. Farrowing rate (90.3 vs. 92.3%), number of pigs born (12.8 vs. 12.0), and the number of pigs born alive (11.2 vs. 10.9) on the subsequent litter were unaffected ($P>0.07$) by adding CC to sow diets. This experiment showed minor differences in sow performance with the addition of 25 ppm L-carnitine and 200 ppb chromium from chromium picolinate.

Key Words: chromium, L-carnitine, sow performance

P091 **Effects of feeding low or high peroxidized distillers dried grains with solubles (DDGS) to sows on reproductive performance, incidence of low birth weight pigs, and within-litter variation of piglet birth weight.** X. Li [1], G. C. Shurson [1], S. K. Baidoo [2], D. D. Gallaher [3], J. E. Anderson [4], L. J. Johnston [5,*], *[1]Department of Animal Science, University of Minnesota, Saint Paul, [2]Southern Research and Outreach Center, University of Minnesota, Waseca, [3]Department of Food Science and Nutrition, University of Minnesota, Saint Paul, [4]Division of Science and Math, [5]West Central Research and Outreach Center, University of Minnesota, Morris.*

An experiment was conducted to evaluate the effects of feeding sows DDGS (gestation = 40%; lactation = 20%) containing low or high peroxidized lipid (LOD or HOD) on reproductive performance, incidence of low birth weight pigs, and within-litter variation of piglet birth weight. Mixed parity sows (n = 48; mean parity = 3.2) were assigned to 1 of 3 dietary treatments [corn-soybean meal control

diets (**CON**), LOD, and HOD] in a completely randomized design. Concentrations of ME and AA were similar between diets within reproductive phase and exceeded NRC (1998) recommendations for sows. Malondialdehyde (MDA) concentrations of CON, LOD, and HOD diets in gestation and lactation were 2.32, 3.70, 4.08, 2.89, 3.24, and 3.36 ng/mg oil, respectively. Individual birth weight of pre-suckling pigs within litter were sorted into 3 categories: Low (≤ 1.0 kg), Medium (> 1.0 kg and < 1.6 kg), and High (≥ 1.6 kg). Litter size and weight were not affected by diet. Sows fed HOD tended to farrow more ($P < 0.10$) dead pigs per litter (1.73 vs. 0.40; SE = 0.45) that were lighter (2.0 vs. 2.9 kg; SE = 0.25) than dead pigs from sows fed CON. Litters from sows fed LOD or HOD gained less ($P < 0.05$) weight than sows fed CON (44.0 or 38.0 vs. 49.9 kg; SE= 2.85). Within-litter variation in birth weight of total pigs born to HOD-fed sows tended to be greater ($P = 0.05$) than that of pigs born to LOD- or CON-fed sows. Feeding HOD to sows decreased ($P < 0.05$) the total Medium pigs born per litter, tended to decrease ($P = 0.09$) the number of live born Low pigs per litter, and increased ($P < 0.05$) the number of Low pigs born dead per litter compared with feeding LOD or CON. Small pigs (≥ one SD below the avg birth weight of the litter) within LOD or HOD treatments tended to have greater ($P = 0.05$) levels of plasma MDA (LOD: 24.8 vs. 17.7 μM; HOD: 19.8 vs. 17.4 μM; SE = 0.09) at birth than Large pigs (≥ one SD above the avg birth weight of the litter). In conclusion, feeding HOD to sows did not affect the number of low birth weight pigs born in total litter size, but increased number of dead pigs born per litter. Small pigs exhibited greater oxidative stress at birth than Large pigs.

Key Words: peroxidized DDGS, birth weight variation, MDA, swine

P092 **Effects of feeding distillers dried grains with solubles (DDGS) to sows on reproductive performance over 3 reproductive cycles.** X. Li[1], G. C. Shurson[1], S. K. Baidoo[2], Y. Li[3], L. J. Johnston[3,*], *[1]Department of Animal Science, University of Minnesota, Saint Paul, [2]Southern Research and Outreach Center, University of Minnesota, Waseca, [3]West Central Research and Outreach Center, University of Minnesota, Morris.*

Effects on reproductive performance were evaluated in sows fed DDGS for up to 3 reproductive cycles. Parity 0 (n = 311) and parity 1 (n = 90) sows were assigned randomly to 1 of 2 treatments and fed either a fortified corn-soybean meal control diet (CON; n = 203) during gestation and lactation, or diets containing 40% DDGS in gestation and 20% DDGS in lactation (DDGS; n = 198). All sows were offered 2.04 kg daily of their assigned diets adjusted for body condition during gestation and allowed ad libitum access to their assigned diets during lactation (avg = 19 d). Concentrations of ME and AA were similar between diets within reproductive phase and exceeded NRC (1998) recommendations for sows. Sow and litter performance data were analyzed using general linear models with repeated measures in time. Sows fed DDGS had lower ($P < 0.05$) BW than those fed CON at breeding (179 vs. 184 kg, Pooled SE = 1.46), d 109 of gestation (225 vs. 231 kg, Pooled SE = 1.81), farrowing (211 vs. 216 kg, Pooled SE = 1.70), and weaning (207 vs. 214 kg, Pooled SE = 1.65). Lactation ADFI and post-weaning interval to estrus were similar between sows fed DDGS and those fed CON. Total piglets born per litter were not different between dietary treatments. However, sows fed DDGS farrowed fewer live piglets (11.0 vs. 11.6, Pooled SE = 0.47; $P < 0.05$) and tended to farrow more dead piglets per litter (0.9 vs. 0.7, Pooled SE = 0.11; $P = 0.07$) than sows fed CON. Feeding DDGS decreased litter size at weaning (9.8 vs. 10.2, Pooled SE = 0.12; $P < 0.05$) compared with feeding CON. Diet had no effect on litter weight at birth. Sows fed DDGS weaned lighter litters than sows fed CON (65.2 vs. 67.8 kg, Pooled SE = 1.15; $P < 0.05$) due to smaller litter size at weaning. Litters nursing DDGS-fed sows gained less weight than litters nursing sows fed CON (47.8 vs. 49.8 kg; Pooled SE = 0.77; $P < 0.01$), but this difference was not present when litter weight gain was adjusted for litter size nursed. Average daily gain and pre-weaning mortality of piglets were not different for DDGS- and CON-fed sows. In conclusion, long-term feeding of DDGS for 3 reproductive cycles did not affect total litter size, but decreased number of live pigs and increased number of dead pigs per litter.

Key Words: DDGS, sow, reproductive performance

NONRUMINANT NUTRITION: VITAMINS AND MINERALS

P093 **The effects of fat soluble vitamin administration by oral gavage or injection on plasma vitamin status of newborn pigs.** Y. D. Jang[1,*], M. D. Lindemann[1], H. J. Monegue[1], R. Stuart[2], *[1]Animal and Food Sciences, University of Kentucky, Lexington, [2]Stuart Products, Bedford, TX.*

The effect of fat soluble vitamin (V) administration to newborn pigs by oral gavage or injection was evaluated in 2 experiments. A total of 65 pigs (Yorkshire × Duroc) were used from 8 litters. Treatments were: Exp. 1-1) control: no vitamins, 2) intramuscular injection, 0.8 mL of a product with 500 IU of VE, 50,000IU of VA, and 50,000IU of VD_3 per mL, and 3) oral administration (Oral), 0.8 mL of a product with 500 IU of V E, 50,000IU of VA, and 50,000IU of VD_3 per mL. Exp. 2-1) control: no vitamins, 2) intramuscular injection, 1.0 mL of the same product from Exp. 1, 3) Oral, 0.60 mL of 84,500 IU of VD_3 per mL, 4) Oral, 1.66 mL of 30,000 IU of VD_3 and 500 IU of VE per mL, 5) Oral, 1.00 mL of 500 IU of VE, 50,000 IU of VA, and 50,000 IU of VD_3 per mL, and 6) Oral, 1.66 mL of 500 IU of VE per mL. The products used were from Stuart Products Inc. (Bedford, TX). The treatments were applied to pigs at d 1 of age. All pigs in the groups treated with VD_3 had higher plasma 25-OH D_3 concentration than the control at d 10 after administration (9.43, 81.83 and 37.85 ng/mL, $P<0.01$ for Exp. 1; 8.25, 110.74, 86.20, 84.68, 77.17, and 6.47 ng/mL, $P<0.01$ for Exp. 2). In addition, the pigs administered the injectable product had the highest values among treatments. At weaning, plasma 25-OH D_3 levels declined from d 10 levels regardless of treatments but when the pigs received VD_3 by injection, plasma 25-OH D_3 levels were maintained to be higher than the other treatments in Exp. 1 (6.23, 30.85 and 9.49 ng/mL, $P<0.01$). In Exp. 2, plasma 25-OH D_3 concentrations were higher in VD_3 treatment groups than all others at weaning (5.02, 40.24, 30.88, 27.03, 26.10, and 5.10 ng/mL, $P<0.01$). The highest plasma α-tocopherol concentration was observed in the pigs of the injection group among all treatments at d 10 of administration both in Exp. 1 (6.85, 15.20, and 4.18 ng/mL, $P<0.01$) and Exp 2. (4.78, 11.26, 4.80, 6.93, 5.37, and 5.80 ng/mL, $P<0.01$). In conclusion, the results demonstrated that VD_3 administration to newborn pigs can elevate plasma 25-OH D_3 concentration regardless of administration routes but only the VE injection increased plasma α-tocopherol concentrations.

Key Words: fat soluble vitamin, piglet, administration routes

P094 **Effects of including microbial phytase in diets fed to pigs and broilers.** J. E. Lowell*, M. Song, J. K. Mathai, H. H. Stein, *Animal Science, University of Illinois, Urbana-Champaign.*

Improved utilization of plant P in feed ingredients has been reported when diets are fortified with microbial phytase. Variability among trials in results has been reported. The objective of this study was to review articles for quantitative responses of pigs and broilers fed diets with microbial phytase. A total of 128 peer-reviewed scientific articles were reviewed and summarized and their data for effects of microbial phytase fed to growing pigs or broilers were recorded and summarized. Data were analyzed using the linear regression procedure to describe relationships between dietary microbial phytase and each reported response. For both species, reported responses to dietary microbial phytase were bone ash (%), ADG, G:F, and apparent ileal digestibility (AID) of P, Ca, N, and AA. For pigs, apparent total tract digestibility (ATTD) of P, Ca, and N were also reported. When microbial phytase was added to diets fed to growing pigs, a linear increase ($P < 0.05$) in bone ash, G:F, and ATTD of P and Ca was observed. There was no effect of microbial phytase on ADG, ATTD of N, and AID of AA. For broilers, a linear increase ($P < 0.05$) in G:F and AID of P, Ca, N, and AA was observed when microbial phytase was added to the diet. There was no effect of phytase on bone ash and ADG. Digestibility of P was found to be the most sensitive to microbial phytase in growing pigs and broilers. Both AID of P in broilers and ATTD of P in pigs should be used to determine the microbial phytase response. However, bone ash is not always an accurate predictor of effects of microbial phytase. If microbial phytase is added to broiler diets, values for AID in feed ingredients should be elevated. If microbial phytase is added to growing pig diets, it is not necessary to elevate AID values. The increase in G:F in pigs and broilers indicates possible energy release when using microbial phytase. More research is needed to confirm this hypothesis and to quantitate the response.

Key Words: bone ash, digestibility, growth rate

P095 **Optimization of dietary phosphorus and calcium to maximize their utilization by growing pigs for sustainable farming.** E. Gonzalo*, M.-P. Létourneau-Montminy, C. Pomar, *Agriculture and Agri-Food Canada, Sherbrooke.*

The impact of dietary calcium (Ca) and P deficiency (depletion) on Ca and P efficiency during a recovery period (repletion) was studied in 60 male pigs (iBW 14.0 ± 1.6 kg, fBW 67.6 ± 6.1 kg) randomly assigned to one of the 4 treatment groups. Pigs were fed fulfilling the estimated nutrient requirements (INRA, 2005) with a control diet (C) or a low-P diet (L) providing 60% of the digestible P and total Ca of C diet during 2 feeding phases of 28 d (15-35 and 35-70 kg BW) in a cross-over design consisting in CC, CL, LC and LL groups. Total body and L2-L4 lumbar region bone mineral content (BMC) and density (BMD) was estimated at the beginning and at the end of each feeding phase by dual x-ray absorptiometry. During the 1st feeding phase pigs fed with C diet had 4 times higher BMC deposition (8.6 vs 2.1 g/d; $P < 0.001$) which resulted at the end of the period in higher ($P < 0.001$) total body BMC and BMD (53% and 15%, respectively) than L fed pigs. Also, L diet fed pigs tend to have lower ADG (698 vs. 751 g/d, $P = 0.057$) than C fed pigs. During the 2nd feeding period CC diets fed pigs had higher total body BMC and BMD (20% and 11% respectively, $P < 0.001$) and tend to have higher ADG (6%, $P = 0.08$) than LC pigs while ΔBMC was similar. When comparing CL fed pigs with those fed in the LC sequence, the latter tend to have lower feed conversion ratio (7%, $P = 0.06$), and a higher Δ BMC (48%, $P < 0.001$). Pigs fed LC compared to LL diet presented higher total body BMC and BMD (34% and 13% respectively, $P < 0.001$) at the end of the 2nd feeding period, due to a higher ΔBMC (21.6 vs 11.9 g/d, $P < 0.001$), and a lower FCR (5%, $P < 0.001$). Results showed that pigs fed the diet deficient in Ca and P from 15 to 35 kg followed by C diet from 35 to 70 kg, are not efficient enough to compensate the bone mineral deficit. Further research is needed to study if LC pigs would recover bone deficit with excess mineral in C diet during the 2nd feeding phase. The results also underline the need to study the consequences of this early P deficiency until slaughter.

Key Words: depletion-repletion, phosphorus, pigs

P096 **Evaluation of the energy and amino acid matrix of a novel microbial phytase (Quantum Blue).** C. Walk[1,*], T. Santos[1], J. Chewning[2], P. Wilcock[1], *[1]AB Vista, Marlborough, United Kingdom, [2]SRS, Fayetteville.*

Dietary phytate is an anti-nutrient that has been shown to increase endogenous amino acid loss and to increase the maintenance energy costs in the animal. The objective of this trial was to determine if an energy and amino acid matrix can be applied to 500 FTU/kg of a phytase in addition to the traditional mineral release when fed to pigs from 22 to 55 kg. Pigs (n = 300; 22.7 kg) were sexed and allotted to 5 treatments with 12 replicates (6 barrows and 6 gilts) of 5 animals per pen and fed a 2 phase diet program [23 - 37 kg (P1) and 37 - 55 kg (P2)]. Treatments were: PC) Positive control diet formulated to meet the nutrient requirements of the pig (P1: calcium (Ca) 0.71%, available phosphorus (AVP) 0.32%, metabolizable energy (ME) 3,300 kcal/kg, and digestible lysine (DL) 1.1%; P2: Ca 0.61%, AVP 0.27%, ME 3,100 kcal/kg, and DL 0.96%); T2) PC -0.15% AVP and 0.16% Ca; T3) T2 + 500 FTU/kg phytase; T4) T2 -52 kcal/kg ME and 0.02% DL; and T5) T4 + 500 FTU/kg phytase. At 43 d, 1 pig/pen (12 pigs per treatment) was euthanized and the 4th metacarpal taken and bone breaking strength (BS), ash weight (AW), and percentage ash (PA) were measured. Reduction of Ca and AVP (T2) did not affect ($P > 0.05$) animal performance, but reduced ($P < 0.05$) AW when compared with the PC. Addition of 500 FTU/kg to T2 (T3) significantly ($P<0.05$) improved AW back to the level of the PC supporting a mineral release for 500 FTU/kg phytase. When energy and DL were reduced along with AVP and Ca (T4) the performance (gain, ADG, and G/F) and bone parameters (AW and PA) were significantly reduced ($P< 0.05$) compared to the PC. The addition of a phytase at 500 FTU/kg to T4 (T5) significantly improved ADG, AW and PA back to the level of the PC while G/F was not significantly ($P > 0.05$) different from the PC or T4. These results show that the addition of 500 FTU/kg phytase to a diet low in AVP, Ca, ME and DL improves the performance back up to the level of a PC supporting the hypothesis that energy and amino acid acids can be considered when including phytase into pig diets.

