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ANIMAL BEHAVIOR, HOUSING, AND WELL-BEING

001 Evaluation of the behavioral differences between physically and immunologically castrated male pigs. A. Keller[1,*], B. Lemmer[2], S. Getty[1], B. Post[1], M. Nickel[3], F. Baier[1], D. Wagner[4], K. Vogel[1], *[1]University of Wisconsin– River Falls, River Falls, [2]North Carolina State University, Raleigh, [3]Iowa State University, Ames, [4]Colorado State University, Fort Collins*.

The standard method of castration for swine in the United States is to physically remove the testes within the first month of life, typically without the use of anesthesia or analgesia. An alternative solution to this welfare issue is to use immunological castration. This pilot study was conducted to evaluate the behavioral differences between male pigs castrated physically by scalpel at less than 10 d of age or immunologically during the finishing period. The study was conducted on 31 male pigs housed in finishing pens from 11 wk of age until 24 wk of age. The 31 pigs were randomly assigned to 3 pens of 8 and 1 pen of 7. Two pens were physically castrated and the other 2 were immunologically castrated, using a commercially available immunological product that was designed to suppress puberty in male swine (Improvest; Zoetis, Florham Park, NJ). The first injection was administered on d 1 of the trial and 4 wk later, a second injection was administered, both by a trained Zoetis employee. Eight weeks after the second injection, the pigs were sent to slaughter. Behavior was assessed using continuous 24-h video surveillance that began on d 1 of the trial to correspond to the first injection date and was repeated at weekly intervals for the duration of the trial. Scan sampling was used on all pigs in all pens at 2-min intervals. Time budgets were recorded and analyzed for comparison between treatment groups and behavior sampling dates. Tukey's tests within the MIXED procedure of SAS 9.3 (SAS Inst. Inc., Cary, NC) were used to analyze the effects of castration treatment, week on trial, and the interaction of castration treatment and week on trial. The number of pigs per pen was used as a weighting variable within the model. Of the behavioral parameters measured (laying, standing exclusively, sitting exclusively, walking, eating while standing, eating while sitting, drinking while standing, drinking while sitting, agonistic while standing, and agonistic while sitting), there were no significant differences between treatments ($P > 0.05$). There was a castration treatment × week on trial interaction effect on expression of mounting behavior. In wk 2, 3, 5, and 7, immunologically castrated pigs showed significantly more mounting behavior compared with physically castrated pigs ($P = 0.0012$). The results of this pilot study suggest that additional research is necessary to understand if behavioral implications exist for immunologically castrated swine.

Key Words: behavior, castration, swine

002 Differential postprandial eating behavior of morning- and evening-fed dairy cows. A. Nikkhah*, *University of Zanjan, Zanjan, Iran*.

The objective of this experiment was to establish postprandial patterns of eating rate in once-daily–fed high-producing lactating dairy cows. Eight multiparous (664 kg [SD 62] BW and 80 d [SD 40] in milk) lactating Holstein cows were studied in a crossover design experiment with two 21-d periods. Cows were kept under thermoneutral conditions and offered an experimental total mixed ration (TMR) based on barley and corn grains, corn silage, and alfalfa hay, as the main starch and forage sources, at either 0800 or 2000 h. The forage-to-concentrate ratio on a DM basis was 50:50, offered for 5 to 10% daily orts. Feed intake was continuously monitored for the entire experiment and collected for data analysis during the third week of both periods. Statistical data analysis was conducted with Mixed Models procedures of SAS (SAS Inst. Inc., Cary, NC) program. Feed intake patterns were expressed every 3 h as a percentage of total daily intake. Feeding the TMR at 2000 vs. 0800 h increased eating rate shortly after feeding ($P < 0.05$), such that morning-fed and evening-fed cows consumed 33 and 45%, respectively, of their daily TMR intake within the first 3 h after feeding. However, within 9 h after feeding, morning-fed (72%) and evening-fed (74%) cows ate comparable amounts of their total daily intake ($P > 0.15$). Based on individual data, some cows in the evening-fed group consumed up to 70% of their total daily intake within only 3 h after feeding. Total daily intake, however, was similar between morning-fed (21.2 kg) and evening-fed (21.4 kg) cows ($P > 0.15$). These results demonstrated that timing of feeding as an external modulator of circadian ruminant physiology significantly contributes to rhythmic regulation of feed intake patterns. Findings provide implications for effective farm management of high-producing cows exposed to various metabolic challenges.

Key Words: dairy cow, intake pattern, timing of feeding

003 Eating behavior patterns of multigrain- and barley-fed lactating dairy cows. A. Nikkhah*, *University of Zanjan, Zanjan, Iran*.

The objective of this research was to establish postprandial patterns of eating in lactating dairy cows on diets based on either solely barley grain or a choice of multiple grains. Eight multiparous (642 kg [SD 57] BW and 72 d [SD 58] in milk) lactating Holstein cows were studied in a crossover design experiment with two 21-d periods. Cows were housed and managed in free individual boxes and fed alfalfa hay–corn silage–based total mixed rations with either barley as the only grain (BR) or a mixture of barley, corn, wheat, and sorghum

(MG). Proportion of cereals in the multigrain treatment was equal, each equal to 25%. Grains were included as 30% of total dietary DM. Diets were prepared as total mixed rations and offered for 5 to 10% daily orts. Cows were fed at 0530, 1330, and 2130 h. Feed intake and eating rate were continuously monitored for the entire experiment and collected for data analysis during the third week of both periods. Feed intake patterns were expressed every 3 h after feeding as a percentage of total daily intake. Statistical data analysis was conducted with Mixed Models procedures of the SAS program (SAS Inst. Inc., Cary, NC). Feeding MG vs. BR increased eating rate shortly after feeding ($P < 0.05$), such that MG and BR cows consumed 80 and 73%, respectively, of their daily total mixed ration intake within the first 3 h after feeding, summing all feeding occasions. Based on individual data, some cows in the MG group consumed up to 90% of their total daily intake within only 3 h after feeding. These suggest a stronger craving for fresh feed in MG cows compared with BR cows, which could indicate improved feed palatability when multigrain rather than solely barley grain was fed. Total daily feed intake was greater for MG vs. BR (21.2 vs. 19.9 kg/d; $P < 0.05$). These results suggest that type/mixture of starch is a determinant of circadian eating patterns and influences voluntary feed intake regulation in lactating dairy cows. Because eating behavior patterns determine circadian patterns of rumen metabolism and peripheral substrate availability, findings on the superiority of MG over BR in stimulating the cow craving for fresh feed provide metabolic and health implications.

Key Words: dairy cow, eating behavior, multigrain

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004 The effect of corrective claw trimming on gait analysis of the sow.

A. Tinkle[1,*], K. J. Duberstein[1], M. E. Wilson[2], M. A. Parsley[3], M. K. Beckman[2], M. J. Azain[1], C. R. Dove[1], *[1]University of Georgia, Athens, [2]Zinpro Corporation, Eden Prairie, MN, [3]Zinpro Corporation, Sheridan, IN*.

Lameness is a major cause of culling in sow herds. The objective of this study was to ascertain kinematic adaptations following corrective claw trimming of sows. In this study, 52 sows individually walked a semicircular (4 m diameter) and then a straight chute (0.6 m wide) system before and 1 and 48 h after trimming (PRE, POST1, and POST48, respectively). Sows were simultaneously video recorded as they passed through the straight chute and moved perpendicularly between 2 synchronized cameras. The straight chute consisted of 2.4 m each of prerecording and recording distance followed by 1.7 m postrecording distance. Sows were electronically timed walking through the recording frame, which each sow repeated until 5 useable repetitions, defined as falling within a 10% deviation of the mean time were achieved**.** After the pretrimming videography, claws were correctively trimmed to approximately 5.5 cm away from coronary band, and then sows were video recorded at 1 and 48 h after trimming. Video recordings were analyzed using a 2-dimensional kinematic software program (Kinovea) to assess duration of swing, stance, breakover, stride length, and 3-limb support phase. Stride duration and velocity, swing:stance ratio, and both stance and breakover as percentages of stride duration were calculated. Data were analyzed using PROC MIXED of SAS ($P < 0.05$ significant; SAS Inst. Inc., Cary, NC). Analysis revealed a decrease in overall stride duration (1.04, 1.02, and 0.98 s in the front and 1.14, 1.11, and 1.07 s in the rear for PRE, POST1, and POST48, respectively; $P < 0.0001$) and breakover (0.12, 0.11, and 0.10 s in the front and 0.14, 0.12, and 0.11 s in the rear for PRE, POST1, and POST48, respectively; $P < 0.0001$). Stride length decreased in the front limbs (106.5, 103.7, and 104.5 cm for PRE, POST1, and POST48, respectively; $P < 0.05$) and velocity increased (104.8, 105.1, and 109.7 cm/s in the front and 93.2, 95.2, and 101.3 cm/s in the rear for PRE, POST1, and POST48, respectively; $P < 0.0001$). The three-limb support phase decreased (47, 46, and 42% in the front and 49, 46, and 42% in the rear for PRE, POST1, and POST48, respectively; $P < 0.0001$). Breakover as a percent of stride duration decreased (12, 11, and 10% in the front and 12, 11, and 10% in the rear for PRE, POST1, and POST48, respectively; $P < 0.001$). This data supports the practice of claw trimming to improve gait efficiency of the sow, which may influence sow longevity and culling rate.

Key Words: claw trimming, lameness, sows

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005 The impact of gestation housing system (individual vs. group) on the reproductive performance of sows.

A. L. Laudwig[1,*], M. Ellis[1], A. M. Gaines[2], B. A. Peterson[2], *[1]University of Illinois, Urbana–Champaign, [2]The Maschhoffs, LLC, Carlyle, IL*.

The objective of the study was to evaluate the effect of gestation sow housing system on sow performance under commercial conditions. The study was performed on a commercial breed-to-wean facility using a randomized complete block design to compare 2 treatments: individual vs. group (8 females/pen) housing. Sows on the individual treatment were housed in gestation stalls (dimensions 0.54 by 2.07 m; floor space 1.12 m^2/female). The group housing was created in the same building by combining 8 stalls by removing the backs and part of the side divisions of the stall. Pens dimensions were 2.20 by 4.71 m, providing a total floor space of 1.30 m^2/female. A replicate was 16 females (8 in 1 group housing and 8 individual housing); a total of 1325 pregnant females were allotted to treatments in 106 replicates at approximately 35 d after mating after pregnancy checking. Sows on both treatments were housed in individual stalls from weaning to d 35 of gestation. Management of females in pregnancy and lactation was in line with standard commercial practice. Data were available for 955 females that completed a first parity and 370 females that completed first and second parity. The experimental unit was the individual sow, and data were analyzed using PROC MIXED of SAS

(SAS Inst. Inc., Cary, NC); the model included the fixed effects of treatment and parity and the random effect of replicate. There was no effect ($P > 0.05$) of treatment on number of piglets born (alive, dead, mummified, and total), piglet and litter weights (birth and weaning), weaning to rebreeding interval, or female BW and body condition. However, females housed in groups had a lower ($P < 0.05$) farrowing rate (3.9% units) and a higher ($P < 0.05$) sow removal rate (5.7% units) and piglet preweaning mortality (1.2% units) than those housed in individual stalls. This study suggests that housing first and second parity females in groups in pens converted from gestation stalls can have a negative effect on reproductive performance.

Key Words: gestation, group housing, sow, stalls

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006 The effect of farrowing pen size on preweaning mortality. A. L. Laudwig[1,*], M. Ellis[1], A. M. Gaines[2], B. A. Peterson[2], *[1]University of Illinois, Urbana–Champaign, [2]The Maschhoffs, LLC, Carlyle, IL*.

The objective was to evaluate the effect of farrowing pen size on preweaning mortality. The study was performed on a commercial breed-to-wean facility using a randomized complete block design to compare 2 treatments: standard (1.52 m pen width) pen size and increased (1.68 m pen width) pen size. The farrowing pens had the same design of farrowing crate; solid pen divisions; and perforated, plastic-coated metal floors. The sows used had been housed during gestation in either individual stalls or groups of 8. Replicates of 2 sows from the same gestation housing system (individual stall or group of 8) and similar parity and breed date (± 2 d) were randomly allotted to farrowing pen size treatment at d 112 of gestation when they were moved from the gestation facility to the farrowing facility. A total of 239 gilts and 287 first parity females were allotted to treatment. Management in the farrowing facility was in line with standard commercial practice. Data were recorded on litter performance variables from birth to weaning (22 ± 3 d). The experimental unit was the sow, and data were analyzed using PROC MIXED of SAS (SAS Inst. Inc., Cary, NC); the model included the fixed effect of treatment and the random effect of replicate. The increased pen size treatment had a greater ($P < 0.05$) total number of piglets born (0.5 piglets) and weaned (0.4 piglets), but there was no effect of pen size on the number of piglets born alive, dead, and mummified. Additionally, preweaning mortality was not different ($P > 0.05$) between treatments. These results suggest that there was no benefit in reducing preweaning mortality for the increased farrowing pen size. However, the study was performed with young (parity 0 and 1) and relatively small animals; further research is warranted to evaluate the impact of farrowing pen size on preweaning mortality in older and larger sows.

Key Words: farrowing pen size, mortality, piglet

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007 Effect of water treatment on drinking preferences of dairy heifers. N. D. Senevirathne*, J. L. Anderson, M. Rovai, *South Dakota State University, Brookings*.

As ground water is hard with high mineral content in eastern South Dakota, there is concern about its effects on dairy cattle drinking behavior, which may consequentially affect health and performance. Our objective was to determine drinking preference of dairy heifers offered water treated with a reverse osmosis system (RO) or by a municipal water treatment plant (MW), compared with local untreated well water (WW). Six Holstein heifers (100 ± 6.5 d of age and 137 ± 5.9 kg BW) were used in a sequential elimination study. Heifers were kept in individual pens (1.5 by 3 m) and fed similar rations of pellets and grass hay. Three containers (14 L) of water were provided for each heifer and refreshed 3 times per day. An extra container on each side was left empty to avoid preferential behavior by location. Throughout the 8-d experiment period, individual water intakes by heifer and water type were measured. During the adaptation phase of the study, heifers were given MW for 3 d to establish baseline intake. During phase 1, all 3 water types were offered for 3 d and the most preferred water of each heifer was removed at the end. During phase 2, the remaining 2 water types were offered for 2 d. Water preference ranking by heifer was determined based on intake amounts. Kendall's coefficient of concordance (W) was calculated to evaluate agreement of preference among heifers. Total average water intake was 16.0 ± 2.14, 15.8 ± 1.95, and 14.9 ± 2.21 kg/d for the adaptation, phase 1, and phase 2, respectively. During phase 1, average intake was 7.10 ± 3.97, 5.10 ± 3.59, and 3.55 ± 4.89 kg/d for RO, MW, and WW, respectively. Three heifers preferred the RO first and MW second. Two heifers preferred MW first and RO second. One heifer chose WW first and was a potential outlier in the group for taste preference. Average preference rankings were 1.67, 1.83, and 2.50 for RO, MW, and WW, with lesser numbers indicating greater preference. Overall, $W = 0.19$ for agreement of preference among heifers, with $P = 0.31$. When the outlying heifer was removed, $W = 0.53$ with $P = 0.07$. Results showed RO was slightly preferred over MW and both were preferred over WW, with more consumption when all 3 water types were offered.

Key Words: dairy heifer, palatability, water treatment

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008 Development of acclimation to reduce flooring novelty in nursery pigs. F. Baier*, A. Keller, A. Munger, K. Vogel, *University of Wisconsin– River Falls, River Falls*.

The difficulty of moving pigs from nursery to finishing facilities may increase the possibility of unnecessary stress and inefficient moving time. Two common novel flooring surfaces experienced during this transition often include diamond-plate aluminum and concrete. The first objective of this study was to determine if the time for nursery pigs to step onto concrete

or aluminum flooring varied (Trial 1). The second objective was to determine if acclimation to new flooring surfaces would improve trailer loading time (Trial 2). All pigs were housed in raised nursery pens with metal mesh flooring. Both trials contained 3 replicates. Trial 1 included 6 pens of 6 pigs that were exposed to a section of either aluminum or concrete flooring involving only 1 specific flooring type in each pen. In both trials, aluminum and concrete flooring were novel to the pigs. Both flooring surfaces measured 0.61 by 0.61 m. Two pens (aluminum flooring and concrete flooring) were included in each replicate of Trial 1 and 4 pens were included in each replicate for Trial 2. Trial 2 included a total of 12 pens of 6 pigs that were concurrently exposed to either both flooring surfaces described in Trial 1 for approximately 4 wk (FLR) or only the existing metal mesh flooring (CTL). For Trial 1, behavior was assessed using focal sampling for the 24 h after each flooring substrate was placed in the pens. The mean time between the introduction of the flooring surface and the placement of 2 feet on the flooring surface was recorded for each individual pig. For Trial 2, trailer loading was video recorded during the transition from nursery to finishing facilities to determine the time elapsed between loading the first pig and loading the last pig within each pen. The experimental unit in both trials was pen. For each trial, differences between treatment means were tested with Tukey's tests in SAS 9.4 (SAS Inst. Inc., Cary, NC). For Trial 1, no difference ($P = 0.3183$) was observed in the mean amount of time for pigs to place 2 feet on concrete flooring (213 ± 1561 s) compared with aluminum flooring (2727 ± 1561 s). For Trial 2, no difference ($P = 0.2293$) was observed in the mean loading time for FLR (121 ± 25 s) and CTL (75 ± 25 s). The results of this pilot study suggest that additional research is necessary to understand the impact of flooring surfaces on the behavior of nursery pigs.

Key Words: behavior, nursery, swine

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009 Effects of feeder space allowance on behavior of slow-growing pigs during the nursery period.

Y. He[1], S. Cui[2,*], J. Deen[3], G. C. Shurson[4], Y. Li[2], *[1]Dep. of Animal Science, University of Minnesota, St. Paul, [2]West Central Research and Outreach Center, University of Minnesota, Morris, [3]Dep. of Veterinary Population Medicine, University of Minnesota, St. Paul, [4]Department of Animal Science, University of Minnesota, St. Paul*.

Pigs that grow slower than their contemporaries may be subject to complications in animal welfare. Competition at the feeder due to limited feeder space allowance and behavior of pigs may partially contribute to this slow growth. This study was conducted to investigate the effect of feeder space allowance on behavior of pigs during the nursery period. Pigs ($n = 440$) were monitored for growth performance from birth to market. Pigs were categorized as slow growers (SG) or fast growers (FG) based on their market weight adjusted to 170 d of age (SG $\leq$ 105 kg and FG > 125 kg). During the nursery period (4 to 9 wk of age), 8 pigs were housed in pens that provided either a 2-space or a 5-space feeder. The behavior of pigs ($n = 192$) in 24 pens (12 pens for each feeder space treatment) was video recorded for the first 4 d after entering nursery and on d 21 in the nursery, respectively. Marking chalk was used to mark the backs of pigs with different patterns for individual identification during video recording. Behavioral time budgets were calculated for each pig by scan sampling of the videos at 5-min intervals for 23 h each day during the recording period. In addition, 96 focal pigs (4 pigs from each of 24 pens) were identified and individually measured for feed consumption rates at 9 wk of age. Data were analyzed using the Glimmix procedure of SAS (SAS Inst. Inc., Cary, NC). Pigs provided with 5-space feeders spent more time eating (5.0 vs. 4.7% [SE 0.2]; $P = 0.05$) than pigs provided with 2-space feeders, indicating that providing more feeder space may increase feeding motivation of pigs. Compared with their counterparts in pens with 2-space feeders, SG pigs in pens with 5-space feeders spent less time standing (8.7 vs. 9.9% [SE 0.7]; $P < 0.05$) and tended to spend more time lying (84.7 vs. 83.9% [SE 0.59]; $P = 0.08$). Feeder space treatments did not affect feed consumption rate and time spent drinking or fighting ($P > 0.10$). These results suggest that providing more feeder space may improve the welfare of SG pigs due to the increased eating and resting activity.

Key Words: feeder space, pigs, slow growth

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010 The role of breeding in positive welfare change.

S. P. Turner*, R. Roehe, J. Conington, S. Desire, R. B. D'Eath, C. M. Dwyer, *Scotland's Rural College, Edinburgh, United Kingdom*.

Selective breeding will be crucial in meeting global challenges of ensuring food security and environmental and economic sustainability. Animal welfare affects efficiency and productivity and forms an important component of sustainability. The paper will consider the opportunities that breeding offers to improve some of the most intractable welfare challenges and, in doing so, how this will lead to direct economic and environmental benefits. Three examples will demonstrate the technical feasibility of breeding to improve welfare and will highlight the benefits to wider sustainability (lamb neonatal survival, foot infections ["foot rot"] in sheep, and aggression between pigs). Each is a long-standing and routine welfare problem. Significant moderate heritabilities (lamb vigor, which contributes to survival, 0.32; foot rot, 0.15–0.25; and aggression, 0.43) show that each can be improved by selection. New rapid and robust phenotyping methods have led to uptake (foot rot) or commercial interest in selection (survival and aggression). Careful choice of selection traits can avoid antagonistic genetic correlations with economic traits (e.g., r_g between aggressiveness and growth, 0.29–0.54) or lead to correlated benefits (e.g., r_g between foot rot and number of lambs

reared to weaning, −0.6). Phenotyping welfare traits can be costly. Examples will be given of how genomic selection or selection on associative effects (heritable effects on growth of group mates) may circumvent the constraints that phenotyping costs currently pose to selection. Estimation of economic weights is difficult for many welfare traits, as their full effects on profitability have not been quantified (e.g., effects on labor requirements and immunocompetence). Economic weights need to be exaggerated in some cases to reflect this or desired gains methodology used. Improving welfare traits by selection presents ethical dilemmas. We argue that the ethical decision is simpler where opportunities for management change are few and unintended changes in other welfare traits are unlikely (e.g., lamb survival in unpredictable climates). This situation will be contrasted with the ethical considerations involved in selection against a complex social behavior (e.g., aggression). Breeding poses both threats to and opportunities for welfare. Used appropriately, it can help to improve longstanding welfare problems. The barriers to achieving this are diminishing but still significant and require a greater understanding of correlated effects on economic and noneconomic traits and low-cost but information-rich phenotyping methods.

Key Words: aggression, breeding, foot rot, survival, welfare

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011 Implementing animal well-being technologies; United States producer perspective.

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How animals are housed may have recently become a hot topic to consumers, but it has always been a priority to animal caretakers. For example, moving pigs from a snow-covered dirt lot to an environmentally controlled building in the 1970s is a form of implementing modern housing to improve animal well-being and, in fact, probably was the largest improvement in swine well-being in 50 yr. More recently, consumer demand has forced pork producers to rethink housing gestating sows, specifically in group pens. This is not a new theory. Historically, sows have been housed in group pens before the implementation of the gestation stall. However, with modern genetics and technological advances, new group-housing options exist and need to be reconsidered. There are multiple options to consider when deciding which housing system to implement, such as existing facility design, reliability, and durability of the system; access to technical support; feeding strategies; grouping strategies; ease of access to animals; and, most importantly, animal well-being and employee capabilities. It is important for the system adopted to be compatible with the caretaker's abilities, because proper husbandry will have a larger impact on animal well-being than a housing system. Sows in any housing system can be managed poorly or extremely well. Therefore, determining which system works best for the caretaker's management style is the most important contribution to animal well-being. Other things to consider when deciding on which housing system to implement are the durability and reliability of the housing system. The capital cost to renovate an existing facility is substantial. Making sure that the equipment invested in is durable enough to sustain the environment will allow the employees more time caring for animals than repairing equipment. There are facility changes that can be implemented after selecting a group-housing system for sows that allow for the caretaker to have easier access to the animals and to provide better care, such as slide-through gates between pens or reducing the gap width of slatted floors. Another form of management strategy to improve well-being of group-housed sows is to consider alternative feeding strategies. Feeding a more fibrous diet may increase satiety and reduce competition. Overall, when adopting a new housing system or technology, there are several management strategies that can be implemented to improve well-being, but the most important to consider is the caretaker's ability and understanding of how to manage that system and, therefore, care for the animals.

Key Words: caretaker, implementation, well-being

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012 Engineering solutions to address challenges to animal well-being.