Key Words: energy, phytase, pigs

P097 **Inclusion of high levels of phytase (Quantum Blue) improves the performance of pigs from weaning to 21 days post-weaning.** G. Cordero*, T. Santos, C. Walk, P. Wilcock, *AB Vista, Marlborough, United Kingdom.*

It is hypothesized that even a low level of dietary phytate is detrimental to piglet performance. This study was therefore designed to determine if high levels of a novel *E. coli* phytase, when added to a starter feed program from weaning to 21 days post-weaning would

improve post-weaning pig performance in diets already meeting available phosphorus (AVP) requirements. Weaned pigs (n= 360, 18-20 d of age, 5.5 kg) were allotted to one of 2 dietary treatments: T1) commercial diet (CD) and T2) commercial diet + 2000 FTU/kg phytase **(**CD+P**)**. There were 27 pens of pigs fed CD and 9 pens of pigs fed CD+P with 10 pigs per pen. All pigs were fed a 2 phase program [0-7 d (P1) and 7-21 d (P2)]. Each phase was designed to meet the nutrient requirements of the pig across treatments with each phase formulated to meet AVP requirements without including the phosphorus (P) released by phytase (P1: AVP 0.45%; Calcium (Ca) 0.80% and phytate-phosphorus (PP) 0.20% and P2: AVP 0.42%; Ca 0.80% and PP 0.22%). P1 was a semi-complex diet (corn/soya/whey/plasma/animal protein) and P2 a simple diet formulated by increasing dietary soya and corn level at the expense of whey, plasma and animal protein. In P1 or P2, pigs fed the CD+P pig had significantly improved gain (P<0.05) and a tendency for improved ADG (P<0.09) with a numerical improvement in G:F when compared to pigs fed the CD. Overall (d0 to 21), pigs fed CD+P showed a significant improvement in gain (P<0.05; CD+P: 6.26 kg and CD: 5.81 kg) with a numerical improvement in G:F when compared to the pigs fed CD. Overall, the weight gain advantage of the CD+P pigs vs. the CD pigs was 0.45 kg after 21 days post-weaning indicating that the addition of 2000 FTU/kg of a phytase in diets adequate in P improved gain in newly weaned piglets. This suggests that the performance benefit seen, when phytase was added over the top of diets formulated to meet the P requirement of the pig, may be due to the breakdown of phytate as an anti-nutrient, rather than P-release from phytase.

Key Words: growth, phytase, pigs

P098 **Effects of phytase with different calcium and phosphorous density diets on growth performance, nutrient digestibility, blood profiles, fecal noxious gas emission, and meat quality in finishing pig.** S. M. Hong, K. H. Kim, I. H. Kim*, *Department of Animal Resource & Science, Dankook University, Cheonan, Republic of Korea.*

A total of 112 finishing pigs [(Landrace × Yorkshire) × Duroc, BW = 57.12 ± 2.34kg] were used in a 10-week growth trial to evaluate the effects of supplementation with phytase in different calcium and phosphorous density diets on performance. The dietary treatments were: T1, basal diet (0.65% Ca, 0.60% P); T2, basal diet (0.60% Ca, 0.55% P) + 0.01% phytase; T3, basal diet (0.55% Ca, 0.50% P) + 0.015% phytase; T4, basal diet (0.50% Ca, 0.45% P) + 0.02% phytase. Phytase was added at 5000 units of FTU/kg feed. Individual pig BW and feed consumption was recorded every 5 weeks to calculate growth performance. At the 5th and 10th week, nutrient digestibility was measured following the procedures by the AOAC (2000), and blood profiles and fecal gas emission were analyzed. At the end of the experiment, pigs were slaughtered for measuring meat quality. Final BW was increased (P<0.05) in T2 and T3 treatments compared with T1 treatment (112.9 or 112.1 vs. 109.5 kg). Pigs fed the T2 and T3 diets had a higher (P<0.05) ADG than those fed the T1 treatment during 0 to 5 week (753 or 748 vs. 699 g) and 0 to 10 week (792 or 786 vs. 750 g). There was no difference (P>0.05) in nutrient digestibility among treatments. The concentrations of serum inorganic phosphorus in T2 and T3 were higher (P<0.05) than that in T1 (11.25 or 10.95 vs. 9.28 mg/dL) at 5th week. No difference (P>0.05) was observed in the concentrations of RBC, WBC, calcium, and lymphocyte percentage among treatments. At the end of 10 week, the fecal ammonia emission was higher (P<0.05) in T1 than those in T3 and T4 on d 3 (17.9 vs. 15.2 or 14.7 ppm) and d 5 (19.8 vs. 17.6 or 17.0 ppm). Total mercaptans emission was higher (P<0.05) in T4 group than T1 group (26.2 vs. 28.8 ppm) on d 5, and the H_2S emission in T4 was higher (P<0.05) than those in T1 and T2 (19.7 vs. 23.3 or 23.0 ppm). The H_2S emission was increased (P<0.05) in T3 and T4 compared with T1 (26.8 or 26.3 vs. 28.9 ppm) on d 7. The meat quality was unaffected (P>0.05) by dietary treatments. In conclusion, dietary supplementation with phytase could improve growth performance, and decrease fecal noxious gas emission in finishing pigs.

Key Words: finishing pigs, growth performance, phytase

P099 **Phosphorus digestibility and concentration of digestible and metabolizable energy in corn, corn co-products, and bakery meal fed to pigs.** O. J. Rojas *, H. H. Stein, *Animal Sciences, University of Illinois, Urbana.*

Two experiments were conducted to determine the standardized total tract digestibility (STTD) of P and the concentration of ME in corn, hominy feed, bakery meal, distillers dried grains with solubles (DDGS), corn gluten meal, corn gluten feed, and corn germ meal fed to growing pigs. In Exp. 1, 84 barrows (BW: 13.7 ± 2.3 kg) were placed in metabolism cages and allotted to a randomized complete block design with 14 diets and 6 pigs per diet. Fourteen diets were formulated to contain corn, hominy feed, bakery meal, DDGS, corn gluten meal, corn gluten feed, or corn germ meal and either 0 or 500 units of microbial phytase. The STTD of P was greater (P < 0.01) in DDGS, corn gluten meal, and corn gluten feed than in corn, hominy feed, bakery meal, and corn germ meal, and the STTD of P was also greater (P < 0.01) in bakery meal than in corn and hominy feed. Addition of phytase increased (P < 0.05) the STTD of P in corn, hominy feed, bakery meal, and corn germ meal, but not in corn gluten meal, corn gluten feed, and DDGS. In Exp. 2, 56 barrows (BW: 14.6 ± 2.2 kg) were placed in metabolism cages and allotted to a randomized complete block design with 7 diets and 8 pigs per diet. Three diets based on corn, hominy feed, or bakery meal and 4 diets containing corn and DDGS, corn gluten feed, corn gluten meal, or corn germ meal were formulated. The concentration of ME was 3,891, 3,675, 3,655, 3,694, 4,400, 3,169, and 3,150 kcal/kg DM in corn, hominy feed, bakery meal, DDGS, corn gluten meal, corn gluten feed, and corn germ meal, respectively. The ME in corn was greater (P < 0.01) than in hominy feed, bakery meal, corn gluten feed, and corn germ meal, but less (P < 0.01) than in corn gluten meal. In conclusion, DDGS, corn gluten meal, and corn gluten feed have a greater STTD of P than corn, hominy feed, bakery meal, and corn germ meal, but phytase can be included in diets containing corn, hominy feed, bakery meal and corn germ meal to improve P digestibility. The ME was greater in corn gluten meal than in bakery meal, corn, and corn co-products.

Key Words: corn co-products, energy, phosphorus

P100 **Meta-analysis of the impact of dietary phosphorus, calcium and microbial phytase on growth performance in pigs.** M.-P. Létourneau-Montminy [1,*], A. Narcy [2], [1]*Agriculture and Agri-Food Canada, Sherbrooke, Canada,* [2]*INRA, Nouzilly, France.*

This study is part of an ongoing program developing a robust mechanistic model predicting phosphorus (P) and calcium (Ca) utilization by pigs in a large range of dietary situations. In the model, the impact of the main modulating factors of P utilization, mainly

dietary P, Ca and microbial phytase (PhytM) on absorption and retention of Ca and P are taken into account. Growth performance is simulated with InraPorc growth model independently of these interfering factors. However, P status is reported to modify growth performance. The objective of the current work was thus to quantify the impact of dietary P, Ca and PhytM on growth performance of pigs. A database including 18 publications (105 experiments, 528 treatments) was used to predict average daily gain (ADG), average daily feed intake (ADFI) and feed efficiency (G:F) in pigs from 5 to 126 kg of BW. The random effect of the experiment has been included in the models as well as Initial body weight (iBW) to study the impact of pig physiological stage on their response to P. The response of the three criteria to non-phytate P (NPP) is curvilinear (NPP and NPP x NPP, $P < 0.010$). Furthermore, increasing dietary Ca reduces ADG especially in low NPP diet (Ca x NPP, $P = 0.030$). The response of growth performance to PhytM is also curvilinear (PhytM x PhytM, $P < 0.050$) and depends on both NPP and Ca (PhytM x PhytM x Ca x NPP, ADG: $P = 0.003$; ADFI: $P = 0.030$; G:F: $P = 0.050$): the more the P deficiency is acute, *i.e.* in high Ca and low NPP diet, the more the response of growth performance to PhytM is high. Also, the response to NPP in relation with Ca in terms of ADFI and G:F depends on iBW (NPP x Ca x iBW; $P < 0.01$): pigs with higher iBW appeared to be less sensitive to P deficiency, which is more pronounced in high dietary Ca. Results of the current meta-analysis show that P deficiency alters growth performance, mainly through reducing ADFI. This emphasizes the need to take into account these laws of response when simulating the metabolic response of growing pigs to dietary P.

Key Words: meta-analysis, phosphorus, pigs

PHYSIOLOGY

P101 **An economical farm technology to quantify estrous cervix morphology in lactating dairy cows.** A. Nikkhah [1,*], S. Karimzadeh [2], *[1]Animal Science, [2]Animal Sciences, University of Zanjan, Islamic Republic of Iran.*

The objective was to examine a cost-effective farm technology to quantify dairy cow cervix morphology in different phases of the cow estrous cycle. Cervix distinctness, central positioning, motility and mucosal secretions were scored daily on a 5-scale basis during proestrus (PE), standing estrus (SE), diestrus (DE) and metestrus (ME) phases in four multiparous Holstein cows (50 ± 14 days in milk, 31 ± 3.6 kg milk yield, 643 ± 66 kg BW, 3.0 ± 0.18 BCS). The design was a split-plot with cow as the main plot and estrous phase as sub-plot. The cervix morphology was video-recorded using a farm apparatus with 45 cm length and 2.7 cm diameter, internal electrical settings, external polyvinyl cover, front lights, and terminal wires connected to a laptop computer installed with an image processing program. The score of 1 represented cervices with fully distinct, central, stable, and mucosal manifestation, and the score of 5 described non-separate, non-central, motile, and non-mucosal cervices. Data were analyzed as a mixed model with phase fixed effect plus random effects of cow within phase and residuals. Results demonstrated a significant differential order, respectively, for SE > PE > DE > ME of an increased cervix distinctness (1.00 > 1.20 > 3.10 > 3.62), greater central positioning (1.13 > 1.50 > 3.73 > 4.15), greater stability (decreased motility) (1.00 > 1.50 > 2.58 > 4.33), and greater mucosal secretions (1.00 > 1.50 > 3.88 > 4.13), respectively. Rectal temperature (RT) was not different (P=0.51) among ME, DE, PE and SE phases, respectively (38.66, 38.33, 38.58, and 38.83°C ± 0.22). Changes of RT and that of cervix morphology were not significant in SE vs. non-SE phases (P>0.20). Therefore, the methodology proved effective in differentiating cervix morphology among the four phases of the estrous cycle in dairy cows. Its cost-effectiveness (< 500 USD) promises further uses in more accurate monitoring of estrus and reproductive tract health and physiology.

Key Words: cervix morphology, dairy cow, estrous

P102 **Libido, semen characteristics and fertility of boars housed in crates versus pens.** E. R. Tosky*, N. E. Dysart, S. E. Swing, W. L. Flowers,*Animal Science, North Carolina State University, Raleigh.*

The objective was to evaluate the effect of housing on libido, semen characteristics and fertility of boars. Mature boars (n=14) were randomly assigned to be housed in crates (0.9 x 2.1 m) or pens (1.8 x 2.5 m). After a 2-wk acclimation period, boars were collected weekly for 10 wk. After this period, the housing environment was switched and boars were collected weekly for a second 10-wk period. During the last two wk of each 10-wk collection period, heterospermic inseminations (AI) across treatments were prepared and used to breed sows. Housing had no effect ($P = 0.45$) on concentration of sperm per ejaculate. Boars housed in pens had shorter reaction times (2.5 s vs. 3.0 s; $P = 0.05$); longer collection times (372.3 s vs. 319.1s; $P = 0.01$); greater collection volumes (230.4 mL vs. 194.1 mL; P= 0.04); and more total sperm per ejaculate (68.1 billion vs. 63.1 billion, $P = 0.05$) compared with boars housed in crates. Percentages of motile and morphologically normal spermatozoa were not different ($P \geq 0.17$) between boars housed in crates compared with their counterparts kept in pens. Despite these similarities, regression analyses revealed that for some boars the transition from a crate to a pen had a negative effect on sperm production, while for others being housed in a crate after being in a pen was stimulatory. Several characteristics associated with straight line and curvilinear movements of individual sperm tended to be greater ($P \leq 0.09$) for boars in crates compared with those in pens. Relative fertility as determined by heterospermic AI and subsequent paternity testing was not influenced by housing (pen = 50.7% piglets; crate = 48.3% piglets; $P = 0.87$). These results indicate that, in general, housing mature boars in pens enhanced their sex drive and sperm production without affecting semen quality or fertility. However, variations among males in the magnitude of this response were observed.

Key Words: boars, housing, sperm

P103 **Methylation patterns in fetal tissues generated from gilts inseminated with fresh or cryopreserved semen.** L. A. Rempel*, J. R. Miles, *Reproduction Research Unit, USDA, ARS, USMARC, Clay Center.*

Environmental influences, such as pollutants, climate, or diet, can alter the epigenetic configuration of gametes. The objective of our study was to evaluate differences in methylation activity of fetal placenta and liver from porcine pregnancies derived from fresh or frozen/thawed semen. Thirty cyclic gilts were single-time inseminated following an altrenogest/gonadotropin synchronization procedure. Pregnant gilts were harvested at d 28 of gestation and placental and liver tissues were collected from the smallest, average and largest

littermate fetuses. Genomic DNA was isolated and 5-methylcytosine (5mC) and 5-hydroxymethylcytosine (5hmC) was measured using an ELISA technique. Pregnancy data and litter statistics were analyzed with GLIMMIX and GLM procedures, respectively. Methylation data were analyzed with MIXED procedures. No differences ($P \geq 0.13$) in litter and piglet traits were detected between gilts bred with fresh semen (9 pregnant/15 bred) or gilts bred with frozen/thawed semen (6 pregnant/15 bred). No global methylation differences ($P \geq 0.12$) were identified in fetal liver. Percent activity of 5mC was not different ($P = 0.93$), but its catalyzed product, 5hmC, and the ratio of 5mC:5hmC were different ($P = 0.09$ and $P = 0.05$, respectively) in placenta derived from fresh semen insemination versus frozen/thawed. Activity of DNA can be impacted by 5hmC, which inhibits DNA methyltransferase (DNMT)1-mediated methylation of target cytosine and 5hmC has reduced affinity for various methyl-CpG-binding proteins potentially affecting transcription activity in promoter regions. Further investigations into the mechanisms yielding hydroxymethylcytosine differences in placenta derived from fresh versus frozen/thawed semen are merited.