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Engineering solutions to address challenges to animal well-being may offer valuable input based on 1) the approach by which we generate and evaluate solutions and 2) the selection and implementation of technology. Animal welfare may be assessed within the 3 main areas summarized by Fraser in 2008: affective state, biological function, and natural living. To attain the highest level of welfare, a state of well-being, animal housing and husbandry should simultaneously address all 3 areas. This can be a significant challenge when there are competing forces that decrease well-being in one area when attempting to increase it in another. Challenges to animal well-being should be addressed with an engineering systems–thinking approach, recognizing that the housing and husbandry of animals is a complex system with interconnected components. Solutions to challenges have, historically, individually addressed challenges, leaving the remainder of the system vulnerable to unintended consequences. For example, the egg-layer industry solution to increasing floor space by adding depth to the cages resulted in unintended challenges with feeder space. Engineering solutions may be derived not only from the way we approach the challenges but also with the selection and implementation of appropriate technologies, such as sensors for monitoring the environment and/or the animal or control systems to provide automated animal management. The classical engineering approach to technology has been related to environmental control, specifically for providing optimal thermal comfort based on a set-point condition or controlling lighting or feeding on a set schedule. This traditional approach to ani-

mal housing and husbandry has been prescriptive but resulted in the ability to increase the scale of animal production. The deficiency in this approach is that it takes a one-size-fits-all approach to the needs of the animals under a given set of conditions. Advances in technology are quickly moving toward viable on-farm capabilities to offer real-time status inputs of individuals or groups of animals, which has the potential to offer a new approach to animal management.

Key Words: management, technology, welfare

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013 Six questions for veterinarians. J. Deen*, *Dep. of Veterinary Population Medicine, University of Minnesota, St. Paul*.

In animal welfare, there are a number of needs, concerns, and constituencies. Veterinarians are expected to understand not only the needs of animals but also the multiplicity of concerns that individuals and societies present. Veterinarians are asked to contribute to a wide range of determinations that are sometimes deterministic but invariably dialogic. One model that we use in training is the following 6 questions. 1) How did we achieve the present norms? The definitions of normative treatment of animals vary by time and society. Understanding historical arcs and sociologic drivers of norms needs better definition, especially as we involve ourselves in processes that change those norms. 2) How anthropocentric are these norms? The norms on allocation of resources to animals can be broadly divided by the relationship to humans. There are those animals that are companions (pets), those animals that are farmed (livestock), those animals that are part of an accepted ecosystem (wildlife), and those that are considered to be detrimental (pests). 3) How do we discriminate levels of consciousness? Our determination of what an animal feels needs a combination of knowledge, observation, anthropomorphism, and conjecture. This is first in terms of immediate responses to an observed stimulant such as pain of an injection or the fear of a predator. But it is also in terms of longer-term expectations of an animal that can result in prolonged changes in responses and outlook. 4) How does the behavior of animals indicate welfare? The examination of behaviors of animals has been used both in clinical settings as well as in research settings to determine the needs of animals and the prioritization of allocation of resources. The strengths of these associations vary widely in level and causal pathways. 5) How does the physical state of animals indicate welfare? The physical proxies of welfare are often more easily measured than the behavioral proxies, especially through the extensive training that veterinarians receive. Yet these physical indicators require the same level of analysis of strengths of association as do behavioral indicators, both independently and in combination. 6) How do the natures and instincts of animals indicate welfare? The functional relationship between natures and instincts and welfare is less studied than behavioral or physical states, especially when evaluated independently of behavior and physical indicators. Strengths of association are more difficult to determine, and yet it is a major concern of many involved in the care of animals.

Key Words: veterinary welfare

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014 The effect of temperament on pork quality. J. A. Calderon Diaz, A. M. Danielson*, S. Azarpajouh, J. M. Mumm, S. Hirano, D. L. Beam, M. Walugembe, J. D. Stock, C. Dematawewa, K. J. Stalder, *Department of Animal Science, Iowa State University, Ames*.

Temperament in pigs could impact meat quality. Studies have suggested that the use of on-farm behavioral tests could help to predict fearfulness and stress response at slaughter. This study aimed to determine breed differences in pig temperament indicators, pork quality characteristics, and their relationship. Pigs from 5 different breeds were housed in mixed sex groups (3 pens of Chester White, 3 pens of Landrace, 4 pens of Yorkshire, 4 pens of Duroc, and 5 pens of Berkshire) of 8 pigs as part of the 2015 National Barrow Show progeny test. The trial started when pigs were approximately 32 kg of BW and finished 84 d later. Before slaughter, pigs were individually released from their holding pen and allowed to walk freely (i.e., no handling involved) until they reached the weighing scale (distance 14 m). Time (s) needed to reach the weighing scale (TS) and body lesions in 11 regions of the pig's body (0 = normal to 5 = severe lesion) were scored as indicators of docility and aggressiveness, respectively. A total body lesion score (TBL) was calculated. Additionally, BW was also recorded. Tenderness, juiciness, and chewiness were scored by a highly trained 3-member professional sensory panel using a 10-point category scale (1 = low degree and 10 = high degree of each characteristic). Pen was considered the experimental unit and data were analyzed using mixed model equations. Models included breed, TBL, and TS as fixed effects. Body weight was included as a linear covariate. Total body lesion score was not a significant source of variation for any of the pork quality traits studied ($P > 0.05$). Pigs with lower TS had greater tenderness scores ($P < 0.05$), but TS had no relationship with either juiciness or chewiness score ($P > 0.05$). Berkshire pigs had greater tenderness scores compared with the other 4 breeds ($P < 0.05$). Berkshire pigs had greater juiciness scores compared with Landrace and Yorkshire pigs ($P < 0.05$). Furthermore, Berkshire pigs had lower chewiness score ($P < 0.05$) compared with Duroc, Landrace, and Yorkshire pigs. Heavier pigs before slaughter had greater tenderness and juiciness scores but lower chewiness scores compared with lighter pigs ($P < 0.05$). Results indicate that temperament indicators such as docility affect some meat quality characteristics. However, other factors such as breed and BW before slaughter had a greater influence in the traits studied.

Key Words: chewiness, juiciness, pig temperament, pork quality, tenderness

015 Development of equations to predict the influence of floor space on average daily gain, average daily feed intake, and gain-to-feed ratio of finishing pigs. J. R. Flohr*, J. C. Woodworth, M. D. Tokach, S. S. Dritz, J. M. DeRouchey, R. D. Goodband, *Kansas State University, Manhattan*.

Data from existing literature examining the influence of floor space allowance on the growth of finishing pigs was used to develop prediction equations for ADG, ADFI, and G:F. Two databases were used: the first included information from studies examining the influence of floor space allowance, and the second included the aforementioned papers along with papers examining the impact of floor space after pigs were removed from the pen. The first database included 27, 25, and 25 papers for ADG, ADFI, and G:F, respectively, and the second database contained 30, 28, and 28 papers for ADG, ADFI, and G:F, respectively. The predictor variables tested were floor space (m^2/pig), k (floor space/final $BW^{0.67}$), initial BW, final BW, feed space (pigs per feeder hole), water space (pigs per waterer), group size (pigs per pen), gender, floor type, and study length (d). Floor space treatments within each experiment were the experimental unit and random effects of decade, paper within decade, and experiment within paper × decade interactions were included in the statistical model. A weighted variance term was included in the statistical model to account for heterogeneity of experimental designs and replication across the existing literature. The statistical significance for inclusion of terms in the model was determined at $P < 0.10$. Further evaluation of models with significant terms was then conducted based on the Bayesian information criterion (BIC). Once the ADG and ADFI models for each respective database were determined, then the G:F model was evaluated as the predicted ADG/predicted ADFI. The optimum equations to predict finishing ADG, ADFI, and G:F for the first database were ADG, g = 395.57 + (15,727 × k) − (221,705 × k^2) − (3.6478 × initial BW, kg) + (2.209 × final BW, kg) + (67.6294 × k × initial BW, kg); ADFI, g = 802.07 + (20,121 × k) − (301,210 × k^2) − (1.5985 × initial BW, kg) + (11.8907 × final BW, kg) + (159.79 × k × initial BW, kg); and G:F = predicted ADG/predicted ADFI. The optimum equations to predict ADG, ADFI, and G:F for the second database were ADG, g = 337.57 + (16,468 × k) − (237,350 × k^2) − (3.1209 × initial BW, kg) + (2.569 × final BW, kg) + (71.6918 × k × initial BW, kg); ADFI, g = 833.41 + (24,785 × k) − (388,998 × k^2) − (3.0027 × initial BW, kg) + (11.246 × final BW, kg) + (187.61 × k × initial BW, kg); and G:F = predicted ADG/predicted ADFI. All multiterm models improved BIC values compared with single-term predictor models, signifying that multiterm models proved to better fit their respective databases.

Key Words: finishing pigs, models, stocking density

016 Evaluating the effects of floor space allowance and pig removal from a group on the growth of finishing pigs. J. R. Flohr[1,*], J. C. Woodworth[1], M. D. Tokach[1], S. S. Dritz[1], J. M. DeRouchey[1], R. D. Goodband[1], G. Gourley[2], [1]*Kansas State University, Manhattan,* [2]*Gourley Research Group LLC, Webster City, IA*.

A total of 1092 finishing pigs (initially 36.3 ± 1.2 kg BW) were used in a 117-d study to evaluate the impact of initial floor space allowance and removal strategy on the growth of finishing pigs up to 140 kg. There were 4 experimental treatments with 14 pens per treatment. The first treatment stocked pigs at 0.91 m^2 (15 pigs/pen) throughout the duration of the study. The other 3 treatments initially stocked pigs at 0.65 m^2 (21 pigs/pen) and were subject to 1 of 3 removal strategies. The second treatment (2:2:2) removed the 2 heaviest pigs from pens on d 64, 76, and 95. Treatment 3 (2:4) removed the 2 heaviest pigs on d 76 and the 4 heaviest pigs on d 105. Treatment 4 (6) removed the heaviest 6 pigs on d 105. All pigs remaining in pens after removals were fed to d 117. Overall (d 0 to 117), pigs initially provided 0.91 m^2 of floor space had increased ($P < 0.05$) ADG compared with pigs in pens on the 2:4 or 6 removal strategy. Pigs initially provided 0.91 m^2 of floor space had increased ($P < 0.05$) ADFI compared with pigs initially provided 0.65 m^2 of floor space. Feed efficiency was poorer for pigs initially provided 0.91 m^2 of floor space compared with pigs on the 2:2:2 or 2:4 removal strategy. Total BW gain per pen was greater ($P < 0.05$) for pens initially stocked at 0.65 m^2 compared with pens initially stocked at 0.91 m^2. Feed usage per pen was less ($P < 0.05$) for pens initially stocked at 0.91 m^2 compared with pens initially providing 0.65 m^2 of floor space and on removal strategies. Feed usage per pen was less ($P < 0.05$) for pigs on the 2:2:2 removal strategy compared with pigs on the 2:4 or the 6 removal strategy. In conclusion, increasing the floor space allowance

Table 016.

	Treatments				
	Initial floor space, m^2				
	0.91	0.65	0.65	0.65	
	Marketing strategy				
Item	None	2:2:2	2:4	6	SEM
d 0 to 117					
ADG, kg	0.92	0.90	0.88	0.87	0.008
ADFI, kg	2.58	2.40	2.39	2.39	0.022
G:F	0.358	0.377	0.370	0.364	0.002
d 0 BW, kg	36.4	36.3	36.3	36.3	0.32
Average BW at time of removal, kg	144.8	132.3	134.9	136.6	0.87
Total BW gain, kg/pen	1603	2032	2077	2083	27.4
Feed usage, kg/pen	4537	5349	5566	5730	46.1

or the time points at which pigs are removed from the pen improved the growth of pigs remaining in the pen.

Key Words: finishing pig, marketing, stocking density

017 Effect of lameness on hock angles of replacement gilts.

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The objective of this study was to investigate whether hock angles significantly differ between lame and sound legs in replacement gilts. Thirteen gilts lame on the rear right leg were moved to a pen where digital images (i.e., still pictures) were recorded while the gilt walked to capture images of the leg flexing forward and backward on both profile views. Standing images were also captured. On average, 9 high-quality images per gilt were used for analysis. Hock angles were measured for both lame and sound rear legs. Angles were measured by tracing the front and back of the joint between the fibula/tibia and tarsals, with the anterior and posterior positions acting as the anchor. Flank-to-flank measurement was recorded to estimate BW. Data were analyzed using mixed model methods with leg (sound or lame), leg position (forward, standing, or backward), and their interaction included as fixed effects. Estimated BW was included as a linear covariate. Gilt was included as a random effect. Hock angle varied between the sound and lame leg. When accounting for the average angle of all 3 positions, lame legs had wider hock angles when compared with the sound leg (141.1 vs. 136.9 ± 1.9 degrees, respectively; $P < 0.05$). Hock angles did not differ between lame and sound legs when the leg was positioned forward ($P > 0.05$). However, while standing and while flexing legs backward, hock angles were greater on the lame leg when compared with the sound leg (136.7 vs. 132.7 ± 2.1 and 145.4 vs. 136.1 ± 2.1 degrees, respectively; $P < 0.05$). Body weight was not a significant source of variation for any traits evaluated ($P > 0.05$). Straighter hock angles on the lame leg could indicate an effort of the gilt to balance her body while moving due to the discomfort she might be experiencing in the lame leg.

Key Words: hock angle, lameness, replacement gilts

018 Understanding tail biters and victimized pigs during outbreaks of tail biting.

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Tail biting is a common problem in growing–finishing pigs, which can compromise health, growth, and welfare of pigs. Because tail biting is an abnormal behavior performed by tail biters toward victimized pigs, understanding these pigs may help us solve the problem. This study was conducted to evaluate immune function of tail biters and victimized pigs. Pigs ($n = 240$; 25.7 ± 2.9 kg initial weight) were housed in 8 pens of 30 pigs for 16 wk. Once visible blood on a tail appeared, pigs in that pen were assessed daily for tail score (0 = no damage, 1 = healed lesions, 2 = visible blood without swelling, 3 = swelling and signs of infection, and 4 = partial or total loss of the tail). Victimized pigs were defined as pigs with tail scores equal to or greater than 2. Meanwhile, a 2-h observation was conducted for 2 consecutive days to identify tail biters. In each pen in which tail biting occurred, blood samples were collected from victimized pigs on the day that tail biting was first observed as well as from tail biters and 2 control pigs with no sign of tail damage. Fourteen biters (6 barrows and 8 gilts), 30 victimized pigs (21 barrows and 9 gilts), and 28 control pigs (14 barrows and 14 gilts) were identified for blood sampling. Total serum protein and IgG concentrations were analyzed using the spectrophotometric method. Data were analyzed using the Glimmix model of SAS (SAS Inst. Inc., Cary, NC). Compared with control and victimized pigs, tail biters had lower total serum protein ($P = 0.01$; Table 018) and IgG concentrations ($P = 0.01$), suggesting poor immunity. There were no differences in total serum protein or IgG concentrations between control and victimized pigs. These preliminary results suggest that tail biters may experience compromised immunity.

Table 018. Total serum protein, IgG, and tail scores of control pigs, victimized pigs, and tail biters

Item	Control	Victims	Biters	$P <$
No.	28	30	14	
Total serum protein, g/L	66.1 ± 1.1[a]	64.5 ± 1.1[a]	60.3 ± 1.5[b]	0.01
IgG, g/L	14.0 ± 0.6[a]	13.1 ± 0.6[a]	10.6 ± 0.9[b]	0.01
Tail score	0.1 ± 0.1[b]	2.5 ± 0.1[a]	0.2 ± 0.1[b]	< 0.001

[a,b]Means within a row without a common superscript differ (P < 0.05).

Key Words: immunity, pigs, tail biting

019 An assessment of swine marketed through buying stations and development of fitness for transport guidelines.

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Culled breeding animals represent 3% of swine slaughtered in the United States. Pigs are culled for multiple reasons including body condition, injury, and poor performance. There are concerns that culled pigs face higher risks of becoming fatigued or nonambulatory during marketing and transport. The objectives of this study were to 1) explore the welfare of culled swine marketed through buying stations, 2) characterize the prevalence of different types of compromised swine, and 3) identify potential risk factors associated with fatigued and nonambulatory pigs. A survey was conducted at

integrated and independent buying stations in 2014. Fifteen individual buying stations were enrolled, representing 4 marketing companies with locations in the United States. Detailed animal assessments were conducted at the time of unloading on all incoming trailer loads with every pig on each load assessed. Pigs were scored for condition on arrival (nonambulatory, fatigued, or dead) as well as body condition, injuries, hernias, skin lesions, vulva lesions, tail bites, lameness, abscesses, and prolapses. Pigs that were segregated from their cohorts by buying station employees due to health and welfare concerns were further evaluated based on their final outcome (rested and recovered, euthanized, or died). The number of trailers per day ranged from 1 to 12 incoming loads. Animals per load ranged from 9 to 177, including culled sows, breeding gilts, boars, and market pigs. A total of 7105 pigs and 122 trailer loads were evaluated. Three pigs were dead on arrival (0.04% of total population). Sows and boars made up 86% of the fatigued animals (total population fatigued = 16%), 73% of the lame pigs (total population lame = 5%), and 82% of the animals with a BCS of 1 (total population with BCS of 1 = 4%). Market pigs made up 9% of those with abscesses (total population abscesses = 6%) and 79% of those with hernias (total population with hernias = 3%). Follow-up assessments were conducted on 119 pigs segregated from their cohort, of which 79 were euthanized (66%). Prevalence ratios of fatigue, severe skin lesions, severe abscesses, and poor BCS were greater in sows and gilts than in market pigs (2.18 [confidence interval {CI} 1.84–2.58], 8.48 [CI 3.99–18.05], 3.22 [CI 1.78–5.85], and 2.36 [CI 1.61–3.46], respectively; $P < 0.01$ for all). The opportunity to identify at-risk pigs that fail to cope with transport and handling stressors can assist decision making about fitness for transport, with implications for humane endpoints and mitigating production losses.

Key Words: culled pigs, transportation, welfare

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020 Aversion to carbon dioxide gas in pigs using approach–avoidance and conditioned place avoidance paradigms.

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Weaned pig responses to CO_2 were examined using approach–avoidance and conditioned place avoidance paradigms. A preference-testing device was designed with 2 identical chambers separated by a sliding door and an exhaust sink. Twelve crossbred pigs were individually trained for 5 consecutive days to enter the treatment chamber (TC) when the sliding door was opened to obtain a food reward and had 6 min to move freely between the chambers before the test concluded. The same methods were used during the testing phase, with CO_2 concentrations in the TC maintained at 1 of 3 levels: 10, 20, and 30%. Tests concluded when loss of posture occurred or after 6 min. Pigs experienced each of the CO_2 treatments on gas day (G), preceded by ambient conditions on 1 baseline day (B) and on 1 wash out day (W) during 3 rounds. We hypothesized that pigs would display avoidance at higher CO_2 levels and that when aversion occurred, conditioned place avoidance would be observed on the W for that round. Behavior was collected using live observations and video recordings. Latency data were analyzed using PROC GLIMMIX in SAS 9.4 (SAS Inst. Inc., Cary, NC) and are presented as least squares means ± SEM. During testing, 2 pigs failed to enter the TC on any of the days and were removed from the analysis. Of the 10 remaining, all pigs entered the TC on all B, G, and W. Loss of posture was displayed by 0, 5, and 4 pigs at 10, 20, and 30% CO_2, respectively (192 ± 23 s for 20% CO_2 and 78 ± 6 s for 30% CO_2). Latency to enter the TC was greater on G than on B and W (3.3 ± 1.38 s for B, 20.8 ± 8.9 s for G, and 10.9 ± 4.5 s for W; $P = 0.0009$). Similarly, latency to leave the TC was less on G than on B and W (213.4 ± 37.1 s for B, 48.9 ± 9.1 s for G, and 273.1 ± 55.5 s for W; $P < 0.0001$). Latency to reenter the TC was greater on G than on B and W (37 ± 10.5 s for B, 106.5 ± 27.9 s for G, and 12.2 ± 3.8 s for W; $P < 0.0001$). No consistent differences were observed for CO_2 levels, suggesting that all the concentrations tested were aversive to pigs to some degree. However, aversion was not sufficient to provoke avoidance behavior by naïve pigs or pigs that lost posture during previous exposure.

Key Words: aversion testing, carbon dioxide, weaned pigs

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021 Divergent selection for residual feed intake alters pig behavioral reactivity to novel stimuli tests.

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Improving feed efficiency is essential for increasing sustainable production and producer profitability. It is also necessary to ensure that feed efficiency modifications do not negatively impact animal welfare, as concerns have been raised on how genetic selection for feed efficiency impacts livestock ability to cope with stress. Therefore, our objective was to determine if divergent selection for residual feed intake (RFI) altered pig behavioral reactivity toward novel stimuli. In Exp. 1, 40 low-RFI (more feed efficient) and 40 high-RFI (less feed efficient) eighth generation Yorkshire RFI selection line barrows (107 ± 9 d old) were evaluated. Experiment 2 evaluated 40 low-RFI and 40 high-RFI ninth generation barrows and gilts (101 ± 9 d old). All pigs were individually tested using both a human approach test (HAT) and a novel object test (NOT). Pigs were tested for 10 min within a 4.9 by 2.4 m test arena, consisting

of 4 zones. Behavior was evaluated using live and video observations, with the hypothesis that behaviorally reactive pigs would display more frequent oral, nasal, and/or facial contact with the human or object (traffic cone); zone entrances; head movements; urination; defecation; escape attempt (rearing on hind legs); and freezing ($\geq$ 3 s of no body movement) behaviors. Data were analyzed using the Glimmix procedure of SAS (SAS Inst. Inc., Cary, NC). In Exp. 1, low-RFI barrows entered fewer zones ($P < 0.0001$), had fewer head movements ($P \leq 0.02$), defecated less frequently ($P \leq 0.03$), displayed a shorter duration of freezing ($P = 0.05$), and froze less frequently ($P < 0.0001$) compared with high-RFI barrows during HAT and NOT. During HAT, low-RFI barrows also attempted to escape less frequently ($P = 0.001$) compared with high-RFI barrows. In contrast, low-RFI barrows took longer to first contact the novel stimuli in HAT and NOT compared with the high-RFI barrows ($P \leq 0.04$). In Exp. 2, low-RFI pigs contacted the novel stimuli in HAT and NOT less frequently compared with high-RFI pigs ($P \leq 0.03$). During NOT, low-RFI pigs attempted to escape less frequently ($P = 0.0002$) and spent less time attempting to escape ($P = 0.04$) but changed head orientation more frequently compared with high-RFI pigs ($P = 0.001$). During NOT, barrows froze more frequently ($P = 0.0007$) and spent a longer time freezing ($P = 0.05$). During HAT, barrows entered fewer zones ($P < 0.0001$), changed head orientation less frequently ($P = 0.002$), froze less frequently ($P = 0.02$), and spent more time contacting the human compared with gilts ($P = 0.03$). These results suggest that selection for low-RFI pigs resulted in lower behavioral reactivity.

Key Words: behavior, feed efficiency, pig

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022 Effects of transdermal flunixin meglumine on pain biomarkers at dehorning. M. D. Kleinhenz[1,*], N. Van Engen[1], P. J. Gorden[1], J. F. Coetzee[2], [1]*Veterinary Diagnostic and Production Animal Medicine, Iowa State University, Ames,* [2]*Pharmacology Analytical Support Team, Iowa State University College of Veterinary Medicine, Ames*.

The objective of this study was to evaluate the analgesic effects of topical flunixin meglumine (Finadyne Transdermal; MSD Animal Health, Milton Keynes, UK) when given at the time of dehorning on pain biomarkers. Twenty-four weaned male Holstein calves, ages 6 to 8 wk of age, were enrolled into the study. The calves were randomly assigned to 1 of 3 treatment groups of 1) topical flunixin and dehorn (DH-FLU), 2) topical flunixin and sham dehorn (SHAM-FLU), and 3) placebo and dehorn (DH-PLBO). Treated calves had tropical flunixin meglumine applied at the label dose of 3.33 mg/kg concurrently with dehorning. Dehorning was performed using an electrocautery dehorner applied to the horn for 10 s. Sham dehorning was completed using a cold dehorner applied to the horn for 10 s. Biomarker parameters collected and analyzed included infrared thermography (IRT), mechanical nociception threshold (MNT), plasma cortisol, and substance P. There were no differences in temperatures detected for the IRT measurements of the medial canthus of the eye, dehorning site, and adjacent skin for the dehorn groups. Mean control point MNT measurements at 49 h were 30.79, 33.93, and 14.02 N for the DH-FLU, SHAM-FLU, and DH-PLBO groups, respectively ($P = 0.0001$). No other differences of MNT were detected between groups for the other test sites and time points. Plasma cortisol reached peak concentration at 20 min after dehorning for the DH-FLU and DH-PLBO groups and at 10 min for SHAM-FLU group. Peak plasma cortisol concentrations were 32.0, 12.7, and 28.8 ng/mL for the DH-FLU, SHAM-FLU, and DH-PLBO groups, respectively. Cortisol concentrations were statistically lower for the DH-FLU group at 90 min after dehorning compared with the SHAM-FLU and DH-FLU groups ($P = 0.04$). Substance P concentrations at 4 h after dehorning were 27.81, 27.08, and 30.36 pg/mL for the DH-FLU, SHAM-FLU, and DH-PLBO groups, respectively ($P = 0.8496$). No differences in substance P concentrations between groups were detected for all time points. In conclusion, topical flunixin meglumine given at the time of dehorning did not provide substantial analgesia based on the pain biomarkers investigated.