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Key Words: cryopreserved semen, methylation, pig

P104 **Effectiveness of OvuGel® for induction of ovulation in a single, fixed-timed insemination program for weaned sows.** W. L. Flowers [1,*], M. E. Johnston [2], S. K. Webel [2], M. E. Swanson [2], *[1]Animal Science, North Carolina State University, Raleigh, [2]JBS United, Inc, Sheridan, IN.*

The objective was to evaluate the effectiveness of OvuGel® for induction of ovulation in a single, fixed-timed insemination (AI) program for weaned sows. OvuGel® contains triptorelin acetate and is deposited intravaginally. The study was conducted on a sow farm in the southeastern U.S. during July and August. Sows (n=398) were blocked by parity (1-2 vs. 3-6) at weaning and assigned within each group to one of three treatments. Control sows (n=202) that exhibited a post-weaning estrus (n=173) were bred once daily. OvuGel® sows (n=98) received 2 mL of OvuGel® and Placebo sows (n=98) received 2 mL of OvuGel® vehicle 96 h after weaning followed by a single AI 20 h later. OvuGel® and Placebo sows were bred without regard to estrus. As a result, farrowing rate was evaluated several different ways. Based on number of sows weaned, farrowing rate was similar ($P = 0.43$) among Control (76.7%) and OvuGel® (78.5%) sows and higher ($P \leq 0.01$) compared with their Placebo (54.1%) counterparts. In contrast, farrowing rate, based on number of sows bred, was highest for Control (90.0%), intermediate for OvuGel® (78.5%), and lowest for Placebo (54.1%) sows ($P \leq 0.05$). Finally, when only sows in estrus were considered, farrowing rate, was similar ($P \geq 0.05$) among Control (90.0%) and OvuGel® (90.3%) treatments and higher ($P \leq 0.05$) compared with sows given the Placebo (80.0%). Control and OvuGel® sows had similar ($P \geq 0.65$) total pigs and pigs born alive (11.4 vs. 11.2 and 11.0 vs. 10.8, respectively). In contrast, total born (10.0) and born alive (9.3) were lowest ($P \leq 0.05$) for sows given the Placebo. There were no differences ($P \geq 0.79$) among treatments in mummified fetuses or stillborn pigs. These results demonstrate that OvuGel® effectively induces ovulation in a population of weaned sows that have follicles capable of ovulating and that a single, fixed-timed AI following OvuGel® for these sows produces farrowing rates and litter sizes comparable to those bred with multiple AI regimens.

Key Words: fertility, ovulation, swine

P105 **Fetal liver glycogen production and glycogenic transcript expression during prenatal development from pig breeds differing in preweaning survivability.** J. R. Miles [1,*], J. A. Noel [2], L. A. Rempel [1], J. L. Vallet [1], B. A. Freking [1], *[1]Reproduction Research Unit, USDA-ARS U.S. Meat Animal Research Center, Clay Center, [2]Animal Science and Industry, Kansas State University, Manhattan.*

Sow productivity is influenced by a number of factors including preweaning piglet mortality. In commercial pigs, low birth weight piglets exhibit the greatest susceptibility to preweaning mortality. In contrast, Meishan (MS) piglets have naturally occurring lower birth weight, and also improved preweaning survival. Furthermore, we have demonstrated that MS piglets have enhanced glycogen metabolism during early neonatal life. The objective of this study was to characterize the expression of glycogenic transcripts along with glycogen levels in livers of MS and White crossbred (WC) fetal piglets to identify breed differences in glycogen metabolism during prenatal development. Eighteen gilts from each breed (MS and WC) were bred at estrus (designed d 0) to boars from their respective breeds. At d 70, 90 and 110 of gestation, gilts were harvested (n=6 breed^{-1}d^{-1}) and fetal livers were collected from the smallest and largest littermates. Liver glycogen was determined using an anthrone method. Expression for key glycogenic anabolic (UDP-glucose pyrophosporylase 2 [*UGP2*] and glycogen synthase 2 [*GSY2*]) and glycogenic (phosphorylase, glycogen liver [*PYGL*] and amylo-alpha-1,6-glucosidase [*AGL*]) transcripts were determined using real-time PCR. All data were analyzed by MIXED procedures for ANOVA. Fetal weight was greater ($P<0.05$) for WC fetuses compared to MS fetuses at d 90 and 110 of gestation. Fetal liver glycogen was greater ($P=0.04$) in MS fetuses compared to WC fetuses, irrespective of fetal size, at d 110 of gestation. However, no apparent breed differences ($P>0.10$) in glycogenic transcripts were observed between MS and WC piglets. These results demonstrate increased glycogen production in MS fetuses during late gestation without a decisive increase in expression of key glycogenic transcripts.[†]USDA is an equal opportunity provider and employer.

Key Words: glycogen, pigs, preweaning mortality

P106 **Effect of melatonin (MEL) or maternal nutrient restriction on cell proliferation in the ovine placenta.** A. W. Eifert [1,*], M. E. Wilson [1], K. A. Vonnahme [2], P. P. Borowicz [2, 3], D. A. Redmer [2, 3], S. Dorsam [2], J. Haring [2], C. O. Lemley [4], *[1]Animal and Nutritional Sciences, West Virginia University, Morgantown, [2]Animal Science, [3]Advanced Imaging and Microscopy Core Lab, North Dakota State University, Fargo, [4]Animal and Dairy Sciences, Mississippi State University.*

Objectives were to determine placental cell proliferation following dietary MEL treatment in a maternal nutrient restriction model. A second experiment was performed to assess MEL receptor dependent modulation in placental cell proliferation. For exp. 1, 31 ewes were supplemented with 0 or 5 mg of MEL per d and allocated to receive 100% or 60% of daily nutrient requirements from d 50 to 130 of gestation. Placenta was collected on d 130 of gestation. For exp. 2, 14 ewes were fitted with Alzet mini osmotic pumps and infused with vehicle, MEL, or MEL receptor 1 and 2 antagonist (luzindole, LUZ) from d 62 to 90 of gestation. Placenta was collected on d 90. Placenta from both exp. 1 and 2 were fixed, paraffin embedded, and examined for percentage of proliferating cells using an immunofluorescence assay. A Ki-67 mouse monoclonal antibody was used to stain proliferating cells within each tissue section and was compared

to non-proliferating cells stained with DAPI. For exp. 1, there was no MEL x nutritional plane interaction ($P > 0.5$) on cellular proliferation in either cotyledon (COT; fetal placental cells) or caruncle (CAR; maternal placental cells). There was a tendency ($P = 0.08$) for MEL ewes to have an increased percentage of proliferating cells in the COT; however, this effect was absent ($P > 0.3$) in the CAR. Nutritional plane did not alter cellular proliferation in either the COT ($P > 0.7$) or CAR ($P > 0.5$). For exp. 2, cell proliferation in the COT and CAR was not affected ($P > 0.30$) by vehicle, MEL or LUZ. Dietary MEL from mid to late gestation may impact COT cell proliferation; however chronic infusion of MEL or LUZ did not change proliferation in either the COT or CAR. Supported in part by USDA-NIFA-AFRI grant 2011-67012-30683 to COL.

Key Words: fetal development, gestational nutrition, melatonin

P107 **Short term protein supplementation during late gestation in beef cows reduces pulsatility index in the uterine artery.** B. R. Mordhorst*, L. E. Camacho, M. L. Bauer, K. A. Vonnahme, *Animal Sciences, North Dakota State University, Fargo.*

Protein supplementation in beef cows has been demonstrated to enhance offspring performance. Our laboratory has demonstrated that supplementation of specific dietary components can enhance umbilical blood flow in sheep. It was our hypothesis that the positive offspring performance observed by others in cattle may be due to increased uterine blood flow. Our objective was to determine if supplementing late pregnant beef cows with protein could augment uterine blood flow. After acclimation to Insentec Roughage Intake Control feeders, multiparous beef cows were assigned to treatments: protein supplement (n = 5) or control (n = 5) and pair fed based on the intake of control cattle. Protein supplemented cows were fed corn dried distillers grain with solubles (DDGS) to 1.7 g/kg of BW. Prior to initiation of supplement (d 175 ± 3), baseline uterine arterial hemodynamics were evaluated. Measurements obtained included pulsatility index (PI), resistance index (RI), heart rate, and uterine blood flow using Doppler ultrasonography. Hemodynamic measurements were assessed from three separate scans with three wave-forms each (i.e. nine total wave-forms were measured). All uterine blood hemodynamics were reassessed on d 200 ± 3 of gestation. Treatment or day of gestation did not impact ($P > 0.29$) cow weight, heart rate, RI, or uterine blood flow. There was however, an interaction of treatment and day of gestation on PI ($P = 0.004$). All cows had a similar PI on d 175 of gestation (1.09 ± 0.07); however, while PI in control cows remained similar by d 200, supplemented cows had a 23.8 ± 5.4% reduction compared to their PI on d 175. Moreover, supplemented cows had a reduced PI compared to control cows on d 200 (1.07 vs 0.87 ± 0.07). It is of interest to note that resistance within the uterine artery decreases after a short period of protein supplementation. Further research is warranted in understanding how uterine arterial hemodynamics can be altered with increased duration of protein supplementation.

Key Words: beef cattle, pregnancy, uterine blood flow

P108 **Feeding time regulation of circadian and periprandial blood glucose patterns in high-producing lactating cows.** A. Nikkhah*, *Animal Science, University of Zanjan, Islamic Republic of Iran.*

The objective was to establish circadian and periprandial peripheral blood glucose (BG) patterns in response to feeding time in lactating cows following 28-d adaptation periods. Four multiparous and four primiparous high-producing lactating Holstein cows (82 days in milk) in tie stalls were used in a cross-over design study with two 6-week periods, each with 4-week of adaptation. A total mixed ration (TMR) with 49.8% DM-based concentrate was fed at either 0900 or 2100 h to permit 5-10% feed refusals. Jugular blood was sampled via catheters every 2-h for two 24-h periods during week-5 of each period. Data were analyzed as linear mixed models. Effects of feeding time, parity, and their interaction were fixed, and effects of period and cow within parity were random. Repeated blood data were analyzed with the best fitted covariance structure. Evening vs. morning feeding increased feed intake within 3-h of feed delivery (55% vs. 46% of daily intake, P=0.06). BG exhibited marked declines at 2-h post-feeding in cows fed at 2100 h vs. 0900 h (67 vs. 73 mg/dL, P<0.01). Time of feeding did not affect daily averages of BG (75.2 mg/dL, P>0.20). Results establish time of feeding as a regulator of postprandial and circadian patterns of BG in once-daily fed lactating dairy cows. Time of feeding can therefore manipulate peripheral energy metabolism and glucose assimilation efficiency in lactating cows. Considering the comparative nature of splanchnic metabolism for optimal mechanistic understanding of gut function in any given species, findings serve as a metabolic model for high-producing livestock and humans.

Key Words: blood glucose, circadian pattern , feeding time

P109 **Periprandial peripheral lactate rhythmicity in lactating cows: Feeding time and diet effects.** A. Nikkhah*, *Animal Science, University of Zanjan, Islamic Republic of Iran.*

The objective was to determine effects of feeding time and dietary forage to concentrate ratio on periprandial rhythms of peripheral blood lactate in lactating cows. Four multiparous and four primiparous Holsteins in tie stalls were used in a 4×4 Latin square design study with a 2×2 factorial arrangement of feeding time and diet type. A higher concentrate (HC, forage to concentrate ratio = 38.5:61.5) or a lower concentrate (LC, forage to concentrate ratio = 50.6:49.4) total mixed ration (TMR) was fed at either 2100 h or 0900 h. The study had four 21-d periods, each with 14-d of adaptation. Jugular blood was sampled via catheters every 2-h for two 24-h periods during sampling weeks. Considering the equally-spaced repeated blood measures, Mixed Models were used to analyze the data. The time of sampling was the repeated factor and cow was the subject. Effects of diet, time of feeding, parity, hour, and two-, three-, and four-way interactions were considered fixed. Random effects were period, day of sampling within period, cow within parity, and four-way interactions between diet, feeding time, parity, cow within parity or day within period. To obtain normal distribution and alleviate residuals variance heterogeneity, data were transformed using Box-Cox algorithm. Feeding at 2100 h vs. 0900 h increased feed intake within 3-h post-feeding, from 26% to 37% of total daily intake. Feed presentation at 2100 h vs. 0900 h tended to increase daily averages of plasma lactate (0.69 vs. 0.65 mmol/L, P<0.10). The HC diet produced a higher plasma lactate than the LC diet (0.70 vs. 0.65 mmol/L, P<0.05). The plasma lactate increased by about 50% shortly post-feeding in evening-fed cows, but no noticeable changes occurred in morning-fed cows. Results demonstrate that time of feeding and diet type but not their interaction alter peripprandial rhythms of peripheral lactate. Time of eating, therefore, can affect splanchnic and peripheral lactate metabolism and energy supply in lactating cows.

Key Words: circadian rhythm, feeding time, peripheral lactate

P110 (GS-PHD) **Effects of maternal nutrient restriction followed by realimentation during early to mid-gestation on conceptus development in beef cows.** L. E. Camacho[1,*], C. O. Lemley[2], K. C. Swanson[1], K. A. Vonnahme[1], *[1]Department of Animal Sciences, North Dakota State University, Fargo, [2]Department of Animal and Dairy Sciences, Mississippi State University.*

We have previously reported that when cows are nutrient restricted from d 30 to 85, fetuses tend to be bigger, and placentas were larger in restricted cows compared to control cows (JAS 2012 Suppl. 3:151). Objectives were to examine how timing of realimentation would impact conceptus development. On d 30 of pregnancy, multiparous beef cows were randomly assigned to dietary treatments: control (C; 100% NRC; n = 12) and nutrient restriction (R; 60% NRC; n = 28). On d 85 cows remained on control (CC; n = 12), restricted (RR; n = 12) or were realimented to control (RC; n =11). On d 140 cows were either slaughtered (CC; n = 6; RR; n = 6; RC; n = 5), remained on control (CCC; n = 6; RCC; n = 5) or were realimented to control (RRC; n = 6). On d 254 all remaining cows were slaughtered. Fetal BW and eviscerated BW were similar ($P \geq 0.43$) among treatments on d 140 and 254. Fetal heart girth, biparietal distance, crown rump length, and ponderal index were similar ($P \geq 0.44$) among treatments on d 140 and 254. Total placentome weight, cotyledon weight, and caruncle weight were not affected ($P \geq 0.08$) by maternal dietary treatment on d 140 and 254. Total placentome number was increased ($P = 0.03$) in RR vs. CC and RC cows on d 140 and similar ($P = 0.59$) by d 254. Average placentome weight, volume, and density were not affected ($P \geq 0.09$) by maternal dietary treatment on d 140 and 254. Gravid and empty uterine weight, and chorioallantoic/amniotic fluid volume were not different ($P \geq 0.29$) among treatments at d 140 and 254. Fetal membranes were similar ($P = 0.63$) among treatments at d 140 but increased ($P < 0.04$) in RRC vs. CCC and RCC on d 254. A larger placenta could not compensate for the longer duration of nutrient restriction as fetal sizes were similar at d 140. Maternal dietary impacts on placental growth and nutrient transferring capacity remain unknown in beef cattle.

Key Words: maternal restriction, placenta, pregnancy

P111 (GS-MS) **Correlation of jejunal vascularity with feed efficiency and angiogenic factor mRNA expression in calves from a gestational nutrient restriction model.** H. C. Cunningham[1,*], R. D. Yunusova[2], M. Du[1], B. W. Hess[1], J. S. Caton[2], A. M. Meyer[1], *[1]Department of Animal Science, University of Wyoming, Laramie, [2]Department of Animal Sciences, North Dakota State University, Fargo.*

We hypothesized that gestational nutrition would affect calf small intestinal vascularity as well as feed intake and efficiency, and that vascularity would be correlated with feed efficiency and angiogenic factor expression. Multiparous beef cows (n = 36) were fed 1 of 3 diets individually from d 45 to 185 of gestation: a control (CON) diet of grass hay and supplement to meet or exceed NRC recommendations, a nutrient restricted (NR) diet providing 70% of CON NE_m, or an NR diet with a ruminally undegradable protein supplement (NRP) providing similar essential AA as CON. Individual feed intake of calves was measured with the GrowSafe System during finishing. At slaughter (552 ± 10.2 kg BW), jejunal samples were perfusion fixed to assess vascularity. Real time RT-PCR was performed to determine jejunal mRNA expression of vascular endothelial growth factor (*VEGF*) and its receptors (*FLT1* and *KDR*), endothelial nitric oxide synthase 3 (*NOS3*), and soluble guanylate cyclase (*GUCY1B3*). Data were analyzed as a mixed model with calf sex as block. Correlations were determined between vascularity and feed efficiency, intake, and angiogenic factors. It was previously reported that maternal nutrition did not affect residual feed intake (RFI), although RFI was positively correlated with small intestinal mass. Maternal nutrition did not affect ($P \geq 0.43$) jejunal capillary area density, number density, surface density, and size or total small intestinal vascularity. Jejunal vascularity measures were not correlated with RFI or G:F ($P > 0.16$). Despite this, feed intake was positively correlated with total small intestinal vascularity ($r = 0.51$; $P = 0.005$). There was a positive relationship between jejunal *KDR* mRNA expression and total small intestinal vascularity ($r = 0.35$; $P = 0.05$), but other angiogenic factors were not correlated with vascularity ($P > 0.13$). In this study, maternal gestational nutrition did not affect small intestinal vascularity, although total vascularity was associated with feed intake and *KDR* expression. This suggests that current nutrition has a greater impact on intestinal vascularity than maternal nutrition.