Key Words: analgesia, dehorning, flunixin meglumine

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023 Opportunities for monitoring and improving animal welfare using precision dairy monitoring technologies. J. M. Bewley*, *University of Kentucky, Lexington*.

Technologies are changing the shape of the dairy industry across the globe. In fact, many of the technologies applied to the dairy industry are variations of base technologies used in larger industries such as the automobile or personal electronic industries. Undoubtedly, these technologies will continue to change the way that dairy animals are managed. This technological shift provides reasons for optimism for improvements in both cow and farmer well-being moving forward. Many industry changes are setting the stage for the rapid introduction of new technologies in the dairy industry. Dairy operations today are characterized by narrower profit margins than in the past, largely because of reduced governmental involvement in regulating agricultural commodity prices. The resulting competition growth has intensified the drive for efficiency, resulting in increased emphasis on business and financial management. Furthermore, the decision-making landscape for a dairy manager has dramatically changed with increased emphasis on consumer protection, continuous quality assurance, natural foods, pathogen-free food, reduced zoonotic disease transmission, reduced use of medical treatments, and increased concern for the care of animals. Lastly, powers of human observation limit dairy producers' ability to identify sick or lame cows or cows in heat. Precision dairy management may help remedy some of these problems. Precision dairy management is the use of automated, mechanized technologies toward refinement

of dairy management processes, procedures, or information collection. Precision dairy management technologies provide tremendous opportunities for improvements in individual animal management on dairy farms. Although the technological "gadgets" may drive innovation, social and economic factors dictate technology adoption success. These new monitoring tools provide new opportunities for monitoring animal welfare. Lying behavior monitors help assess cow comfort. Feeding and rumination technologies monitor nutrition and rumen health. Image-based technologies can provide insight into previously subjective measures such as BCS and locomotion score. Adding temperature or milk monitors may help detect disease early, reducing pain and production losses associated with disease. Precision dairy monitoring technologies may help not only monitor animal welfare but also provide dairy producers with a new set of tools for changing animal welfare.

Key Words: animal welfare, precision dairy, productivity, technology

024 Improving welfare, health, and productivity in pigs by optimizing adaptation. J. E. Bolhuis*, B. Kemp, *Adaptation Physiology Group, Wageningen University, Wageningen, the Netherlands*.

Welfare problems in pigs often arise from an imbalance between the challenges they are exposed to and their adaptive capacity. A major challenge for pigs is the weaning transition. Weaning often results in reduced growth, intestinal problems, and damaging behaviors. The natural behavior of pigs and their adaptive strategies can inspire us to reduce weaning-related problems. We found that early ingestion of feed can be stimulated by facilitating information transfer from sow to piglet, through both flavor learning in utero and social learning. This early feeding, in turn, seems vital for a good postweaning performance. Also, enrichment substrates that stimulate early sampling of feed positively affect piglet performance around weaning. We are developing a multilitter group housing system for lactating sows and their piglets in which both opportunities for sow–piglet information transfer and enrichment substrates are provided. Piglets raised in this system and kept in large groups after weaning show improved performance until at least 9 wk of age. Measures that facilitate the weaning transition in pigs typically also reduce the occurrence of damaging behaviors directed at pen mates, such as tail biting and ear biting. These behaviors both reflect and generate welfare problems and are influenced by multiple factors. Apart from the impact of early life conditions, we studied the contribution of (genetic) characteristics of pigs and of their environment to the tendency of displaying damaging behaviors. Tail biting seems associated with fearfulness, serotonin metabolism, and (genetic and phenotypic) production characteristics. Excessive levels of damaging behaviors lead to reduced growth in the victims, and we therefore investigated the impact of a novel breeding strategy, targeting indirect genetic effects on growth. Pigs with high indirect genetic effects on growth inflicted less tail damage and showed less ear biting. They also seemed less fearful and showed lower leukocyte, lymphocyte, and haptoglobin levels. Enrichment with straw bedding had similar beneficial effects additive to those of the new genetic strategy. On most farms, it is, however, not feasible to provide pigs with straw, and we therefore studied the effectiveness of a simple enrichment material—a burlap sack—and found a twofold reduction in damaging behaviors and a fivefold reduction in the proportion of animals with a tail wound. In conclusion, small and large changes in genetic background, early life conditions, and quality of the environment that contribute to the adaptive capacity of pigs and reduce their stress load can be used to improve pig welfare and performance in concert.

Key Words: behavior, pigs, welfare

BREEDING AND GENETICS

025 Number born alive accuracy changes by including crossbreed records when estimating Large White and Landrace breeding values from a large seed stock supplier. D. L. Beam[1,*], J. W. Mabry[2], K. J. Stalder[1], *[1]Department of Animal Science, Iowa State University, Ames, [2]Iowa State University, Ames*.

Swine breeding companies use purebred performance records to estimate breeding values by traditional quantitative methods. Some have access to crossbred progeny performance records from client herds. Increased selection accuracy, which results in improved genetic progress, can be obtained by increasing the number of records for an individual or its relatives. The objective of this study was to estimate the change in prediction accuracy for purebred Large White (LW) and Landrace (LR) animals when using field data from crossbred progeny for numbers born alive. Data were obtained from a large pig breeding company and consisted of 603,606 sow records, of which 319,253 were purebred sow records. This included records from company nucleus farms, company multiplier farms, client daughter-nucleus farms, and client-owned closed herd commercial farms. Breeding values and prediction accuracies for number born alive were estimated for all animals using BLUP. The number of purebred LR and LW sows in the data set was 78,619, of which 17,147 were company owned and 49,899 were client owned. The percent of purebred sows with pedigree information was 99% in company nucleus herds, 87% in client daughter-nucleus herds, 87% in client-owned closed herds, and 45% in company multiplier herds. The number of crossbred sows in the data set was 72,704, of which 34% had pedigree information. Three client herds with pedigree information on more than 70% of their LR/LW crossbred sows were used for accuracy comparisons. Change in accuracy and Pearson correlations between differ-

ent accuracy estimates with and without crossbred daughter records were calculated for active purebred sows. For sows with 0 daughter records, the increase in accuracy was 0.001 ± 0.001 and the correlation between accuracy estimates was 1.00. For sows with 1 to 9 crossbred daughter records, the increase in accuracy was 0.09 ± 0.04 and the correlation between accuracy estimates was 0.59. The increase in accuracy for sows with 10 to 19 crossbred daughter records was 0.16 ± 0.04 and the correlation between accuracy estimates was 0.40. For sows with > 20 crossbred daughter records, the increase in accuracy was 0.23 ± 0.03 with a correlation between accuracy estimates of 0.71. These results suggest that including crossbred daughter records increases the selection accuracy in purebred sows with daughter litter records, and the magnitude of this increase in accuracy implies that the potential exists to impact selection and mating decisions, resulting in increased genetic progress.

Key Words: accuracy, breeding value, number born alive

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026 Genomewide association study for residual feed intake and component traits of feed efficiency in pigs divergently selected for residual feed intake.

N. V. Serão[1,2,*], E. D. Mauch[2], S. K. Onteru[3], M. F. Rothschild[2], J. C. M. Dekkers[2], *[1]North Carolina State University, Raleigh, [2]Iowa State University, Ames, [3]National Dairy Research Institute, Karnal, India*.

The objective of this work was to identify genomic regions associated with residual feed intake (RFI; defined as observed minus expected feed intake) and component traits of feed efficiency in 2 lines of pigs selected for high RFI (H-RFI) and low RFI (L-RFI). Phenotypic and genotypic data on 994 L-RFI pigs from generations 0 to 10 and 698 H-RFI pigs from generations 4 to 10 were used. Phenotypic data included ADFI and ADG from approximately 40 to 118 kg, backfat depth (BF) and loin muscle area (LMA) at off-test, feed conversion ratio (FCR; feed-to-gain ratio), and RFI (ADFI adjusted for ADG, BF, and metabolic BW). All animals were genotyped using the Illumina PorcineSNP60 BeadChip. After quality control, 51,098 SNP were used for analyses. Genomewide associations were performed 1 SNP at a time as a fixed effect (combined test for additive and dominance effects) in an animal model. Models also included the fixed effects of sex and contemporary group. Appropriate covariates were fitted for each trait analyzed. Analyses were performed separately for each line and jointly. Single nucleotide polymorphism associations were deemed significant based on Bonferroni adjustment when $-\log_{10}(P) > 6$. The total number of significant associations using data on L-RFI, H-RFI, and the joint lines for each trait were 0, 0, and 32 for ADFI; 0, 87, and 119 for ADG; 12, 0, and 15 for BF; 5, 2, and 4 for FCR; 0, 4, and 0 for LMA; and 1, 1, and 0 for RFI, respectively. All associations with ADFI were located on SSC1, between 168 and 179 Mb. All associations for ADG were found near this same region on SSC1 (154–180 Mb), with the exception of 3 unmapped. One SNP in this region was also associated with FCR, in addition to associations found on SSC2, SSC6, SSC7, and SSC8. Backfat depth showed the most significant association in this study (joint: $-\log_{10}(P) = 23.1$), with a QTL on SSC2 (162 Mb). Other associated regions for BF were found on SSC1, SSC2, SSC7, SSC8, SSC9, and SSC17. All 4 associations for LMA were found in the H-RFI line (on SSC12 and SSC16). Each RFI line had a significant association for RFI on SSC2 (67 Mb; L-RFI) and SSC6 (30 Mb; H-RFI). Results indicate that regions associated with RFI and component traits of feed efficiency might (ADFI and ADG) or might not (BF, FCR, LMA, and RFI) be the same across lines of pigs divergently selected for RFI. Financial support from the Agriculture and Food Research Initiative–National Institute of Food and Agriculture (number 2011–68004–30336) is appreciated.

Key Words: genomics, quantitative trait loci mapping, swine

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027 Performance of genomic prediction using haplotypes in New Zealand dairy cattle.

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Genomic prediction has traditionally been performed using models that fit covariates for SNP genotypes; however, moving to fit covariates for haplotypes may improve accuracy, bias, or run time. Approximately 58,000 Holstein Friesian, Jersey, and Kiwi Cross dairy cattle from New Zealand were genotyped on Illumina BovineSNP50 or BovineHD panels. Genotypes at 37,740 SNP were phased using LinkPHASE and DAGPHASE. Haplotype blocks were assigned based on length: 125 kb, 250 kb, 500 kb, 1 Mb, or 2 Mb, corresponding to, on average, 2, 4, 8, 15, or 30 SNP per block. Genotyped females with milk fat records were separated into training (n = 23,907) and validation (n = 14,478) based on birthdates before or after 1 June 2008. BayesA was run in GenSel fitting either SNP genotype or haplotype allele dosage; low frequency haplotype alleles were ignored, by filtering on their frequency in the training population: 1, 2.5, 5, and 10%. The SNP model had an accuracy of 0.304, whereas the most accurate haplotype model, 500 kb (1% filter), had an accuracy of 0.308; both models had regression coefficients of yield on prediction that deviated from unity by 0.052 (i.e., bias). The 250-kb haplotype model with 1% filter had an accuracy of 0.307 and bias of 0.045. These 2 haplotype models fit approximately twice the number of features as the SNP model and took much longer to run (24 vs. 13 h). Using 125-kb haplotypes (10% filter) afforded performance similar to the SNP model in terms of number of features, accuracy, bias, and computation time. The 1- to 2-Mb haplotypes were too long for this population, with decreased accuracy (0.208–0.300) and increased bias (0.066–

0.175) compared with the SNP model. BayesB and BayesN were run using the 250- (1% filter) and 125-kb (10% filter) haplotypes but provided no improvement in accuracy or bias compared with BayesA when pi values were either 0.80 or 0.95 and fitting all haplotypes within a fitted window for BayesN. The runtime for the BayesB haplotype model (8–10 h) was approximately half that of BayesA haplotype model (15–24 h), bringing this in line with the runtime for the BayesA SNP model (13 h), whereas the runtime for the BayesN haplotype model (28–39 h) was almost double that for the BayesA haplotype model. Fitting fixed length haplotypes did not provide substantial improvement over fitting SNP genotypes for genomic prediction of milk fat yield in New Zealand dairy cattle.

Key Words: dairy, genomic prediction, haplotypes

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028 The use of alternative genomic metrics in swine nucleus herds to manage the diversity of purebred and crossbred animals. J. T. Howard[1,*], F. Tiezzi[1], Y. Huang[2], K. A. Gray[2], C. Maltecca[1], *[1]North Carolina State University, Raleigh, [2]Smithfield Premium Genetics, Rose Hill, NC*.

In livestock breeding populations, regions of the genome with a high frequency of runs of homozygosity (ROH) have reduced diversity. Metrics that reduce ROH frequency may provide an attractive way to manage the diversity and ensure long-term gains while avoiding inbreeding accumulation. The 2 objectives of the current work were to characterize the frequency of ROH in Landrace (LR), Large White (LW), and their cross (LR × LW) through a combination of real and simulated genotypes and to determine the impact of optimizing different inbreeding metrics for nucleus and crossbred populations. A ROH statistic (ROH5Mb: "1" if SNP was in ROH of 5 Mb and "0" otherwise) was calculated across the genome for genotyped LR (n = 1206) and LW (n = 1349) dams and simulated crossbred genotypes derived from mating 81 LR sires to 100 LW dams. High ROH5Mb frequencies were declared for a contiguous set of SNP within the top 5%. In addition to random mating, pedigree, genomic, or shared ROH-based relationship matrices were used to minimize relationships between mating pairs within breed and the latter 2 were in crossings. Mating plans with 25 sires available with a restriction on the maximum number of mating were devised for within-breed and across-breed mating populations of 625 and 1250 dams, respectively. Each plan was replicated 25 times. Regions of shared high ROH5Mb frequency were found on SSC1, SSC3, and SSC14 and regions with a high ROH5Mb frequency within a breed were found to persist in the crossbreeds. Runs of homozygosity and genomic-based relationship matrices decreased the proportion of the overall genome in a ROH by 2.45- and 2.19-fold when compared with pedigree-based relationships. Furthermore, the use of pedigree-based relationships was not able to decrease regions with high ROH5Mb frequency more heavily than ROH- or G-based relationships. The use of alternative genomic relatedness metrics such as ROH allow for relationships to be minimized for targeted regions of low diversity.

Key Words: inbreeding, mating designs, swine

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029 Mitigating the effect of seasonality on sow reproductive performance using genetic selection. M. R. Bryan[1,*], C. Maltecca[1], K. A. Gray[2], Y. Huang[2], F. Tiezzi[1], *[1]North Carolina State University, Raleigh, [2]Smithfield Premium Genetics, Rose Hill, NC*.

The objective of the study was to estimate variance components and inbreeding effect for sow reproductive performance considered as different traits according to the season of conception. Reproductive and pedigree data were obtained for 18,648 Landrace litters from nucleus farms in Texas (n = 1) and North Carolina (n = 2). Traits included number born alive (NBA), total number born (TNB), number born dead (BD), and fetal loss (FL) calculated as BD/TNB. Season of conception was defined as winter (December–February), spring (March–May), summer (June–August), and fall (September–November). Variance components and genetic correlations were estimated with gibbs1f90 using a multiple-trait model with trait by season represented in the model. The model included fixed effects of contemporary group (herd by year) and parity and the random additive genetic effect of sow. For the inbreeding estimates, level of inbreeding was also included in the model as a covariate. Heritability estimates were greatest for NBA, TNB, and BD for conception in summer months with estimates of 0.198, 0.208, and 0.165, respectively, and for FL for spring conception with an estimate of 0.172. Heritability estimates were lowest for spring conception for NBA (0.107) and TNB (0.086), for fall conception for BD (0.122), and for summer conception for FL (0.138). Genetic correlations were greatest for NBA (0.946) and TNB (0.934) in spring and winter, and the relationship between spring and fall for BD (0.987) and PWM (0.935). Genetic correlations were lowest for NBA (0.794) and TNB (0.733) for spring and summer, for spring and winter for BD (0.817), and for fall and winter for FL (0.823). The estimates and SE of inbreeding depression for each trait by season are shown in Table 029. The results suggest that NBA, TNB, BD, and FL should be treated as different traits according to season of conception, and summer performance appears to be determined by a different ge-

Table 029. Estimates and SE of inbreeding depression for each trait by season

Trait	Spring	Summer	Fall	Winter
NBA	−0.03 (0.02)	−0.05 (0.02)	−0.06 (0.02)	−0.02 (0.02)
TNB	−0.04 (0.03)	−0.04 (0.02)	−0.06 (0.02)	−0.02 (0.02)
BD	−0.0037 (0.01)	0.01 (0.0092)	−0.0019 (0.0096)	−0.0066 (0.0091)
FL	0.0002 (0.0008)	0.0005 (0.0007)	0.0005 (0.0009)	−0.0001 (0.0006)

netic background compared with the other seasons. Selection for increased performance during the summer months may be a more effective method to mitigate seasonal infertility than selection for performance across the year. It is also suggested that increased inbreeding may be especially detrimental for sows conceiving during the summer and fall season.

Key Words: genetics, seasonality, sow

030 Genomewide association study for meat quality traits in an F_2 Duroc × Piétrain population.

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Meat quality is essential for consumer acceptance and ultimately impacts pork production profitability, and it is subject to genetic control. We performed genomewide association analysis of pork quality traits to increase our understanding of the genetic basis of variation in these traits. Thirty-eight meat quality and carcass traits were recorded in 948 F_2 pigs from the Michigan State University Duroc × Piétrain F_2 resource population. The F_0, F_1, and 336 F_2 pigs were genotyped with the Illumina Porcine SNP60 beadchip, and the remaining F_2 animals were genotyped with the GeneSeek Genomic Profiler for Porcine LD chip. Monomorphic SNP and low-quality genotypes where discarded, and the remaining missing genotypes where imputed (accuracy = 0.968). A total of 44,911 SNP remained for analysis. Analysis was performed using linear mixed effects models using the R gwaR package. Fixed effects of sex, contemporary group, and age at slaughter and a random polygenic effect with variance proportional to marker relationship matrix G were included. Type I error rate was controlled at false discover rate = 5%. Ten putative QTL regions were found for 16 meat quality and carcass traits. Table 030 shows for each trait the chromosomal location for the QTL, the physical peak position, the *q*-value, and the total number of annotated genes found in the region. These regions can now be further evaluated to search for functional candidate genes. For instance, a QTL associated with backfat thickness was identified on chromosome 6. This region includes genes that encode the enzymes phosphoglucomutase 1 and acyl-CoA dehydrogenase C4 to C12 straight chain, which are involved in pathways for glycogenolysis and lipolysis, respectively. The QTL and genes in the regions should be further investigated to assess their potential to improve pork quality.

Key Words: genomewide association study, meat quality, swine

Table 030.

Trait	Chromosome	Peak position, Mb	*q*-value	Region genes
Carcass backfat 10th rib (CBF10)	1	304.96	0.0025	48
Warner–Bratzler shear force (WBSF)	2	2.92	0.0003	36
Tenderness/overall tenderness (OT)	2	58.8	0.0001	116
Tenderness/OT	3	136.52	0.045	9
Tenderness/OT	5	68.19	0.027	67
Last lumbar backfat/CBF10/ loin muscle weight	6	104	0.029	104
Loin muscle area/dressing percentage	7	35	0.041	14
Number of ribs/carcass length	7	103	0.009	153
Belly weight	11	84.39	0.006	11
Tenderness/OT/WBSF/ juiciness/drip loss/pH ultimate/cook yield/protein percentage	15	135	0.0026	206

031 Characterization of objective feet and leg joint measurements between selection and second gestation and between separate gestation ages in swine.

J. D. Stock[1,*], J. A. Calderón Díaz[2], B. E. Mote[3,4], K. J. Stalder[1], *[1]Department of Animal Science, Iowa State University, Ames, [2]Iowa State University, Ames, [3]University of Nebraska– Lincoln, Lincoln, [4]Fast Genetics Inc., Saskatoon, SK, Canada*.

The objective of this study was to evaluate feet and leg joint angle measurements between time of selection and after first parity. A secondary objective was to evaluate feet and leg joint angle measurements across gestation days. Gilts were selected from a single gilt population and then moved to 3 different farms. Digital images of profile and rear stance were obtained from maternal gilts at selection (n = 319 gilts; average age 21.6 ± 1.8 wk, range 19 to 25) and during second gestation (n = 277; average gestation 26.7 ± 17.2 d, range 0 to 87). Joint angles for knee, front and rear pastern, hock, and rear stance were measured using the angle feature in image analysis software. To evaluate symmetry and joint angle differences due to age, only females with repeated measures at selection and 0 to 21 d of second gestation (126 females) were used. Mixed model equations were used including parity (0 or 1) and side where images were taken (left or right) as fixed effects. Parity was included as repeated variable. Knee and rear pastern angles decreased (weakened) and hock angles increased (straightened) as age progressed ($P < 0.05$). All joint measurements were symmetric between left and right legs ($P > 0.05$) except for the hock, where a difference ($P < 0.05$) was observed. To evaluate gestation age effects on joint angles, only the measurements taken during the second gestation were used. Data was analyzed using mixed model equations including farm and side as fixed effects and gestation age as a

continuous covariate. Animal was included as a random variable. Farm was a significant source of variation for knee, front and rear pasterns, and rear stance angle measurements ($P < 0.05$). Additionally, asymmetry was detected in knee and front and rear pasterns ($P < 0.05$). Front pastern and hock angles increased (straightened) as gestation age increased, whereas knee angle decreased (weakened; $P < 0.05$). Results suggest that as age increases, leg structure changes, with rear leg joints showing greater variation from selection to first parity than front leg joints. Front leg differences may be significantly different across ages; however, angle differences are small. Results suggest environmental factors such as farm where animals are housed contribute to angle differences. Small angle changes in front leg could indicate structure that carries over the life of the animal; however, rear leg structure still requires further investigation for longevity implications.

Key Words: digital imagery, feet and leg conformation, gilts

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032 Quantitative trait loci and candidate genes associated with heifer pregnancy rate and stayability in beef cattle. M. Saatchi[1,2,*], D. J. Garrick[1,3], [1]*Iowa State University, Ames,* [2]*American Simmental Association, Bozeman, MT,* [3]*Massey University, Palmerston North, New Zealand*.

It has long been recognized that marker-assisted selection offers considerable promise over traditional selection for low-heritability and difficult-to-measure traits such as fertility. The objectives of this study were to map QTL and identify a candidate gene or genes associated with heifer pregnancy rate and stayability in beef cattle populations. A BayesB model was used to simultaneously analyze 54,555 SNP markers, and from those analyses, QTL were identified by characterizing the proportion of additive genetic variation explained by every nonoverlapping 1-Mb region of the genome. There were 4 significant 1-Mb windows located on BTA24 in the region from 25 to 31 Mb for heifer pregnancy rate, and these cumulatively explain 6.1% of additive genetic variance in the Black Angus population. Two significant 1-Mb QTL located on BTA6 at 40 and 71 Mb were identified for stayability in the Simmental population and explained 1.4 and 6.3% of additive genetic variances, respectively. The identified QTL regions harbor very promising candidate genes (*Cadherin* and *AUTS2* genes for heifer pregnancy rate and *KIT* and *SLIT* genes for stayability) in their corresponding populations. Further investigations are needed to identify the causal variants harbored within the identified regions of the genome. Once found, knowledge of such mutations would create new opportunities for the selection of more fertile animals.

Key Words: beef cattle, candidate gene, marker, quantitative trait loci, stayability

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033 [No abstract.]

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034 Genomic prediction using a model based on haplotype clusters. S. D. Kachman*, *University of Nebraska– Lincoln, Lincoln*.

Marker-based models used for genomic prediction are often based on the underlying assumption that the genetic markers are the casual variants. An alternative 2-stage model for genomic prediction uses haplotype clusters as hidden states in a hidden Markov model. The genomic effects are modeled as haplotype effects associated with the haplotype clusters instead of marker effects associated with markers. In the first stage, hidden Markov model parameters of the haplotype cluster model are estimated based on the genotypic data. In the second stage, a Bayesian model based on the estimated haplotype cluster model is used to model the underlying haplotype effects at the haplotype loci. The haplotype effect alleles are treated as nonemitting states in the haplotype cluster model. The prior for the haplotype effects is a mixture of a multivariate normal distribution and a point mass at zero distribution. Including a missing genotype as a possible observed state in the hidden Markov model allows for animals to be genotyped with different SNP panels.