Key Words: developmental programming, feed efficiency, small intestine

P112 (GS-MS) **Nutrient restriction during early and mid-gestation followed by realimentation alters caruncular arterial vasoreactivity in response to bradykinin in beef cows.** A. Reyaz[1,*], M. S. Sane[2], F. Yao[2], L. E. Camacho[1], C. O. Lemley[3], J. S. Haring[1], K. C. Swanson[1], S. T. O'Rourke[2], K. A. Vonnahme[1], *[1]Department of Animal Sciences, [2]Department of Pharmaceutical Sciences, North Dakota State University, Fargo, [3]Department of Animal and Dairy Sciences, Mississippi State University, Starkville.*

It is hypothesized that altered utero-placental blood flow in nutrient restricted cows would be due to changes in placental arterial sensitivity to bradykinin (BK). The objective of this study was to examine the effects of maternal nutrient restriction on caruncular (CAR) artery vasoreactivity during early and mid-gestation followed by realimentation in multiparous beef cows. Cows received 100% (CCC; n = 12) NRC requirements from d 30 to d 254, 60% (RCC; n = 10) NRC requirements from d 30 to d 85 with realimentation on d 85 and 60% (RRC; n = 12) NRC requirements from d 30 to d 140 with realimentation on d 140 of gestation. At d 140 and d 254 of gestation cows were slaughtered and arteries that terminated into the maternal portion of the placentome (CAR artery) were dissected and used for in vitro vasoreactivity assays and qPCR. Endothelium intact rings were contracted with norepinephrine (10^{-6} M) and a dose response curve (DRC) to BK was performed, in the presence or absence of BK2 receptor antagonist HOE 140. On d 140, no effect was observed when arteries were treated with BK ($P = 0.09$) or pre-incubated with HOE 140 ($P = 0.67$) prior to performing a BK DRC. By d 254, CAR arteries from the RCC group were more sensitive ($P < 0.01$) to BK induced relaxation vs. CCC and RRC arteries. There was a treatment x dose interaction ($P = 0.04$) when arteries were pre-incubated with HOE 140 with a rightward shift in RRC arteries and relaxation was delayed in response to BK vs. CCC and RCC groups. There were no differences ($P = 0.16$) in mRNA expression of BK2 receptor by treatment or day of gestation. Data suggests that realimentation on d 85 in the RCC group might alter CAR vasoreactivity to BK and compensates for the lost nutrients towards late gestation. Also, arteries from RCC cows relaxed when treated with HOE 140 indicative of an adaptive response or perhaps a shift from a BK2 to a BK1 receptor mediated pathway for vasorelaxation post nutrient restriction. Alterations in placental vasoreactivity may impact utero-placental blood flow and nutrient availability to the developing calf.

Key Words: bradykinin, cow, placenta

RUMINANT NUTRITION

P113 **Effects of evening vs. morning mixed ration delivery on rumen microbial protein synthesis.** A. Nikkhah*, *Animal Science, University of Zanjan, Islamic Republic of Iran.*

The objective was to determine effects of providing a total mixed ration (TMR) at 0900 h vs. 2100 h on urinary excretion of purine derivatives and estimates of rumen microbial protein synthesis in lactating cows. Four multiparous (77 ± 25 days in milk) and four primiparous (90 ± 33 days in milk) Holstein cows were used in a cross-over design study with two 6-week periods. Each period had 3-week of adaptation. The TMR had forage to concentrate ratio of 50.2:49.8 (dry matter based). Lights were on from 0345 h until 2245 h. Two ml of urine sample was taken, diluted 5 times in distilled water, and stored at -20°C for later analysis of purine derivatives including allantoin and uric acid to estimate duodenal microbial protein flow. Cows were housed in tie stalls in a metabolism unit under thermoneutral conditions. Data were analyzed as linear Mixed Models with fixed effects of feeding time, parity, and their interaction. Least square means were estimated with Restricted Maximum Likelihood method, and degrees of freedom were calculated using Satterwaith method. Daily urinary excretion of allantoin (421 vs. 455 ± 29 mmol/d, P=0.30), uric acid (49 vs. 53 ± 2.2 mmol/d, *P*=0.12), and total purine derivatives (470 vs. 507 ± 28 mmol/d, *P*=0.24) were not significantly different for cows fed at 2100 h vs. 0900 h, respectively. As a result, daily estimates of duodenal microbial protein flow were not significantly different for cows fed at 2100 h vs. 0900 h, respectively (2263 vs. 2456 ± 152 g/d, *P*=0.26). Neither parity nor its interaction with feeding time affected urinary purine derivatives and microbial protein flow estimates. Findings of this study do not provide evidence for any effect of feed delivery timing on estimates of rumen microbial protein synthesis in once daily-fed lactating dairy cows.

Key Words: microbial protein, feed delivery time, lactating cow

P114 **Effects of feed provision timing (2100 vs. 0900 h) on cow milk fatty acids profiles.** A. Nikkhah*, *Animal Science, University of Zanjan, Islamic Republic of Iran.*

The objective was to determine feeding timing effects on milk fatty acids profiles. Four multiparous (645 ± 75 kg body weight, mean ± SD) and four primiparous (576 ± 46 kg body weight) lactating Holstein cows in tie stalls were monitored in a cross-over design experiment with two 42-d periods. Each period had 28-d of adaptation. Cows received a total mixed ration (TMR) with forage to concentrate ratio of 50.2:49.8 (dry matter basis), permitting 5-10% orts. Lights were on from 03:45 until 22:45 h. Data were analyzed using Mixed Models with fixed effects of treatment, parity and their interaction, and random effects of period and cow within parity. Feeding at 2100 vs. 0900 h increased (*P*<0.05) milk fat percent (3.5 vs. 3.0 ± 0.18%) and yield (1220 vs. 1050 ± 60 g/d) and the proportion of C18:0 (14.9 vs. 13.5 ± 0.45 g/100 g fatty acid), but did not affect proportions (g/100 g fatty acid) of total short (9.5 vs. 10 ± 0.51), medium (34.6 vs. 34.7 ± 0.41), and long (55.0 vs. 54.4 ± 0.54) chain fatty acids in milk. Feed delivery at 0900 h vs. 2100 h increased (*P*<0.05) milk proportions (g/100 g fatty acid) of C10:0 (1.7 vs. 1.5 ± 0.05), C12:0 (2.4 vs. 2.1 ± 0.14), C12:1 (0.07 vs. 0.06 ± 0.003), C13:0 (0.09 vs. 0.08 ± 0.003), C13:1 (4 vs. 3.6 ± 0.14) and C18:3 n-3 (3.2 vs. 3.0 ± 0.06) and tended to increase (*P*<0.10) proportions (g/100 g fatty acids) of C8:0 (0.52 vs. 0.42 ± 0.06) and C18:1trans-9 (2.2 vs. 1.0 ± 0.62). Considering non-signficant effects on milk proportions of CLAcis9 trans11 and CLAtrans10 cis12 while increasing milk fat yield, evening vs. morning feeding could improve milk yields of these CLA. Evening instead of morning feeding increased eating rate shortly post-feeding, and, thereby increased rumen fermentation rate and volatile fatty acids levels. The altered microbial action and rumen conditions may have in part contributed to the altered milk fatty acids profiles. Results, therefore, provide evidence that time of feeding can be a feasible strategy to manipulate milk fat yield and milk fatty acids profiles. Findings have metabolic and health implications.

Key Words: dairy cow, feed provision timing, milk fatty acid profile

P115 **Feeding timing: A chronophysiological regulator of post-prandial intake circadian rhythms in dairy cows.** A. Nikkhah*, *Animal Science, University of Zanjan, Islamic Republic of Iran.*

The objective was to determine periprandial patterns of feed intake in response to altered feeding time with 28-d adaptation periods. Four multiparous (645 ± 75 kg BW; 77 ± 25 days in milk, mean ± SD) and four primiparous (576 ± 46 kg BW; 90 ± 33 days in milk) tie-tall-housed lactating Holstein cows were used in a cross-over design study with two 6-wk periods, each with 4-wk of adaptation. A total mixed ration (TMR) with 49.8% dry matter-based concentrate was presented ad libitum at either 0900 or 2100 h. A metabolic acquisition system was used to monitor continuous feed intake electronically. Mixed Models used to analyze the data included fixed effects of feeding time, parity, and their interaction, and random effects of period and cow within parity plus residuals. The amount of TMR consumed within 3-h post-feeding was 55% of the total daily intake in the 2100 h-fed cows and only 46% in the 0900 h-fed cows (*P*=0.06). While the proportion consumed within 6 -h post-feeding was similar (*P*=0.51) for the 0900 h-fed (62.6%) and the 2100 h-fed (65.7%) cows, within 9-h post-feeding, the 2100 h-fed cows consumed greater TMR (80% vs. 73%, *P*<0.05). By 15-h post-feeding, the 0900 h-fed cows and the 2100 h-fed cows had consumed 96% and 90% of their daily intake, respectively (*P*<0.05). Total daily dry matter intake was greater when feed was delivered at 2100 h vs. 0900 h in primiparous cows (20 vs. 18 kg/d, *P*<0.05) but not in multiparous cows (20 kg/d). Results reveal that evening vs. morning feeding of a TMR increased feed intake and eating rate shortly post-feeding and, thereby, altered periprandial and circadian patterns of nutrient intake in both primiparous and multiparous lactating cows. Parity, however, can mediate the chronophysiological impact of feeding time on total daily feed intake.

Key Words: chronophysiology , feeding time, intake rhythm

P116 **Feeding Corn Shredlage™ increases total tract dietary starch and fiber digestibility by lactating dairy cows.** L. Ferraretto*, R. Shaver, *Department of Dairy Science, University of Wisconsin, Madison.*

The study objective was to determine the effect of feeding a TMR containing Corn Shredlage™ (SHRD) compared to conventional-processed corn silage (KPCS) on total tract dietary starch and NDF digestibility by dairy cows. Both treatments were harvested using a self-propelled forage harvester fitted with either novel cross-grooved rolls (2.5 mm roll gap) and chopper set at 30 mm theoretical length of cut (LOC) or conventional rolls (3 mm roll gap) and 19 mm LOC for SHRD and KPCS, respectively. One hundred and twelve cows

stratified by DIM, milk, breed and parity were randomly assigned to 14 pens. Pens were randomly assigned to the two treatments in a completely-randomized design. A 2-wk covariate adjustment period with cows fed a 50:50 mixture of the treatment diets was followed by an 8-wk treatment period with cows fed their assigned treatment diet. The TMR contained (DM basis) KPCS or SHRD (50%), alfalfa silage (10%), and concentrate mixture (40%). Fecal samples were collected during wk 5 and 8 of treatment period. Total tract NDF digestibility (NDFD) was calculated using lignin as an internal marker, whereas total tract starch digestibility (TTSD) was determined using a fecal starch equation. The SHRD and KPCS silages were evaluated for ruminal in situ NDF (24 h) and starch (12 h) digestibilities using Dacron polyester cloth bags (9 x 18 cm) containing 5 g DM of undried, unground samples incubated in duplicate in 3 ruminally-cannulated cows fed a common diet. Data were analyzed using Proc MIXED of SAS with treatment, wk, and treatment x wk interaction as Fixed effects and pen within treatment as a Random effect or treatment as Fixed effect and cow as Random effect for in vivo and in situ measurements, respectively. Cows fed SHRD had greater diet TTSD (98.9 vs. 97.3%) and NDFD (36.1 vs. 32.2%) than cows fed KPCS. Ruminal in situ starch digestibility was 17% units greater for SHRD than KPCS at 12 h, but not for NDF at 24 h. Feeding Corn Shredlage™ increased total tract dietary starch and NDF digestibility by lactating dairy cows.

Key Words: corn silage, digestibility, Shredlage

P117 **Ruminal fermentation by dairy cows fed low-fat corn dried distillers grains with solubles in combination with rumen-inert fat.** H. A. Ramirez Ramirez [1,*], P. J. Kononoff [1], K. Karges [2], *[1]University of Nebraska, Lincoln, [2]Dakota Gold Research Association, Sioux Falls, South Dakota.*

Four lactating ruminally cannulated Holstein cows with (mean ± SD) 98 ± 11 DIM and 603 ± 52 kg BW were used in a Latin square to test the effects of feeding regular dried distillers grains with solubles (DDGS) or low-fat distillers grains with solubles (LF-DDGS) combined with rumen inert fat (RIF, as Ca-salts of long chain fatty acids) on rumen NH_4 concentration, pH and VFA profile. Cows were housed in a tie-stall barn, fed once a day and milked twice daily. In each 21 d period cows were randomly assigned to 1 of 4 dietary treatments (values expressed on a DM basis): control diet (CON) was a conventional dairy ration (no corn ethanol by-products); a second diet (DG) contained 30% DDGS; a third diet (LF) contained 30% LF-DDGS and; a fourth diet (COMBO) contained 30% LF-DDGS supplemented with 1.9% RIF. There was no significant effect on NH_4 averaging 27.9 mg/dL across treatments. The CON and COMBO diets had similar mean pH (6.18 ± 0.12) whereas DG and LF resulted in lower ($P < 0.01$) pH (5.87 ± 0.12). No effect on total concentration of VFA was observed (119 ± 4.75 mmol/L) but molar proportion of acetate (Ac) was greatest ($P < 0.01$) in cows consuming CON, intermediate for COMBO and lowest for DG and LF (67.6, 63.4 and 61.2 ± 1.44 mol/100 mol, respectively). An inverse pattern was observed for molar proportion of propionate (Pr) that resulted in DG and LF having the greatest ($P < 0.01$), COMBO was intermediate and CON was the lowest (23.1, 20.6 and 18.0 ± 1.06 mol/100 mol, respectively); as a result Ac:Pr was greatest ($P < 0.01$) in the CON diet followed by COMBO; DG and LF had the lowest ratio (3.8, 3.12 and 2.71 ± 0.19). Molar proportions of butyrate were higher ($P < 0.01$) for the diets containing ethanol by-products (12.6 ± 0.52 mol/100 mol) compared to CON treatment (11.3 ± 0.52 mol/100 mol). Feeding DDGS and LF-DDGS resulted in a modest decrease in the concentration of Ac with a concomitant increase in Pr, thus lower Ac:Pr ratio. These effects were reversed by supplementation with RIF indicating that a high inclusion of LF-DDGS supplemented with RIF supports adequate ruminal fermentation in lactating dairy cows.