Key Words: Bayesian, genomewide association study, genomic prediction

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035 Advances in genomic selection and genomewide association I. Misztal*, *University of Georgia, Athens*.

Genomic selection (GS) was applied to all major farm species including dairy, beef, pigs, and chickens. Initial methodology was a multistep procedure consisting of BLUP evaluation, extraction of pseudo-observations for genotyped animals, running genomic predictions via estimation of SNP effects or genomic relationships, and combining genomic and conventional predictions in an index. A newer single-step procedure works as BLUP with combined pedigree and genomic relationships. Experiences with GS indicate that 1) a few thousand genotyped animals are required for a reasonable increase in accuracy over BLUP, 2) SNP effects are not QTL, 3) SNP selection seem to increase the accuracy of genomic EBV more with small but almost none with large genotyped population, 4) differences between methods based on estimation of SNP effects and genomic relationships are small, 5) gains with SNP chip > 50,000 are minimal, 6) gains from genotyping low-accuracy animals are small, 7) across-breed/line prediction does not work, 8) genomic predictions decay over time requiring constant phenotyping, and 9) a single-step procedure is much simpler to use than a multistep procedure and is usually more accurate. Experiences are in agreement with findings that the number of effective SNP is a function of effective population size and equals about 10,000 for cattle and less than 5000 for

pigs and broiler chicken. Gains in accuracy due to genomics for different types of animals can be explained by decomposition of genomic EBV due to phenotypes, pedigree, and genomic information. Practical applications of GS indicate many potential problems and potentially genomic prediction that is less accurate than the conventional prediction. Problems include genotyping errors, pedigree errors, incorrect imputation, issues with deregression, inaccurate index, etc. Any application of GS requires a proper validation; a validation technique used in dairy may be unsuitable for pigs. For commercial use, the most flexible yet least trouble-prone methodology is a single-step procedure that, with recently developed algorithm for inversion of genomic relationship matrix, can accommodate any number of genotyped animals at low cost.

Key Words: commercial application, genomic selection, single step

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036 Discovery of quantitative trait loci using a quantitative trait loci–effects model in a multigenerational pedigree. R. L. Fernando[1,*], J. Zeng[1], H. Cheng[1], D. Habier[1], A. Wolc[2], D. J. Garrick[3], J. C. M. Dekkers[1], *[1]Iowa State University, Ames, [3]Hy-Line International, Dallas Center, IA, [3]Massey University, Palmerston North, New Zealand*.

Bayesian methods developed for genomic prediction using SNP have become increasingly popular for QTL discovery in livestock. However, the hypothesis test for association based on SNP markers may not be valid for detecting QTL. This is because the posterior probability that SNP in a genomic segment have nonzero effects is not equivalent to the posterior probability that a QTL exists in that segment. This discrepancy between association studies and QTL discoveries is expected to be bridged by modeling effects of unobserved QTL genotypes, which permits direct inferences on the QTL effects, their contributions to genetic variance, and their locations. In addition, it has been shown that structured sources of information in a reference population, such as multiple generations, can be better exploited in a QTL-effects model. Therefore, we hypothesized that using a QTL-effects model would benefit QTL discovery. The performance of the QTL-effects model for QTL discovery was compared with a marker-effects model, BayesB, using a 10-generation population simulated from real chicken genotypes and pedigree. We also demonstrated the manner in which credible intervals can be obtained for the positions of multiple unobserved QTL with an example. The QTL-effects model generally had less bias for the estimation of genetic variance contributed by the simulated QTL. The proportion of false positives at markers from the QTL-effects model was closer to the proportion of false positives at QTL than from BayesB. When the proportion of false positives at QTL was limited to a small value, less than 0.2 for example, the QTL-effects model had greater power than BayesB in detecting QTL, especially for those contributing larger fractions of genetic variance. For a particular region of interest, the number of QTL segregating in that region can be inferred from the QTL-effects model. Conditional on the number of QTL, the posterior distribution for the ordered putative QTL position gives a credible interval for its location. These findings are important to researchers who are interested in characterization of QTL.

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037 Modeling networks for prediction and causal inference in quantitative genetics and genomics. G. J. M. Rosa*, *University of Wisconsin–Madison, Madison*.

Networks can be used to represent biological systems, which are composed of interconnected components. Each component or variable in a network is symbolized by a node (or vertex), whereas relationships among them are symbolized by edges. In genetics, for example, networks are used to represent gene regulation systems, co-expression, epistatic interactions, etc. A network modeling approach commonly used in genetic analyses refers to correlation networks. Correlation networks, however, are not able to reveal causal relationships between variables. Conversely, some other network modeling approaches do explore potential direction of edges connecting nodes, by probing conditional independences encapsulated in the joint distribution of the set of variables. Such methods belong to a set of data analysis tools termed stochastic graphical models, which include techniques such as path analysis, Bayesian networks, and structural equation models. In this talk, I will present a brief overview of some graphical modeling approaches and illustrate their application in prediction and causal inference in the context of quantitative genetics and genomics. Examples to be presented involve complex phenotypic traits and genomic information, such as molecular markers and gene expression scores, in different livestock species.

Key Words: causal inference, graphical models, Markov blanket, networks, prediction

DAVID H. BAKER AMINO ACID SYMPOSIUM

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038 David H. Baker: A study in academic scholarship. R. A. Easter*, *University of Illinois at Urbana–Champaign, Mahomet*.

It is arguable that David Baker significantly defined nonruminant animal nutrition research in the second half of the 20th century with over 450 peer-reviewed publications on a plethora of topics and about 50 PhD students who carry forward his legacy of contributions to the field. At the core of his success was an incredible intellect, a deep and ever-expanding understanding of the intricacies of metabolism and biology, an un-

canny awareness of published literature, and a knack for experimental design that yielded unambiguous answers to simple but profoundly important questions. His tools were nonruminant animals—chickens, swine, dogs, cats, and, on rare occasions, rodents. The experiments were built around cleverly designed diets often formulated with purified nutrient sources, reliable, easily measured indicators: growth, efficiency of feed conversion, blood, and tissue parameters. He defied the bioavailability of a several vitamins, mineral elements, and AA in a variety of ingredients, clarified AA interactions and aspects of sulfur AA metabolism in chickens, elucidated the effect of intestinal parasites on nutrient requirements, determined the essentiality of dietary taurine for the feline and the nonessential nature of arginine for gravid swine, and much more. He was driven by a deep love of science and the acquisition of new knowledge, all of which was underpinned by absolute integrity in his work and his dealings with those around him. He was a powerful communicator who enjoyed writing and credited an elementary teacher with his ability to communicate clearly and succinctly. He gave significant priority to mentoring his graduate students as well as many others who sought his advice. David's roots were deeply imbedded in livestock agriculture and he was motivated to do his part to improve the well-being and productivity of the animals with which he worked and the success of those whose livelihood depended on them. By any measure, he was remarkably successful.

Key Words: Baker, nonruminant nutrition, scholar

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039 Comparison of the effects of reduced–crude protein, amino acid–supplemented diets on growth performance in swine. C. E. Vonderohe[1,*], K. M. Mills[1], M. D. Asmus[1], E. R. Otto-Tice[1], C. V. Maxwell[2], B. T. Richert[1], J. S. Radcliffe[1], *[1]Purdue University, West Lafayette, IN, [2]Department of Animal Science, Division of Agriculture, University of Arkansas, Fayetteville*.

Seven hundred twenty mixed-sex pigs were placed in 12 rooms at the Purdue Swine Environmental Research Building to measure the effect of reduced-CP, AA-supplemented diets on growth performance and carcass characteristics. Pigs were blocked by BW and gender and allotted to room and pen with 10 mixed-sex pigs/pen. Pigs were fed a 9-phase, wean–finish feeding program and weighed at the start and end of each dietary phase. Within each phase, control pigs consumed corn–soybean meal–20% distiller's dried grains with solubles–based diets containing no synthetic AA. The 2X diet was balanced using synthetic AA to the seventh limiting AA and represented the lowest CP diet. The 1X diet was formulated using synthetic AA to meet a CP value halfway between the control and 2X diets. Diets were formulated to identical NE concentrations and balanced to meet standardized ileal digestible AA requirements. Data were analyzed using the GLM procedure in SAS (SAS Inst. Inc., Cary, NC) and treatment means were separated using the Tukey procedure in SAS. Pigs fed the control and 1X diet consistently grew faster ($P < 0.005$), had greater feed efficiency ($P < 0.001$), and were 4 kg heavier at market weight ($P < 0.001$) than animals fed the 2X diet. There were no consistent effects of diet on ADFI throughout the project. Carcass data were analyzed for sex, diet, and sex × diet effects. There were no ($P > 0.10$) interactions between sex and diet. Pigs fed the 1X (75.5 mm) and control (75.1 mm) diets had greater ($P < 0.02$) loin depth compared with 2X (73.5 mm)-fed pigs. Backfat depth was not affected ($P > 0.10$) by diet. Pigs fed the 1X diet (55.78%) had greater percent lean than pigs fed the 2X diet (55.22%) with control-fed pigs (55.62%) being similar to both ($P < 0.05$). Gilts were leaner ($P < 0.001$) and had reduced backfat ($P < 0.02$) and increased percent lean ($P < 0.001$) compared with barrows. Overall, the reduced performance and carcass characteristics observed in pigs fed the 2X diets indicates an inaccurate estimate of AA NRC (2012) requirements or ratios to lysine in this extremely low–CP diet.

Key Words: amino acids, growth, swine

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040 Quantifying variable amino acid efficiencies in lactating sows. R. R. White[1,*], S. Zhang[2], N. Regmi[2], N. L. Trottier[2], *[1]Virginia Tech, Blacksburg, [2]Michigan State University, East Lansing*.

This study estimated new and variable individual AA efficiencies that could be incorporated into diet formulation for lactating sows. Literature used to estimate AA efficiencies in the NRC (2012) swine model were mined for feed intake, sow weight loss, dietary N, litter weight gain, litter size, milk yield, and milk AA composition data. Models were derived to estimate variable AA use efficiencies in milk. A mixed-effect regression of AA efficiencies on diet composition, feed intake, and weight loss was conducted accounting a random study effect. Models were evaluated using the root mean squared error (RMSE), concordance correlation coefficient (CCC), and corrected Akaike information criteria. Arginine, Lys, Phe, Thr, and Val efficiencies decreased ($P < 0.05$) with increasing dietary N and all AA efficiencies increased ($P < 0.05$) with increasing milk yield. Only Leu and Met efficiencies decreased ($P < 0.05$) with increasing weight loss. Equations predicted measured AA efficiencies with RMSE between 5.3 and 15.4% and CCC between 0.97 and 0.99. The AA efficiencies were also modeled as a function of dietary N, feed intake, weight loss, and efficiencies of Leu, Met, and Cys (these explanatory AA were selected based on their individual fit for direct prediction). Histidine, Ile, and Lys efficiency models improved with Leu and Cys efficiencies included as covariates but models of Arg, Phe, Thr, or Val efficiency did not improve. Energy allowable milk was calculated based on the difference between energy supply and maintenance requirements and the lactation energy use efficiency. Amino acid allowable milk was calculated from modeled AA efficiencies and standard-

ized ileal digestible (SID) AA supply. The minimum of energy and AA allowable milk estimates and their mean were calculated. A first-limiting nutrient model (minimum of energy and AA allowable milk) had an RMSE of 110%. A co-limiting nutrient model (mean of energy and AA allowable milk) had a lower (32%) RMSE. To more fully investigate the utility of a co-limiting nutrient model, a multisubstrate Michaelis–Menten equation was fit to predict milk yield as a function of AA and ME supply. After a stepwise elimination of nonsignificant parameters, the final model (based on Arg, Leu, Met, Phe, Thr, and Val SID intake) returned a RMSE of 10% and very good concordance (0.77). These results suggest that nutrients co-limit milk production and that moving toward a more response-driven model may help define more precise diets that account for dynamic mammary uptake of AA.