Key Words: oil removal, milk fat depression

P118 **Finishing beef cattle on totally mixed and self-fed rations**, C. L. Engel [1,*], V. L. Anderson [1], B. R. Ilse [2], *[1]Carrington Research Extension Center, North Dakota State University, Carrington, [2]Big Horn County, Montana State University, Hardin.*

A winter feeding study evaluated finishing beef cattle on self-fed (SF) or totally mixed rations (TMR). Angus calves (n= 207; BW = 359.8 ±5.14kg) were blocked by sex and randomly allotted to three dietary treatments. Experimental unit was pen (n= 23hd/pen), year (n= 3) was the replicate. The feeding period was 160 d each year. Treatments were bunk fed TMR (52% corn, 30% wheat midds, 15% hay, 2% supplement), or two SF rations containing 40% corn, 40% wheat midds, 2% supplement (CM) or 27% Corn, 27% wheat midds, 26% Barley, 2% supplement (CMB). The SF diets were offered in self-feeder with 6.1 m of bunk space. Grass hay round bales were offered free choice, accounting for an estimated 17% intake in both SF treatments. Feed delivered was considered consumed. Calves were weaned, preconditioned for 60 d, and adapted to the finishing diets over a 14 d period. Cattle were weighed every 28 d with feed intake, gain and efficiency calculated. Cattle were marketed at a commercial abattoir. Carcass data were collected by a trained grader. Feed disappearance tended to be higher (P = 0.13) for CM and CMB compared to TMR (11.46, 11.91, and 10.56 ± 0.40 kg; respectively). Overall ADG was greater (P = 0.03) for TMR (1.45 ± 0.03 kg) compared to CM and CMB diets (1.36 and 1.37 ± 0.03 kg). Feed efficiency was similar (P = 0.28) for all diets. Carcass traits differed slightly with more (P = 0.05) KPH for SF compared to TMR. Ribeye area (REA) and dressing percent (DP) tended to be lower for CM diet ($P \geq 0.06$; 78.39 ± 0.90 sq. cm. and 61.41 ± 8.01%, respectively). Both TMR and CMB had similar REA of 79.48 ± 0.90 sq. cm. and DP of 62.07 and 62.23 ± 8.01%, respectively. Yield grade and marbling scores were similar ($P \geq 0.94$) for all treatments (2.91 ± 0.09 and 542 ± 14.51, respectively). While TMR diets showed improved performance for some parameters, all diets resulted in acceptable weight gains and carcass performance. Both TMR and SF diets containing proportions of corn, midds and barley, can be used effectively to finish beef cattle.

Key Words: beef cattle, finishing, self-fed

P119 **Effect of soybean hull and enzyme inclusion on corn-based diet digestibility.** J. R. Russell[*], M. S. Kerley, *University of Missouri, Columbia.*

A continuous culture study was conducted to determine the effects of increasing fiber inclusion and enzyme addition on digestibility, microbial efficiency (MoEff), VFA and lactic acid (LAC) production. The hypothesis was fiber digestibility, acetate (ACE) and acetate:propionate (APR) would increase while propionate (PRO) would decrease with the inclusion of soybean hulls (SH) and a commercial dried fibrolytic fermentation product. Eight treatments (TRT) were arranged in a 4x2 factorial in a complete randomized design comprised of 4 diets (DIET) with increasing

SH to corn proportions (0, 7, 14 and 28% SH) and 2 inclusion rates of a proprietary mix of *B. subtilis, A. oryzae* and *T. viride*; 0.045% (ENZ) or 0% (CONT). The TRT were randomly distributed over 24 fermenters and two replications were performed (n=48). Three fermenter and effluent sample collection days followed 4 acclimation days. VFA samples were collected at 0, 4 and 8 hours post-feeding on sample days and compiled by timepoint. There were no interactions (P>0.05) with the exception of a DIETxENZ interaction (P<0.05) for LAC. NDF digestibility (NDFd), ACE and APR increased linearly (P<0.05) as SH inclusion increased but PRO decreased linearly (P<0.05) as SH inclusion increased. Nitrogen digestibility was quadratic (P<0.05) and greatest for 7% SH. MoEff and LAC responded linearly and quadratically (P<0.05) with the greatest values generated by 0% SH and the lowest by 14% SH. The butyrate (BUT) was also linear and quadratic (P<0.05) though BUT was greatest for 14% SH and lowest for 0%. Analyzing ENZ effects, ACE and APR were greater (P<0.05) for ENZ but PRO was greater (P<0.05) for CONT. Evaluating effects of hours post-feeding, the ACE, LAC and PRO were all linear and quadratic (P<0.05). Acetate and LAC were greatest at hour 4 and PRO was greatest at hour 8. Both BUT and APR were linear (P<0.05) as BUT increased over time while APR decreased. Based on NDFd values and VFA production the conclusion is that fiber digestibility increased as SH inclusion increased in corn-based diets. The increased APR is typical for increased fiber fermentation and indicates that enzyme addition improved fiber digestion as well.

Key Words: digestibility, fermentation, soybean hulls

P120 **Complex 1 and 3 ratio and complex 1 proteins diverge among steers with different residual feed intake phenotypes.** M. M. Masiero*, N. O. Minton, M. Kerley, W. J. Sexten, *Animal Science, University of Missouri, Columbia.*

Sixty crossbred steers in the growing phase fed a no-roughage ration were used to determine if mitochondria complexes I and III (C1, C3) differed relative to residual feed intake (RFI) or effective energy RFI (EERFI). We hypothesize metabolic efficiency (-RFI) occurs in cattle via mitochondrial function. Individual DMI was collected using GrowSafe feed intake system and used to calculate RFI and EERFI. EERFI was calculated similar to RFI, expected DMI was based on energy required for maintenance, fat and protein tissue gain and methane losses. Blood samples were collected to isolate mitochondria lymphocyte. C1 and C3 quantities were measured using immunocapture. C1 proteins were separated into bands using gel electrophoresis and measured by densitometry. In experiment one (n=30) C1 proteins, C1 quantity and ADG did not differ (P>0.05) between -RFI (-0.89) and +RFI (1.18), C1:C3 was greater (P=0.03), C3 (quadratic, P=0.04) DMI (P=0.01) and gain/feed (P=0.01) were less for -RFI compared to +RFI. Using EERFI (R^2=0.33) band III percent, C1 quantity and ADG did not differ (P>0.05) between -RFI (-1) and +RFI (0.98), band I percent trended greater (P=0.06), band II percent (P=0.05) and C1:C3 were greater (P=0.02), C3 (P=0.04) DMI (P=0.01) and gain/feed (P=0.01) were less for -RFI compared to +RFI. In experiment two (n=30) band I and band II percent, C1 and C3 quantity, C1:C3, and ADG did not differ (P>0.05) between -RFI (-1.28) and +RFI (0.85), band III percent trended greater (P=0.07) and DMI (P=0.01) and gain/feed (P=0.01) was less for -RFI compared to +RFI. Using EERFI (R^2=0.58) band I percent, C1 and C3 quantity, C1:C3 and ADG did not differ (P>0.05) between -RFI (-1.34) and +RFI (0.92), band III percent was greater (quadratic, P=0.03), band II percent (quadratic, P=0.03) DMI (P=0.01) and gain/feed (P=0.01) were less for -RFI compared to +RFI. In conclusion, mitochondrial complexes are at least in part responsible for metabolic efficiency differences in cattle.

Key Words: feed efficiency, mitochondria, residual feed intake

P121 **Effect of feeding distillers dried grains with solubles during lactation on milk fatty acid composition.** C. Shee*, R. P. Lemenager, M. C. Claeys, J. P. Schoonmaker, *Animal Science, Purdue University, West Lafayette.*

Dried distillers grains with solubles (DDGS) is high fat and protein, and when fed to lactating beef cows alters milk production and composition, and may alter milk fatty acid composition. Because specific fatty acids have been demonstrated to impact growth and carcass composition, changes in milk fatty acid profile of cows could affect the growth and carcass composition of the progeny. Therefore, Angus x Simmental cows (n = 54, BCS = 5.17 ± 0.06, BW = 653 ± 9 kg) with male progeny were fed forage based diets supplemented with either distillers grains (DDGS, n = 27) or soybean meal (SBM, n = 27) from calving until mid lactation (129 d post-partum) to determine effects of DDGS on milk fatty acid (FA) composition. Diets were formulated to be isocaloric (0.95 Mcal/kg NE_g) and consisted of rye hay supplemented with DDGS at 1% of BW (19.4% CP) or corn silage and hay supplemented with SBM (11.7% CP). Cow-calf pairs were allotted to treatment by cow and calf BW, breed and age. Milk samples were collected on d 68 and 116 ± 10 d post-partum for analysis of fatty acid methyl esters by gas chromatography. Cow BW, BCS and milk FA profile were analyzed using the MIXED procedure of SAS for repeated measures. Cow starting weight and BCS did not differ between treatments (P > 0.90). Cow BW ($P \geq 0.43$) and BCS ($P \geq 0.13$) did not differ at any time point during the study. Dietary DDGS increased the percentage of long chain FA in milk (P <0.01) including C18:0 (P <0.01), and decreased the percentage of medium chain FA (P <0.01) including C14:0 (P <0.01) on both d 68 and 116 dpp. Short chain FA ($P \geq$ 0.13) were not affected at either time point. Dietary DDGS also decreased saturated FA content of milk (P <0.01) on both days, increased monounsaturated FA (P <0.01) such as C18:1n9 (P <0.01), and increased polyunsaturated FA (P <0.01), including C18:2n6 (P <0.01) and CLA (P <0.01). In summary, feeding DDGS to cows from early to mid lactation increased the percentage of long-chain, monounsaturated and polyunsaturated FA in milk, and decreased the percentage of medium-chain and saturated FA. These changes in milk FA composition may be responsible for pre-weaning growth differences seen in the male progeny and could potentially program them for altered carcass composition.

Key Words: distillers grains, milk fatty acid profile

P122 **Effects of maternal metabolizable protein supplementation during late gestation on wether offspring organ weights.** M. Van Emon [1,*], C. Schauer [2], A. Meyer [3], K. Maddock-Carlin [1], K. Vonnahme [1], [1]*Department of Animal Sciences, North Dakota State University, Fargo,* [2]*Hettinger Research Extension Center, North Dakota State University, Hettinger,* [3]*Department of Animal Science, University of Wyoming, Laramie.*

The objective of the current study was to determine the effects of maternal MP intake during late gestation on wether offspring organ weights upon exiting the feedlot. Ewes (n = 295) were stratified by BW, BCS, age, and expected lambing date to one of three dietary

treatments. Maternal dietary treatments were applied at d 100 of gestation, were isocaloric, and contained: 100MP: 100% of MP requirements; 80MP: 80% of MP requirements; and 60MP: 60% of MP requirements during the last 4 weeks of gestation for a ewe carrying twins. At 89 ± 5 (SD) days of age wether lambs (n = 31 for 60MP, n = 33 for 80MP, and n = 24 for 100MP) were placed in the feedlot for an average of 128 ± 17 d. The feedlot ration was balanced to meet or exceed CP and NE requirements of growing lambs and included approximately 85% whole, shelled corn and 15% commercial market lamb pellet. Wethers were fed a mixed diet ad libitum via bulk feeders and had continuous access to fresh water and shade. Thirty wether lambs (n = 10/maternal treatment) were harvested at 217 ± 17 d of age at the NDSU Meat Lab for collection organ weights. Statistical analysis was accomplished utilizing the MIXED procedures of SAS. Maternal MP intake had no effect ($P \geq 0.23$) on all wether offspring organ weights expressed as an actual weight or as the organ weight expressed per unit of brain weight, except the duodenum and kidneys. The total duodenal weight and duodenal weight expressed per unit of brain weight were linearly reduced ($P = 0.03$) as maternal MP intake increased during late gestation. There was a quadratic effect ($P = 0.02$) for kidney weight and kidney weight expressed per unit brain weight, with 60MP1 and 100MP1 being increased compared with 80MP1. These results suggest that restricted maternal MP intake during late gestation may alter wether duodenal and kidney weights and ultimately the potential for nutrient absorption.

Key Words: metabolizable protein, organ weights, wethers

P123 **Comparison of liver and jejunal mass and energy use between high and low efficiency steers.** L. Prezotto [1,*], F. E. Doscher[1], S. I. Paisley [2], K. C. Swanson [1], A. M. Meyer [2], *[1]Animal Science, North Dakota State University, Fargo, [2]Animal Science, University of Wyoming, Laramie.*

We hypothesize that a portion of the individual differences observed for feed efficiency in finishing cattle can be attributed to liver and small intestine size and energy use. The objective of this study was to investigate the relationship of residual feed intake (RFI) with jejunal and hepatic mass and in vitro O_2 consumption in market weight steers. Hereford-Angus crossbred steers (n = 59) were fed a common finishing diet (11.4% CP, 2.0 Mcal NE_m/kg, 1.35 Mcal NE_g/kg; DM basis) for 57 d using the GrowSafe feed intake system. At the conclusion of this period, RFI was calculated by subtracting expected feed intake from the actual feed intake for steers with at least 1.02 cm fat thickness at the 12th rib (n = 40). Expected feed intake was determined by regressing ADG and metabolic midweight on actual feed intake. The 20% most efficient (n = 8) and 20% least efficient (n = 8) steers were selected and randomly allocated to 2 slaughter dates occurring 5 and 7 d after the end of the feed intake test. At slaughter, the liver and small intestine were collected and weighed. Hepatic and jejunal samples were then collected for in vitro O_2 consumption analysis. Data were analyzed in PROC MIXED of SAS 9.2 with RFI class (high vs. low efficiency) as a fixed effect in the model. Body weight and actual masses (g) of the liver, jejunum, and whole small intestine of steers from the high and low efficiency groups did not differ ($P > 0.12$). Small intestinal mass expressed per unit of BW was greater for low efficiency compared with high efficiency steers (8.50 vs. 7.63 ± 0.28 g/kg BW; $P = 0.04$), although there were no differences in relative liver and jejunum masses ($P > 0.23$). No differences were observed for in vitro O_2 consumption of the liver or small intestine when expressed per unit of tissue or relative to BW ($P > 0.22$). Results of this study suggest that small intestinal mass relative to BW is decreased in high efficiency compared with low efficiency steers despite similar energy use of intestinal and hepatic tissues.

Key Words: feed efficiency, gastrointestinal tract, oxygen consumption

P124 **Effects of rumen-protected arginine supplementation and arginine-HCl injection on site and extent of digestion, ruminal fermentation, and intestinal amino acid disappearance in forage-fed steers.** A. M. Meyer [1,*], S. I. Klein [2], M. Kapphahn [2], D. V. Dhuyvetter [3], R. E. Musser [4], J. S. Caton [2], *[1]Department of Animal Science, University of Wyoming, Laramie, [2]Department of Animal Sciences, North Dakota State University, Fargo, [3]Ridley Block Operations, [4]SODA Feed Ingredients, LLC, Mankato, MN.*

Four ruminally cannulated steers were used in a 4 x 4 Latin square to evaluate the effects of Arg supplementation via either a rumen-protected product or intravenous injection. Steers were fed ad libitum grass hay (7.2% CP and 67.6% NDF) with the following treatments (2x/d): no Arg (CON), 27 mg Arg/kg BW injected intravenously (Arg-INJ), 90 mg rumen-protected Arg/kg BW (Arg-180), and 180 mg rumen-protected Arg/kg BW (Arg-360). Each period consisted of a 7-d washout (hay only), 7-d adaptation, and 7-d collection period. Data were analyzed with treatment as a fixed effect and steer and period as random effects; repeated measures analysis was used whenappropriate. There were no differences in hay DMI, total DMI, microbial efficiency, or OM, NDF, or ADF digestibility ($P \geq 0.10$). Nitrogen intake was greatest in Arg-360, intermediate in Arg-180, and least in CON and Arg-INJ ($P = 0.009$) due to differences in rumen-protected Arg intake, and total tract N digestibility followed this pattern ($P = 0.003$). Ruminal NH_3 was greater ($P = 0.004$) in Arg-360 compared with CON and Arg-INJ. Acetate:propionate was less ($P < 0.001$) in Arg-INJ than all other treatments. Steers fed Arg-180 had increased ($P \leq 0.01$) isobutyrate and isovalerate than Arg-INJ and Arg-360, although total VFA and other VFA were unaffected ($P \geq 0.10$). Duodenal flow of Arg was greatest in Arg-360, intermediate in Arg-180, and least in CON and Arg-INJ ($P < 0.001$). Ileal flow of Arg was greatest in Arg-360, intermediate in Arg-180, and least in CON ($P = 0.01$). Steers fed Arg-360 had greater ($P = 0.01$) ileal flow of Orn and tended to have greater ($P = 0.09$) ileal flow of Glu than all other treatments. Small intestinal disappearance (g/d) of Arg was greatest in Arg-360, intermediate in Arg-180, and least in CON and Arg-INJ ($P = 0.003$), despite similar Arg disappearance when expressed as a % ($P = 0.96$). Results of this study indicate that feeding rumen-protected Arg increases small intestinal Arg flow with minimal effects on ruminal fermentation and total tract digestibility.

Key Words: arginine, digestibility, ruminal fermentation

P125 **Chemical composition and in vitro intestinal digestibility of isolated rumen microbial fractions.** A. J. Carpenter [1,*], S. W. Fessenden [2], M. D. Stern [2], *[1]Animal Sciences and Industry, Kansas State University, Manhattan, [2]Department of Animal Science, University of Minnesota, Saint Paul.*

The objective of this experiment was to estimate intestinal digestibility of microbial N from rumen microorganisms. Rumen fluid was collected from 4 steers fed the same diet, and 3 populations of rumen microorganisms (liquid-associated bacteria (LAB), solid-associated bacteria (SAB), and liquid-associated protozoa (LAP)) were isolated by differential centrifugation. Intestinal digestibility

of N (ID) was determined using the in vitro (pepsin and pancreatin) steps of the 3-step procedure of Calsamiglia and Stern (1995). Total-N content of each fraction was different ($P < 0.05$) with LAB having the highest N content (8.1 *vs.* 6.1 *vs.* 5.6% of DM for LAB, SAB, and LAP, respectively). Purine concentration was greatest ($P < 0.05$) in LAB compared with SAB and LAP (3.1 *vs.* 1.0 *vs.* 0.9 mg/g of bacterial DM, respectively). Similarly, LAB had a higher ($P < 0.05$) purine:N ratio compared with SAB and LAP (37.4 *vs.* 12.3 *vs.* 11.1 mg/g of bacterial N, respectively). Total amino acids (AA) (wt/wt) varied ($P < 0.05$) with each treatment (35.9 *vs.* 29.8 *vs.* 27.72% for LAB, SAB, and LAP, respectively). Most individual AA (g/100 g of total AA and wt/wt) exhibited differences ($P < 0.05$) between the 3 populations. Essential AA content (g/100 g of total AA) was highest ($P < 0.05$) in LAB and lowest in LAP (47.15 *vs.* 46.02, respectively). Non-essential AA content was greatest ($P < 0.05$) in LAP followed by SAB and LAB (53.3 *vs.* 52.3 *vs.* 51.8 g/100 g total AA, respectively). LAB was highest ($P < 0.05$) in ID followed by LAP and SAB (71.2% *vs.* 68.2% *vs.* 57.5% for LAB, LAP, and SAB, respectively). Results demonstrate that microbial fractions have differing digestibilities in the small intestine and suggest that ID of mixed rumen microbes can be influenced by the relative amount of each microbial population.

Key Words: intestinal protein digestibility, microbial protein, rumen microbes

P126 **Non-esterified fatty acids and its relationship with mediators of the acute phase response in dairy cows.** F. da Rosa[1, 2, 3,*], P. Montagner [3, 4], E. Schmitt [5], A. Schneider [3, 6], C. C. Brauner [2, 3], E. Schwegler [3, 4], M. Weschenfelder [3, 4], A. R. Krause[2, 3], F. Del Pino [3, 7], M. N. Corrêa [3, 4], *[1]Animal Sciences, University of Illinois, Urbana, [2]Animal Sciences, [3]Núcleo de Pesquisa, Ensino e Extensão em Pecuária (NUPEEC), [4]Department of Veterinary Clinics, Federal University of Pelotas, [5]Brazilian Agricultural Research Corporation, EMBRAPA - CPAFRO, Porto Velho, [6]Nutrition College, [7]Department of Biochemistry, Federal University of Pelotas, Brazil.*

The aim of this study was assess the concentration of acute phase protein during the peripartum period in pluriparous dairy cows with three different levels of non-esterified fatty acids (NEFA) in the postpartum. Nineteen cows from a commercial herd kept in a semi-extensive system in southern Brazil were enrolled in this study. The animals were categorized into three groups according to serum NEFA concentrations. High group (GH): higher NEFA concentration; intermediate group (GI) and low group (GL): lower NEFA concentrations. The blood was collected on 23, 14, 7 and 3 d prepartum, on the day of partum and on 3, 6, 9, 16 and 23 d postpartum. In these time points were analyzed the concentrations of NEFA, Haptoglobin (Hp) and Paraoxonase (PON). Statistical analysis was performed using the SAS program. NEFA was compared between groups by analysis of variance using one-way ANOVA, Haptoglobin and Paraoxonase measurements were analyzed by repeated measures using the MIXED procedure with a value of $P<0.05$ considered significant. It was observed a significant effect ($P=0.001$) for serum NEFA concentrations among the GH, GI and GL groups: 0.6-1.04 mmol/L; 0.42-0.59 mmol/L and 0.28 – 0.4 mmol/L, respectively. Postpartum Hp concentration was higher in GH (1.08 ± 0.19 g/L) than in GL (0.93 ± 0.16 g/L) ($P=0.002$). Regarding the Paraoxonase, in the prepartum period it showed difference between groups ($P=0.008$), whereas the GL (127.29 ±5.3 U/mL) had higher concentrations than the GI (110.26 ±4.9 U/mL) and also higher than GH (97.58± 5.1 U/mL). In addition, these effects ($P=0.001$) were maintained (GL: 110.85±5,1 U/mL; GI: 105.38±4,6 U/mL; GH: 86,01±4,6 U/mL) during the postpartum. Considering the immune response, our results showed that the acute phase protein occurs in dairy cattle during the peripartum period and further emphasize that there is a link between inflammatory mediators and energetic metabolism. In summary, the present study indicated that pluriparous dairy cows with higher concentration of non-esterified fatty acids in the postpartum had higher values of Hp and lower values of PON during the transition period.

Key Words: acute phase response, dairy cattle, energetic metabolism

P127 **Loin quality of Brazilian native lambs fed with different levels of crude glycerin.** H. A. Ricardo*, C. M. Cunha, A. R. M. Fernandes, J. C. S. Osorio, F. M. Vargas Junior, M. A. P. Orrico Jr., L. O. Seno, *Grande Dourados Federal University, MS, Brazil.*

The crude glycerin has been successfully used in ruminant nutrition because shows potential as gluconeogenesis substrate replacing energy concentrates. The objective of the study was to evaluate the effects of replacing coarse ground corn by different levels of crude glycerin on Loin quality traits. We used 24 lambs with mean body weight of 20 kg. Animals used in the study belong to a group of native wool sheep of the State of Mato Grosso do Sul, Brazil, called as "Pantaneiros." The experiment was conducted in a completely randomized design with 4 treatments: 0, 2.5, 5.0, and 7.5% of crude glycerin inclusion on dry matter (DM). Diets were formulated to be isonitrogenous and isoenergetic only varying the inclusion of crude glycerin in replace of coarse ground corn, to provide an average gain of 0.2 kg/day. Oat hay was used as roughage and concentrate was composed of corn and/or crude glycerin, soybean meal, ground soybean and mineral mix, with a roughage:concentrate ratio of 25:75. Animals' body condition was used as slaughter criterion. As soon animals had a body condition between 3.0 and 3.5 slaughter was performed at the Grande Dourados Federal University Meats Laboratory. Initial pH was taken after slaughter on *Longissimus* muscle between 12th and 13th ribs, and final pH was taken 24 h postmortem. Loins were removed from the left side of chilled carcasses, between the first and the last lumbar vertebra. Slices of each Loin with 2.54 cm were used to determine lean color scores (L*, a*, and b*), cooking loss (CL), water holding capacity (WHC) and Warner-Bratzler shear force (WBSF). Data were analyzed using Proc GLM in SAS as a completely randomized design. Crude glycerin levels did not affect initial pH ($P = 0.12$), final pH ($P = 0.99$), L* ($P = 0.42$), a* ($P = 0.12$), b* ($P = 0.35$), CL ($P = 0.43$), WHC ($P = 0.50$), and WBSF ($P = 0.84$). Results from this study indicate that addition of crude glycerin until 7.5% can replace corn and does not affect Loin instrumental characteristics of Brazilian native lambs.

Key Words: co-products, corn, shear force

P128 **Increasing preconception RUP supplementation improves mature beef cow return to estrous cyclicity but does not impact milk production or reproductive performance.** A. F. Summers*, D. M. Larson, A. S. Cupp, *Animal Science, University of Nebraska, Lincoln.*

Previous literature reports improved AI conception rates in beef heifers supplemented distillers grains with solubles (DDG) during development compared with heifers receiving a dried corn gluten and corn germ (CON) based supplement. The objective of this experiment was to determine the effect of feeding two differing RUP supplements on preconception first calf heifer (FCH) and cow reproductive

efficiency and performance. A 3 yr study utilized 75% Red Angus x 25% MARC III composite cows (yr 1= 210; yr 2= 221; yr 3= 201). Cows were stratified by BW, calving date, age and randomly assigned to graze summer pasture and received one of two supplements: DDG or CON (28% CP) for 60 d (FCH) or 45 d prior to the beginning of the breeding season (mature cows). Supplements were designed to be isocaloric and isonitrogenous, but differed in RUP. First calf heifers were offered supplement at 0.30% BW and mature cows 0.25% BW. Estrus was synchronized via 2 injections of $PGF_{2\alpha}$ administered 14 d apart. Milk production was measured in all FCH and approximately 50 mature cows each yr via weigh-suckle-weigh. Final BW was similar among treatments for FCH and mature cows ($P \geq 0.25$). However, BW change tended ($P = 0.12$) to be greater for DDG compared to CON supplemented FCH (56 vs. 38 ± 3 kg). Similarly, ADG also tended to be greater ($P = 0.12$) for DDG compared with CON supplemented FCH. A greater proportion ($P = 0.01$) of mature cows supplemented DDG attained estrous cyclicity after the beginning of supplementation. Milk production was similar ($P \geq 0.61$) among treatments for FCH and mature cows. Although similar proportions of FCH were in estrus prior to the breeding season, DDG supplemented FCH tended ($P = 0.13$) to attain earlier estrous cyclicity after supplementation. Estrous synchronization rate, AI conception, and pregnancy rates were similar ($P \geq 0.41$) among treatments for FCH and cows. In summary, preconception supplementation improved the proportion of mature cows attaining estrous cyclicity prior to the breeding season and tended to improve BW gain in FCH.

Key Words: beef cow, fertility, protein supplementation

P129 **Evaluation of field pea forages in growing and finishing feedlot rations.** V. Anderson [1,*], B. Ilse [2], [1]*Carrington Research Extension Center, North Dakota State University, Carrington,* [2]*Big Horn County Extension, Montana State University, Hardin.*

The objective of this study was to evaluate variations of field pea forage fed as hay in growing and finishing feedlot rations. Weaned crossbred steers (n=156) were conditioned together for three weeks, blocked by weight and randomly assigned to one of 16 pens in the randomized complete block design. Initally, steers averaged 328.4 kg (P>0.62). The treatments were 1) pea hay; 2) pea-barley hay; 3) pea residue and 4) grass hay. Growing diets included 30.06% forage (dm BASIS) and averaged 13.07, 12.97, 15.58, and 16.48% crude protein, respectively. Finishing rations were formulated with 14.98% forage(DM basis) and averaged 12.83, 12.78, 14.10, and 14.53% crude protein, respectively. Forages were tub ground and fed in TMRs with dry rolled corn and barley, modified distillers grains, calcium carbonate, and an ionophore supplement. Growing rations (NEg 1.26 Mcal/kg) were fed for two months with finishing diets (NEg 1.39 Mcal/kg) offered for the next four months until animals were harvested in early May. During the growing phase, DMI was highest ($P = 0.06$) for pea hay (11.18 kg) and pea-barley hay (10.80 kg) compared with pea residue (10.49 kg) or grass hay (10.29 kg) resulting in improved ADG ($P < 0.01$) for pea hay (1.94 kg) and pea barley hay (1.87 kg) vs. pea residue (1.66 kg) and grass hay (1.63 kg). During finishing, gains were greatest ($P = 0.02$) for pea hay (1.71 kg). Over the entire feeding period, pea hay fed calves gained the fastest ($P = 0.01$; 1.78 kg) followed by pea barley hay (1.70 kg), pea residue (1.67 kg), and grass hay (1.65 kg). Feed efficiency during the finishing phase and for the entire 160 d growing and finishing period was improved ($P = 0.05$ and $P = 0.09$, respectively) for pea hay (5.66 and 5.90, respectively). Final weight averaged 602.0, 611.6, 616.0, and 629.2 kg for pea hay, pea-barley hay, pea residue and grass hay treatments, respectively. Carcass quality traits were not affected by treatment. Based on equal feed cost per pound of gain, pea hay and pea-barley hay are valued at 230 and 158 percent of the dollar value of grass hay, respectively, during the growing phase, and pea hay was worth 193 percent of grass hay in finishing diets.

Key Words: beef, field pea, forage

P130 **Effect of treating corn stover with calcium hydroxide on nutrient digestibility.** C. Kirby [1,*], A. Wertz-Lutz [2], D. Holzgraefe[2], M. Kerley [1], [1]*University of Missouri, Columbia,* [2]*ADM Alliance Nutrition, Quincy.*

The objective of this research was to determine if addition of calcium hydroxide (CaOH) to corn stover altered fiber content and digestibility when compared with native (NAT) and hydrated (HYD) corn stover. Prior to treatment, 680 kg of corn stover was ground through a 5 cm screen. From this ground corn stover, a d 0 sample was collected and NAT mini silos were made by packing a uniform amount into 15 barrels. From the same ground stover, 227 kg batches of HYD and CaOH treatments were mixed. A 50:50 wt:wt blend of corn stover and water yielded HYD treatment, whereas CaOH was added to the 50:50 blend to yield the 6.6% CaOH treatment. A d 0 sample was collected, and a uniform amount (6.4 kg) of each respective treatment packed into each of 15 mini silos per treatment. All mini silos were sealed air-tight until sampling. At d 3, 7, 14, 21 and 28 relative to manufacture, 3 mini silos per treatment were sampled. It was hypothesized that CaOH treatment would lessen NDF content and improve IVNDFD. Digestibility of hemicellulose and cellulose was measured using ANKOM equipment. Other analyses performed included, DM, ADF, NDF and CP content; TDN was calculated. Treating stover with CaOH decreased NDF ($P \leq 0.001$) content compared with HYD and NAT. This change occurred immediately after treatment. However, IVNDFD peaked on d 21 and differed ($P \leq 0.05$) from HYD and NAT. Gas production per 100 g of NDF also was increased ($P \leq 0.01$) for CaOH compared with NAT and HYD at d 21. Gas production and IVNDFD did not differ between HYD and NAT, so CaOH improved fiber digestion but not concomitantly or only due to change in cell wall composition. In conclusion, CaOH treatment improves corn stover digestibility and length of treatment affects magnitude of improvement. Changes in fiber content and IVNDFD with CaOH treatment improved ($P \leq 0.001$) calculated TDN by 8% and 6% when compared with NAT and HYD, respectively. It is speculated that improved digestibility occurs due to change in cell wall accessibility over time rather than immediate solubilization of hemicellulose.

Key Words: corn stover, calcium hydroxide, cattle

P131 **Dietary inclusion of condensed distillers solubles in gestating and lactating beef cows.** C. N. Shee*, R. P. Lemenager, M. C. Claeys, J. P. Schoonmaker, *Animal Sciences, Purdue University, West Lafayette.*

Two experiments were conducted to assess the performance of gestating (Exp 1) or lactating (Exp 2) beef cows fed increasing concentrations of condensed distillers solubles (CDS). In Exp 1, Angus x Simmental cows (n = 48, BCS = 5.37 ± 0.23, BW = 530 ± 35 kg) were fed one of four diets starting on d 181 of gestation until

2 weeks before calving. In Exp 2, another set of Angus x Simmental cows (n = 48, BCS = 5.42 ± 0.49, BW = 557 ± 31 kg) were fed similar diets from calving until mid-lactation (93 dpp). Diets consisted of a corn silage haylage-based control (CON), a 30% DDGS diet (DG), a 15% CDS diet (LOW) or a 30% CDS diet (HIGH). Diets were formulated to be isocaloric and isonitrogenous. Cows were allotted by cow breed, BW, age, and calf breed. Cows in Exp 2 were also allotted by calf birth weight and sex. A weigh-suckle-weigh was performed 77 ± 7 dpp (Exp 1) and 60 ± 17 dpp (Exp 2) to assess milk production. Milk samples were collected on d 74 (Exp 1) and on d 57 (Exp 2) to analyze composition. Cow starting BW ($P = 0.99$), BCS ($P \geq 0.32$) and calf birth weight ($P \geq 0.77$) did not differ for either study, but by the end of Exp 1, cow BW ($p = 0.05$) was decreased and BCS was increased ($P < 0.01$) due to feeding CDS. In Exp 1, LOW decreased DMI 23.6% and HIGH decreased DMI 14.3% relative to CON ($P < 0.01$). In Exp 2, LOW decreased DMI 23.4% and HIGH decreased DMI 12.8% relative to CON ($P < 0.01$). Milk production, fat, protein, total solids and somatic cell count ($P \geq 0.19$) did not differ among treatments for either study. Dietary treatment did not affect calf weight ($P \geq 0.26$) for either experiment. Calf ADG ($P \geq 0.42$) did not differ in Exp 1, but during Exp 2 ADG ($P = 0.05$) was decreased in LOW calves until end of maternal treatment. Timed artificial insemination ($P \geq 0.43$) and overall pregnancy rates ($P \geq 0.91$) did not differ for either study. In conclusion, CDS may need to be included at higher rates in low quality roughage diets or higher quality roughages should be included in the diet to maintain DMI at a level that matches the energy needs of the gestating or lactating cow.

Key Words: beef cow, condensed distillers solubles, performance

P132 **Pancreatic enzyme activity in high and low efficiency steers.** F. Doscher[1,*], L. Prezotto[1], S. Paisley[2], A. Meyer[2], K. Swanson[1], [1]*Animal Science, North Dakota State University, Fargo,* [2]*Animal Science, University of Wyoming, Laramie.*

The purpose of this study was to determine if activity of pancreatic digestive enzymes differs between steers of high and low feed efficiency. We hypothesize that as an animal becomes more efficient, the amount of pancreatic digestive enzymes secreted will increase in order to keep up with metabolic demands. Hereford-Angus crossbred steers (n = 59) were fed a common finishing diet (11.4% CP, 2.0 Mcal NEm/kg, 1.35 Mcal NEg/kg; DM basis) for 57 d using the GrowSafe feed intake system. Measurements for 12th rib fat were taken using ultrasound. Residual feed intake (RFI) was calculated for all steers with at least 1.02 cm fat thickness at the end of the feed intake period (n = 40) by subtracting the expected feed intake from the actual feed intake. Expected feed intake was determined by regressing ADG and metabolic midweight on actual feed intake. The 20% most efficient (n = 8) and 20% least efficient (n = 8) steers were selected and randomly allocated to 2 slaughter dates occurring 5 and 7 d after the end of the feed intake test. At slaughter, the pancreas was removed, trimmed of fat and weighed. Samples of each pancreas were immediately flash frozen for further analysis of protein content and α-amylase and trypsin activity. Data were analyzed in PROC MIXED of SAS with RFI class (high vs. low efficiency) as a fixed effect in the model. There was a trend ($P < 0.1$) toward high efficiency steers having greater pancreatic weight (g) per kg of body weight. No significant differences were observed ($P > 0.2$) between high and low efficiency steers for protein concentration or pancreatic α-amylase and trypsin activity. These data indicate that more efficient steers may have a trend for increased pancreatic mass without an alteration in pancreatic digestive enzyme activity. In this study there were no differences in production of pancreatic enzymes associated with differing feed efficiency.

Key Words: beef cattle, feed efficiency, pancreatic enzymes

P133 **Effects of corn processing methods on rumen digestion and microbial growth in no-roughage diets.** R. M. Harvey*, N. F. Johnson, N. O. Minton, W. A. Moore, J. R. Russell, M. C. Westerhold, J. G. Yoder, J. Sexten, M. S. Kerley, *Animal Sciences, University of Missouri, Columbia.*

Five Hereford steers with rumen fistula and duodenal "T"-type cannula were used in a 5x5 Latin square design to evaluate the effect of corn processing method on rumen digestion and microbial growth when fed with or without roughage. We hypothesize feeding a whole-shelled corn diet with no roughage would have similar ruminal and post-ruminal digestibility characteristics compared to processed corn diets containing roughage. Diets were whole-shelled corn (WC), cracked corn (CC), CC with 8% hay (CC+H), steam-flaked corn (SF) and SF with 8% hay (SF+H). Each steer was randomly assigned to one of five diets for each of the five, one-week periods. Each period consisted of four days for diet adaption and three days for sample collection. All diets were fed at 1.8% BW DMI split between a morning and evening feeding and were balanced to meet or exceed NRC (2000) nutrient requirements. Data were analyzed using the GLM procedure in SAS version 9.3 (2011). Rumen organic matter and crude protein digestibility did not differ across diets ($P>0.10$). When contrasting CC to SF and CC+H to SF+H diets, microbial nitrogen flow post-ruminally increased ($P<0.10$) with SF diets. Microbial efficiency (MOEFF) followed a similar increase with SF diets having greater ($P<0.05$) MOEFF than CC diets. There was no difference in post-ruminal microbial nitrogen flow or MOEFF in the SF diets compared to the WC diet ($P>0.10$). We concluded feeding SF will increase RDP and improve MOEFF compared to feeding a CC diet. Whole-shelled corn diet did not affect ruminal or post-ruminal digestibility characteristics compared to SF diets. Rumen protein digestion measurements were similar to model predicted RDP values. Our conclusion was WC with no roughage had similar digestion and microbial growth characteristics as SF and SF+H corn-based diets.

Key Words: corn processing, microbial efficiency, RDP

P134 **Influence of increasing supplementation of corn dried distiller's grains with solubles to growing steers fed medium-quality hay on growth performance, feeding behavior, and blood metabolites.** A. Islas*, R. S. Goulart, T. C. Gilbery, M. L. Bauer, K. C. Swanson, *Animal Science, North Dakota State University, Fargo.*

Seventy steer calves (287 ± 10 kg of BW), predominantly of Angus, Simmental, and Shorthorn breeds fed a medium-quality grass legume hay (ad libitum intake) were used to investigate the effects of increasing supplementation of corn dried distiller's grains with solubles (DDGS; 0, 0.5, and 1% of BW; DM basis) on growth performance, hay feeding behavior, and plasma metabolites. The experiment was conducted from Dec 7, 2011 through Feb 28, 2012. Steers were blocked by BW to three pens (n = 23 or 24) and assigned

randomly to one of three DDGS amounts (n = 7 or 8 per treatment). Hay and DDGS intake as well as feeding behavior traits (time at feeder, visits per d, visit size, time per visit, meals per d, meal size, and time per meal) were measured with Insectec RIC feeders. A meal was defined as eating periods that might include short breaks separated by intervals not longer than 7 minutes. Total DMI increased linearly ($P < 0.01$), whereas hay intake (kg/d and % of BW) decreased linearly ($P < 0.01$) with increasing DDGS. Average daily gain and G:F responded quadratically ($P \leq 0.02$); ADG and G:F increased to a lesser extent when DDGS supplementation increased from 0.5 to 1% than from 0 to 0.5%. Total time (min/d) at the hay feeder and number of visits daily to the hay feeder decreased (quadratic $P \leq 0.03$) with increasing DDGS supplementation. Conversely, hay visit size (kg/visit) responded quadratically ($P = 0.04$) with the greatest intake per visit observed for the 0.5% DDGS treatment. Number, size and duration of hay meals decreased linearly ($P < 0.01$) with increasing DDGS supplementation. Plasma urea concentrations increased (linear and quadratic $P < 0.05$) with increasing DDGS supplementation. Supplementation of DDGS improved feed efficiency, reduced hay intake, and altered feeding behavior of steers consuming medium-quality hay.

Key Words: cattle, distillers dried grains with solubles, medium quality hay

P135 **Evaluation of supplement level and supplemental protein source for growing cattle on medium quality hay.** W. Moore*, W. J. Sexten, B. R. Wiegand, M. S. Kerley, *Animal Science, University of Missouri, Columbia.*

Experimental objective was to determine optimal rumen-undegradable amino acid levels required to increase performance. Ninety-six crossbred steers (272.8±53.6 kg) were used to evaluate the effect of supplementation level and protein source on calf performance. Steers were assigned to a 2x2 factorial arrangement with two supplements at two levels in a randomized complete block design. Dried distillers grains plus solubles based supplements were balanced (BAL) for post-ruminal amino acid needs at 0.88 kg/d (0.75% BW) or 1.7 kg/d (1.5% BW) ADG or non-balanced (NON). Supplements were fed at 0.75% or 1.5% BW/head/d (DM basis). Fescue hay (10.6% CP) was offered ad libitum. We hypothesized balancing post-ruminal amino acids would increase backgrounding ADG and final BW. After 84 d backgrounding period, steers were stratified by feed, level, and body weight block (light or heavy) and placed on corn-based no-roughage finishing diet. Increasing supplementation level reduced hay DMI ($P<0.05$). During the 84 d backgrounding period, supplement ($P<0.05$) and hay ($P<0.10$) DMI was greater for BAL cattle due to greater ($P<0.05$) final BW. Final BW and ADG was greatest for BAL 1.5% ($P<0.05$) and was not different for NON 1.5% and BAL 0.75% ($P>0.10$). Final BW and ADG for BAL 0.75% and NON 0.75% was not different ($P>0.10$) while NON 1.5% was greater than NON 0.75% ($P<0.05$). An interaction for backgrounding G:F was observed ($P<0.10$) were BAL 1.5% was greatest ($P<0.10$) with no difference ($P>0.10$) between NON 1.5%, NON 0.75%, and BAL 0.75%. Actual DM supplementation levels were 0.725% and 1.42% for BAL 0.75% and 1.5% BW respectively and 0.704% and 1.39% for NON 0.75% and 1.5% BW respectively. 93 d finishing performance was not different for BAL compared to NON ($P>0.10$), however, steers supplemented 0.75% had greater DMI ($P<0.05$), lighter initial BW ($P<0.05$), lighter carcass weight ($P<0.05$), lower dressing percent ($P<0.05$) and tended to gain faster ($P<0.10$) than steers supplemented at 1.5% of BW. Balancing post-ruminal AA was effective in increasing ADG, final body weight, and G:F for backgrounding calves supplemented at 1.5% of BW and had no effect on finishing performance.

Key Words: amino acids, beef, supplementation

P136 **Effect of cinnamaldehyde, monensin and tannin on trans fatty acid formation in continuous culture system.** A. Ishlak [1,*], M. Gunal [2], A. AbuGhazaleh [1], *[1]Animal Science, Food and Nutrition, Southern Illinois University, Carbondale, [2]Department of Animal Science, Süleyman Demirel University, Isparta, Turkey.*

The objective of this study was to examine the effects of cinnamaldehyde, monensin and tannin on feed digestibility, fermentation and *trans* fatty acid (FA) formation. Four continuous fermenters were used in a 4 x 4 Latin square design with 4 periods of 10 days each. Treatment diets were: control diet (44:56 forage to concentrate; CON), control plus cinnamaldehyde at 120 mg/d (CIN), control plus monensin at 36 mg/d (MON). The tannin was included at 10% of diet (DM basis) replacing some of the forage and grains (39% forage, 51% concentrate, 10% tannin; TAN). Fermenters were fed treatment diets three times daily at 120 g/d and effluents samples were collected on days 8, 9 and 10 of each period to measure feed digestibility and FA. On day 10 of each period, samples were collected from each fermenter at 3 and 6 h post morning feeding for volatile fatty acid (VFA) and ammonia-N analyses. Compared with CON, the digestibility of DM, NDF and OM were not affected ($P>0.05$) by supplements but protein digestibility decreased ($P<0.05$) with CIN and TAN. The proportions of acetate decreased and the proportions of propionate increased with CIN and MON relative to CON. Ammonia-N concentration decreased ($P<0.05$) with all supplements, particularly with TAN. The concentration of C18:0 decreased ($P<0.05$) with all supplements and was least with MON (54.34, 38.06, 9.33, 38.96 mg/g of DM for CON, CIN, MON and TAN, respectively). The concentration of vaccenic acid increased ($P<0.05$) only with CIN and MON (13.2, 26.8, 27.5 and 9.4 mg/g of DM, respectively). Relative to CON, the concentration of *c*9*t*11conjugated linoleic acid (CLA) was highest with TAN and was least with MON (0.52, 0.59, 0.19, and 2.69 mg/g of DM, respectively). Results from this study show that the addition of cinnamaldehyde, monensin and tannin to ruminant diets altered rumen fermentation and increased the formation of *trans* FA.

Key Words: cinnamaldehyde, monensin and tannin, fatty acids, fermenters

P137 **Effect of blackberry and pomegranate oils on trans fatty acid formation in continuous culture system.** A. AbuGhazaleh [1,*], M. Gunal [2], A. Ishlak [1], *[1]Animal Science, Food and Nutrition, Southern Illinois University, Carbondale, [2]Department of Animal Science, Süleyman Demirel University, Isparta, Turkey.*

A continuous culture fermenter system was used in this study to compare the effects of three oil sources on vaccenic acid (*t*11 C18:1; VA) and conjugated linoleic acid (*c*9*t*11 CLA) production. Four continuous culture fermenters were used in a 4 x 4 Latin square design with four periods of 10 days each. The diets were: 1) control (CON), 2) control plus soybean oil (SBO), 3) control plus blackberry oil (BBO), and 4) control plus pomegranate oil (PMO). Oil supplements

were added at 30g/kg of diet DM and treatment diets were fed at 45g d^{-1} (DM basis) in three equal portions during the day. Effluents were collected from each fermenter during the last 3 days of each period and analyzed for nutrients and fatty acids (FA) composition. On day 10 of each period, additional samples were collected from each fermenter at 3 and 6 h after the morning feeding and analyzed for volatile fatty acids (VFA). The concentration of *t*11 C18:1 (vaccenic acid; VA) in effluents was similar ($P > 0.05$) among oil supplements and all were greater ($P < 0.05$) than the CON. Compared with the CON, the concentration of stearic acid was greatest ($P < 0.05$) with the SBO and least ($P < 0.05$) with the PMO. The concentration of *c*9*t*11 CLA increased with oil supplements and was greatest ($P < 0.05$) with the PMO. Compared with the CON, oil supplements had no effects ($P > 0.05$) on dry matter (DM) and neutral detergent fiber (NDF) digestibility, total VFA and the molar proportions of acetate and propionate. In conclusion, all three oil sources were equally effective in increase the production of VA; however, PMO effect on VA may have resulted in part from inhibiting the final step in the biohydrogenation of VA to stearic acid.

Key Words: blackberry oil, pomegranate oil, trans fatty acids, fermenters

P138 **Intake, in situ disappearance, and ruminal fermentation characteristics of bermudagrass hay diets supplemented with different types of distillers' grains for lactating cows.** K. P. Coffey*, A. N. Young, E. B. Kegley, P. Hornsby, J. Hollenback, D. Philipp, *Animal Science, University of Arkansas Division of Agriculture, Fayetteville.*

Distillers dried grains with solubles (DDG) may vary substantially in their nutrient composition and availability, primarily because of different processing methods used. This variation may impact the value of DDG as supplements for ruminants offered low and medium-quality hay diets. Our objective was to determine the impacts of supplementation with DDG from different sources on forage intake, in situ forage disappearance, and ruminal fermentation characteristics of a bermudagrass hay basal diet by lactating beef cows. Four, eight year-old, multiparous, ruminally cannulated beef cows (533 ± 14.0 kg avg. BW) were offered 1 of 4 diets during 4 periods in an experiment with a 4 × 4 Latin Square design. Cows were housed and fed in individual 37-m^2 pens with wood chip bedding and were given ad libitum access to bermudagrass hay with either no supplement (CONT) or 0.45% of BW (DM basis) from either conventional DDG (CDDG), a lower-fat DDG (LFDDG), or a heated LFDDG (HDDG). Nylon bags containing ground bermudagrass hay (particle size < 2 mm) were inserted in reverse order into the rumen beginning on d 11 and continued through d 16 for incubation times of 132, 84, 60, 48, 36, 28, 20, 12, 6, and 0 h each period, and rumen samples were collected on d 16 immediately prior to feeding, and 2, 4, 6, 8, 10, and 12 h after feeding. Hay DMI was greater ($P < 0.05$) from CONT compared with CDDG and LFDDG, but total DMI, ruminal pH, total VFA, and in situ forage disappearance parameters were not different ($P \geq 0.27$) among treatments. Ruminal ammonia tended ($P = 0.06$) to be greater from CDDG compared with CONT and HDDG. Molar proportions of propionate, butyrate, and acetate:propionate were greater ($P < 0.05$) from cows receiving DDG compared with CONT, but no differences were observed ($P \geq 0.19$) among DDG types. Therefore, when offered at lower levels, variation in types of DDG does not seem to have a substantial effect on intake and ruminal fermentation by lactating beef cows offered medium quality bermudagrass hay.

Key Words: bermudagrass, distillers dried grain

P139 **Influence of nutrient restriction and melatonin supplementation of pregnant ewes on maternal and fetal pancreatic β-cell morphology.** F. Doscher[1,*], C. Lemley[2], L. Camacho[1], P. Borowicz[1], J. Caton[1], A. Meyer[3], K. Vonnahme[1], K. Swanson[1], *[1]Animal Science, North Dakota State University, Fargo, [2]Animal Science, Mississippi State University, [3]Animal Science, University of Wyoming, Laramie.*

Objectives were to determine the effects of maternal feed intake and melatonin supplementation from mid- to late gestation on maternal and fetal pancreatic weight and β-cell morphology. Thirty-one primiparous western white-faced ewes were allocated to receive either 60% (RES) or 100% (ADQ) of nutrient requirements and supplemented with 0 (CON) or 5 mg/d melatonin (MEL) in a 2 × 2 factorial arrangement of treatments. Dietary treatments began on d 50 of gestation and continued until d 130 when ewes were euthanized. The pancreas was removed from both the ewe and fetus and trimmed of mesentery and fat. Pancreatic tissue was immersion fixed in formalin and embedded in paraffin blocks for histological measurements to quantify and characterize cells containing insulin (β-cells). AxioVision and ImagePro Plus software was used for generating and analyzing images, respectively. Maternal pancreatic mass was decreased (g; $P < 0.001$) in RES vs. ADQ and increased ($P < 0.02$) in MEL vs. CON. No differences ($P > 0.12$) were observed between treatments for fetal pancreatic mass. Histological examination of maternal and fetal slides revealed that the ratio of insulin producing cells to area of pancreatic tissue was not different between treatments ($P > 0.10$) but area of β-cells in fetal pancreas was reduced ($P = 0.04$) in fetuses from RES ewes compared to ADQ (4957 μm^2 vs. 2630 μm^2, SEM = 769.9). Area of pancreatic β-cells was greater ($P < 0.001$) in fetuses compared to ewes. Dietary restriction resulted in smaller β-cells in fetal pancreas while no effect was observed with melatonin supplementation. Therefore, maternal nutrient restriction may impact the development of the fetal endocrine pancreas by decreasing fetal β-cell size.

Key Words: ewe, fetal development, pancreas

P140 **Prediction of barley silage dry matter by near infrared reflectance spectroscopy.** C. F. O'Neill[1,*], A. R. Harding[1], S. E. Murray[1], M. L. May[2], L. O. Burciaga-Robles[2], O. R. Rasmussen[3], C. R. Krehbiel[1], *[1]Oklahoma State University, Stillwater, [2]Feedlot Health Management Services Ltd., Okotoks, Canada, [3]FOSS North America, Eden Prairie.*

Using near infrared reflectance spectroscopy (NIRS) for the prediction of barley silage DM was examined and NIRS equations were developed using commodity specific or broad based calibration sets. Fifteen fresh samples of both barley silage and barley straw were split into two groups: water added (WTR) and fresh. Water was added to WTR samples to ensure a broad range of DM values were represented in the equations. Samples were split, weighed and scanned (InfraXact, FOSS North America, Eden Prairie, MN). Samples were dried in a forced air oven at 55°C, in twelve 4 hour intervals samples

were weighed and scanned. For each sample DM was calculated and correlated to NIRS spectra at each interval. Silage samples were blocked by calculated DM and randomized to either the validation set (n = 128) or calibration set (n = 639). A commodity specific barley silage NIRS equation (SIL) was developed from the silage calibration set (SE of calibration (SEC) = 3.7663, R^2 = 0.9791). A second calibration set (n = 1406) was developed with the addition of barley straw samples (n = 767) to the barley silage calibration set and a broad based barley silage NIRS equation (SIL-STR) was derived (SEC = 2.9269, R^2 = 0.9770). The SIL and SIL-STR equations for DM of barley silage were validated using the independent barley silage validation set. The R^2 and SE of prediction (SEP) for the validation of SIL and SIL-STR equations were 0.9800 and 3.782 and 0.9770 and 3.9580, respectively. The DM content of barley silage can be accurately predicted using NIRS technology. The use of a broad based barley silage calibration provides comparable results to a commodity specific calibration while increasing the robustness of a NIRS equation.

Key Words: near infrared reflectance spectroscopy, NIRS, silage

P141 (GS-PHD) **Near-infrared reflectance spectroscopy to predict starch concentration in lactating dairy cattle feces.** S. M. Fredin*, L. F. Ferraretto, M. S. Akins, C. R. Heuer, P. C. Hoffman, R. D. Shaver, *Dairy Science, University of Wisconsin, Madison.*

Fecal starch is a good predictor of total tract starch digestibility in lactating dairy cows. However, current fecal starch measurements are labor intensive and expensive. An experiment was conducted to develop and validate a near-infrared reflectance spectroscopy (NIRS) equation to estimate concentration of starch in feces. A total of 295 fecal samples were utilized from three experiments previously conducted using lactating dairy cows fed rations varying in feed composition. Fecal samples were dried at 60°C for a minimum of 72 h, ground through a 1-mm screen with a Wiley or Udy mill, and analyzed for starch content. Fecal samples averaged 2.50 ± 1.97% starch (range of 0.32 to 19.61%, DM basis). The same samples were scanned on a Foss 6500 and calibrations were developed using WinISI software. Partial least squares regression methods were used to cross- validate the NIRS calibration using the samples from the calibration process. Fecal starch was predicted with good accuracy ($R^2 \geq 0.87$) by NIRS and moderate standard errors of calibration (SEC $\leq$ 0.48) for all mathematical transformations. Calibrations tended to under estimate starch concentration in fecal samples containing greater than 10% starch. Therefore, more fecal samples with >10% starch content may be needed in the development of a more robust calibration. Overall, NIRS is a good estimate of fecal starch concentration. Accurate, inexpensive, and rapid estimates of fecal starch will help dairy farmers and their nutritionists determine whether starch in rations fed to dairy cattle is adequately digested.

Key Words: fecal starch, near-infrared reflectance spectroscopy

P142 (UGS) **Effects of microbial fermentation products on milk production in dairy cows during heat stress.** R. M. Wagner[1,*], S. I. Kehoe [1], D. DuBourdieu [2], *[1]Animal and Food Science, University of Wisconsin, River Falls, [2]R&D Lifesciences, Menomonie.*

Heat stress is a problem that reduces milk production for dairy producers. The objective of this research was to determine the production benefits of feeding a combination microbial product containing fermentation products from Bacillus subtilis, Trichoderma viride, and Aspergillus oryzae (Lactomace; R & D Lifesciences, LLC, Menomonie, WI) during a summer heat wave. Two pens of lactating dairy cattle were matched in DIM and assigned to either a Control treatment with no microbial product (C) or a Microbial treatment (M) fed 5 gm/hd/day for the first 30 days and 10 gm/hd/d for the second 30 days. Daily milk yield and DMI and calculated 3.5% fat-corrected milk (FCM) and FCM:DMI ratio were recorded. Milk fat and protein % were collected from bulk tank samples after the first 30 d and 60 d. During data collection, Heat Index (HI) rose to an average of 32^{0}C thereby causing significant heat stress. Data were analyzed using a paired TTest. During periods of high HI, from 29^{0}C to 45^{0}C, least squares means of FCM were significantly higher for the M group compared with C (42.41 ± 1.71 kg and 38.45 ± 1.71 kg, respectively). During this heat time frame, milk yield from C cows was reduced by 15% and M cows by 5% although least squares means were significantly higher for the C group (41.54 ± 1.85 kg and 39.25 ± 1.58 kg for C and M, respectively). The M group had significantly higher FCM:DMI ratios (0.78 ± 0.05 and 0.67 ± 0.05 kg FCM/kg DMI for M and C, respectively). Dry matter intake was not different between treatments (24.60 ± 1.62 kg and 25.26 ± 4.56 kg for M and C, respectively). During the high HI time frame, milk fat % increased in the M treatment compared with a decrease in C cows (+0.56% compared with -0.46% for M and C, respectively). Results of this study conducted on a commercial dairy farm in WI during summer months indicate that FCM is significantly increased with an increased FCM efficiency. These results indicate that supplementation of these fermentation byproducts may improve digestion and utilization of feedstuffs in the diet thus abating the effects of heat stress and supporting production.

Key Words: dairy cows, heat stress, supplementation

P143 (UGS) **Effect of corn processing and distiller's grains inclusion on intake, rumination, and resting time of finishing steers fed a high concentrate diet.** Z. E. Carlson*, A. Islas, R. S. Goulart, T. Gilbery, M. L. Bauer, K. C. Swanson, *Animal Science, North Dakota State University, Fargo.*

Twenty-four steers, predominantly of Angus, Simmental, and Shorthorn breeding, were utilized to study the effects of dried-rolled corn processing size and corn dried distiller's grains plus solubles (DDGS) inclusion on rumination, resting, eating, and drinking time of steers consuming a high-concentrate diet (90%). Steers were part of a larger study (n = 64; initial BW 352 ± 8.4 kg) in which steers were blocked by BW into 3 pens equipped with Insentec feed troughs. Within each pen, steers were assigned randomly to 1 of 4 experimental treatments (n = 5 or 6 per treatment): 1) fine-rolled corn (approximately 1500 µm) and 20% DDGS; 2) fine-rolled corn and 40% DDGS; 3) coarse-rolled corn (approximately 3000 µm) and 20% DDGS; and 4) coarse-rolled corn and 40% DDGS. For this study, 24 steers were selected randomly from 2 of the pens (n = 6 per treatment). Rumination, resting, eating, and drinking time were monitored visually over a 24-h period with observations recorded every 5 min. Dry-rolled corn processing (coarse vs. fine) and DDGS inclusion (20 vs. 40%) had no effect ($P > 0.12$) on time at the feed trough. However, steers consuming coarse corn spent more time drinking ($P = 0.03$) than those fed fine corn (35.4 vs. 23.8 ± 3.51 min). Total time of intake (eating + drinking time) was not affected (P

> 0.05) by corn processing or DDGS amount. Total rumination time (standing + laying time) was not affected ($P > 0.10$) by processing or DDGS amount. However, steers fed 40% DDGS ruminated less while standing than steers fed 20% DDGS ($P = 0.03$; 55 vs. 102 ± 13.9 min). Differences in resting time (not ruminating, eating, or drinking) were not observed ($P > 0.33$) between corn processing or DDGS treatments. Corn fermentability and nutrient source may alter time spent drinking and ruminating by finishing cattle.

Key Words: cattle, corn processing, distillers grains

TEACHING

P144 **Illustrating the effects of fetal crowding on brain development in teaching laboratories.** J. Morton*, T. Rathbun, J. Gonzalez, D. Davis, *Animal Sciences and Industry, Kansas State University, Manhattan.*

The supply of nutrients and exposure to stressors during prenatal development affect growth, organ functions, and body composition throughout life. These responses are referred to as "fetal programming." Our objective is to develop a teaching laboratory that illustrates the effects of fetal crowding on brain development. Gravid pig uteri are a "natural experiment" because growth of each fetus is limited by its placenta. The fetal response to nutritional stress leads to "brain sparing" as measured by an increase in the ratio of brain to liver weight. We found brain and liver measurements were not easily adapted to student laboratories because gravid uteri often are collected in advance of the lab and stored frozen. The frozen and thawed brain and liver lose their structure and their weights don't accurately reflect their initial weights. A related indicator of brain sparing in low birth weight fetuses is a relatively larger head in proportion to the body. In student labs for reproductive physiology and growth courses we tested the ability of students to detect relationships between head measurements and fetal crown-to-rump length or fetal weight. The student's measurements revealed a negative relationship ($r^2 = 0.6$ to 0.8) between relative head size (circumference/mm crown-to-rump) and the length or weight of the fetus. This result is consistent with the concept of brain sparing. In the growth class there were both graduate and undergraduate students. The graduate students were tasked with summarizing and interpreting the data. They also led teams of undergraduates in interpreting a published abstract that described results of uterine crowding on fetal muscle development. In lectures these data were used to illustrate the effects of fetal nutritional stress on development of individual organs. Because these effects occur without exogenous treatments, the sow uteri collected from commercial abattoirs provide a low-cost source of laboratory material. This lab can anchor discussions of the fetal origins of postnatal traits in animals and humans, and lead to a broader discussion of epigenetic programming.

Key Words: teaching laboratory, pig, fetus

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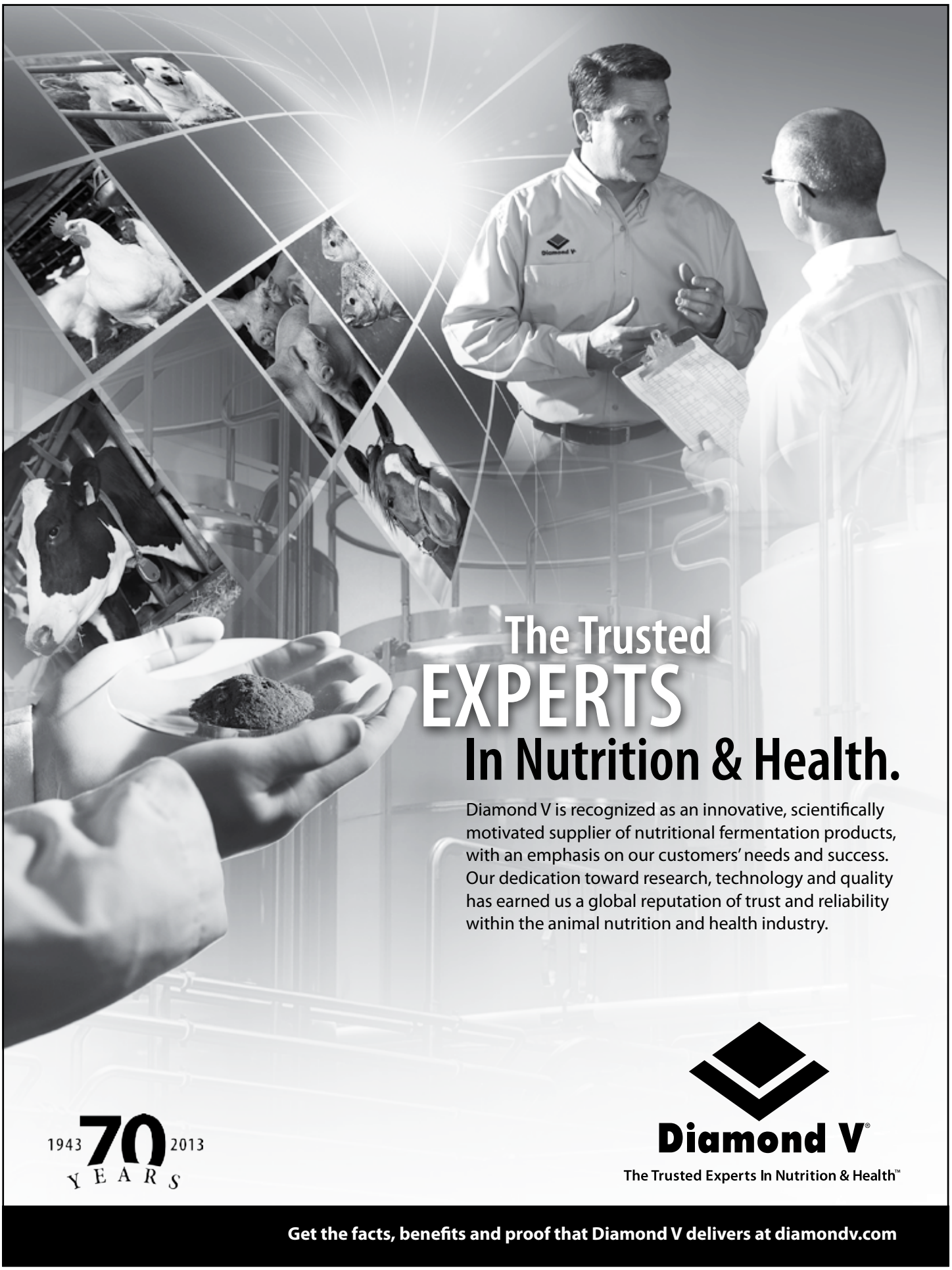
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