Key Words: amino acid, lactating sow, variable efficiency

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041 Citrulline and de novo arginine synthesis in perinatal and young pigs. J. C. Marini[1,2,*], U. Agarwal[1], I. C. Didelija[1], B. Stoll[1], D. G. Burrin[1], *[1]USDA-ARS Children's Nutrition Research Center, Baylor College of Medicine, Houston, TX, [2]Section of Critical Care Medicine, Baylor College of Medicine, Houston, TX.*

Arginine is a conditional essential AA that becomes essential when its demand (e.g., growth, disease) exceeds its production. The endogenous synthesis of arginine is a multiorgan process where citrulline synthesized by the gut is utilized by 2 renal enzymes (argininosuccinate lyase [ASL] and argininosuccinate synthase [ASS]) to produce arginine. Because ASS and ASL are present in the gut of neonatal pigs, it is believed that the intestinal–renal axis for arginine synthesis is not functional in the newborn. However, this is not consistent with the high plasma citrulline concentrations seen in perinatal pigs. To address this apparent paradox, we measured citrulline production and concentrations in premature (P-10; 10 d preterm and 1.0 ± 0.1 kg BW), neonatal (P8; 8 d and 2.5 ± 0.2 kg BW), and young pigs (P30; 30 d and 7.5 ± 0.3 kg BW). We also used stable isotopes to study the interorgan production of citrulline and arginine in neonatal and young pigs. Premature pigs (P-10) have a reduced ($P < 0.001$) ability to produce citrulline (23 ± 2 μmol·kg^{-1}·h^{-1}) when compared with older animals (74 ± 4 and 41 ± 3 μmol·kg^{-1}·h^{-1} for P8 and P30, respectively). Plasma citrulline concentrations, however, were not different ($P = 0.31$; 171, 190, and 145 μmol/L for P-10, P8, and P30, respectively). A substantial dilution of the citrulline tracer in the portal circulation of P8 and P30 pigs indicated enteral citrulline production. Likewise, the appearance of labeled arginine in the renal vein demonstrated citrulline utilization for arginine synthesis by both age groups. Based on the labeling pattern of the arginine released by the PDV, we were unable to detect any arginine synthesis by the gut; the arginine released by the PDV was likely to originate from protein breakdown because the essential AA phenylalanine was also released. The quantitation of organ fluxes indicated a production of 22 ± 7 and 21 ± 7 μmol of citrulline/L blood flow by the PDV (P8 and P30, respectively) and a renal conversion into arginine of 19 ± 7 and 16 ± 5 μmol/L blood flow, respectively. This demonstrates that the intestinal–renal axis for arginine synthesis is present in the neonatal pig. Although ASS and ASL were present in the small intestine of P8 pigs, they were localized in the tip of the villus whereas the enzymes responsible for the synthesis of citrulline were present in the base and crypt. The lack of co-localization of these enzymes prevents the gut from synthesizing arginine and explains the high levels of circulating citrulline observed in perinatal pigs.

Key Words: arginine, citrulline, neonate, pig, tracer

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042 An update on modeling dose–response relationships: Accounting for correlated data structures and heterogeneous variance in linear and nonlinear mixed models. M. A. D. Goncalves, N. M. Bello*, S. S. Dritz, M. D. Tokach, J. M. DeRouchey, J. C. Woodworth, R. D. Goodband, *Kansas State University, Manhattan*.

Advanced methods for dose–response assessments are used to estimate concentrations of a nutrient that optimize a given outcome of interest, thereby determining nutritional requirements for optimal performance. Traditionally, many dose–response methods use a fixed-effects framework that assumes mutually independent observations with homogeneous variances. Yet experimental data often present a design structure that includes correlations between observations (e.g., blocking, nesting, etc.) as well as heterogeneity of variances that can mislead inference if disregarded. Our objective is to demonstrate practical implementation of computationally intensive linear and nonlinear mixed models methodology to describe dose–response relationships accounting for correlated data structure and heterogeneous variances. To illustrate, we model data from a randomized complete block design study to evaluate the standardized ileal digestible (SID) Trp:Lys dose–response on G:F of nursery pigs. A base linear mixed model was fit to explore the functional form of G:F relative to Trp:Lys and assess model assumptions, in particular residual homoscedasticity. Next, we fitted 3 competing dose–response mixed models to G:F, namely a quadratic polynomial (QP), a broken-line linear (BLL) ascending model, and a broken-line quadratic (BLQ) ascending model, all of which included heteroskedastic specifications, as dictated by the base model, and used parameter estimates from the base model as initial values. The GLIMMIX procedure of SAS (version 9.4; SAS Inst. Inc., Cary, NC) was used to fit the base and QP models and the NLMIXED procedure was used to fit the nonlinear models. We further illustrate the use of a grid-search approach to facilitate convergence and parameter estimation in nonlinear mixed

models, as this seemed to be the most common implementation problem. Model fit between competing dose–response models was compared using maximum likelihood–based Bayesian information criterion (BIC). The QP, BLL, and BLQ models fitted on G:F of nursery pigs yielded BIC values of 353.7, 343.4, and 345.2, respectively, indicating a better fit of BLL followed closely by BLQ. The BLL breakpoint estimate of the SID Trp:Lys was 16.5% (95% confidence interval [CI] 16.1–17.0), whereas the BLQ estimate was 16.0% (95% CI 15.5–16.6). Importantly, accounting for heterogeneous variance enhanced inferential precision as the breadth of the CI for mean breakpoint decreased by approximately 44%, from 95% CI 15.8 to 17.4 to 95% CI 16.1 to 17.0 SID Trp:Lys. In summary, we illustrate the use of linear and nonlinear mixed models for dose–response relationships accounting for heterogeneous residual variances, discuss important diagnostics and their implications for inference, and provide practical recommendations for computational troubleshooting.

Key Words: dose–response, heterogeneous variance, linear and nonlinear mixed models

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043 Effects of standardized ileal digestible valine-to-lysine ratio on growth performance of twenty-five– to forty-five–kilogram pigs under commercial conditions. M. A. D. Goncalves[1,*], M. D. Tokach[1], S. S. Dritz[1], N. M. Bello[1], K. J. Touchette[2], R. D. Goodband[1], J. M. DeRouchey[1], J. C. Woodworth[1], *[1]Kansas State University, Manhattan, [2]Ajinomoto Heartland, Inc., Chicago, IL*.

Two experiments were conducted to estimate the standardized ileal digestible (SID) Val:Lys requirement for growth performance in 25- to 45-kg pigs. In Exp. 1, 1134 gilts (PIC 337), initially 31.2 kg (SD 2.0) BW, were used in a 19-d trial with 27 pigs/pen and 7 pens/treatment. In Exp. 2, 2100 gilts (PIC 327), initially 25.4 ± 1.9 kg BW, were used in a 22-d trial with 25 pigs/pen and 12 pens/treatment. In both experiments, treatments were blocked by initial BW in a randomized complete block design. In Exp. 1, there were 6 treatments with SID Val:Lys at 59.0, 62.5, 65.9, 69.6, 73.0, and 75.5%. For Exp. 2, there were 7 treatments with SID Val:Lys at 57.0, 60.6, 63.9, 67.5, 71.1, 74.4, and 78.0%. Diets were formulated to ensure that Lys was the second limiting AA throughout the experiments. Responses were analyzed separately for each experiment using general linear and nonlinear heteroskedastic mixed models, including initial BW as an explanatory covariate and BW block as a random effect. In Exp. 1, ADG linearly increased with increasing SID Val:Lys ($P = 0.009$; 680, 717, 717, 712, 744, and 726 ± 17.1 g, respectively), whereas no significant treatment differences were observed for G:F (0.467, 0.467, 0.472, 0.474, 0.481, and 0.472 ± 0.0084, respectively). In Exp. 2, ADG (quadratic, $P = 0.002$; 621, 662, 717, 708, 708, 726, and 717 ± 16.1 g, respectively) and G:F increased (linear, $P < 0.001$; 0.415, 0.420, 0.437, 0.429, 0.433, 0.441, and 0.439 ± 0.0046, respectively) with increasing SID Val:Lys. There was no evidence of experiment × treatment interaction. Therefore, data from the 2 experiments were combined for analysis using experiment and BW block within experiment as random effects. Competing models, namely a broken-line linear model, a broken-line quadratic model, and a quadratic polynomial (QP), were compared using Bayesian information criterion. In the combined analysis, the best-fitting model for ADG was a QP (prediction equation: $-1.15 + 4.13 \times$ SID Val:Lys $- 2.78 \times$ SID Val:Lys$^2 + 0.012 \times$ initial BW) with optimum ADG estimated at 74.4% (95% confidence interval [CI] 69.5 to > 78.0) SID Val:Lys. The best-fitting model for G:F was also a QP (prediction equation: $-0.04 + 1.36 \times$ SID Val:Lys $- 0.94 \times$ SID Val:Lys^2) with optimum G:F estimated at 72.3% (95% CI 64.0 to > 78.0) SID Val:Lys. In conclusion, 67% SID Val:Lys was able to capture 99% of maximum ADG and G:F in 25- to 45-kg pigs.

Key Words: growth, pig, valine

Table 043. Standardized ileal digestible Val:Lys ratio at different performance levels

	Percent of maximum performance			
Item	95%	97%	99%	100%
ADG	58.9	62.3	67.3	74.4
G:F	< 57.0	60.4	65.5	72.3

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044 Determination of lysine adequacy on a population basis for growing pigs. C. E. Zier-Rush[1], C. Neill[2], S. B. Jungst[2], N. Matthews[2], D. S. Rosero[1,*], R. D. Boyd[1], *[1]The Hanor Company, Inc., Franklin, KY, [2]PIC, Hendersonville, TN*.

Nutrient requirements are primarily determined for a growth phase and mean population without considering population variation and important variables that define population response. For lysine curves to be financially useful, responses must be established using multiple criteria and equations must be developed for financial modeling. This study defined the response to 4 standardized ileal digestible (SID) lysine curves using 6 population growth (whole-body and carcass) and carcass primal parameters. A total of 2048 pigs (PIC Camborough × TR-4 or 327) were used in a growth assay from 20.4 (± 0.3 kg) to 119.0 (± 1.1 kg) with a fixed-time end point (110 d). Pigs were placed in 65 pens (30 to 32 pigs/pen and 0.70 m^2/pig), blocked by BW, and randomly allotted within gender and genotype to 4 dietary treatments administered in 5 phases of growth (20 kg BW phases). Dietary treatments corresponded to 4 different SID lysine curves that deviated from the 2008 PIC lysine specifications. Curves were 92, 98, 104, and 110% of the PIC standard lysine curve {SID lysine:ME [g SID lysine/Mcal ME (NRC, 1998)] = $(2.7 \times 10^{-5} \times \text{BW}^2) - (0.0153 \times \text{BW}) + 4.114)$}. Diets were corn–soybean meal based with 15.0% corn distiller's dried grains with solubles and 2.7% choice white grease as a fat source. Major ingredi-

ents were constant within diet phase, but crystalline AA were adjusted as required. Feed medication and ractopamine were not used. Data were analyzed as a randomized complete block design with pen as the experimental unit. Whole-body ADG improved as lysine increased (quadratic, $P = 0.02$; 0.82, 0.85, 0.83, and 0.82 kg/d for the 92, 98, 104, and 110% curves, respectively) as did G:F (quadratic, $P < 0.001$; 0.399, 0.418, 0.425, and 0.418 for the 92, 98, 104, and 110% curves, respectively). Likewise, carcass G:F improved as lysine increased (linear, $P < 0.001$; 0.294, 0.303, 0.308, and 0.308 for the 92, 98, 104, and 110% curves, respectively). The effect of increasing lysine on population growth was reflected by the reduction of the proportion of pigs sold as substandard (quadratic, $P = 0.014$; 6.5, 3.7, 2.8, and 4.3% for the 92, 98, 104, and 110% curves, respectively), which improved full-value market pigs (quadratic, $P = 0.008$, 91.2, 94.6, 95.3, and 92.9% for the 92, 98, 104, and 110% curves, respectively). Carcass lean increased as lysine increased (linear, $P = 0.011$; 52.5, 52.6, 52.6, and 52.8% for the 92, 98, 104, and 110% curves, respectively) as did the primal yield ($n = 309$) relative to a 98.2-kg carcass, with the latter being identical in response form to other criteria (linear, $P = 0.037$; 87.5, 87.7, 88.0, and 87.9% for the 92, 98, 104, and 110% curves, respectively). This study determined the lysine curve on a population basis, using criteria not captured in interval studies. Response asymptote for each criterion was achieved at 104% of the 2008 PIC lysine requirement.

Key Words: growing pigs, lysine, population, requirements

045 Evaluating protein quality of human foods using the pig as a model. H. Stein*, *University of Illinois at Urbana–Champaign, Urbana, IL*.

The need to provide nutritious food has increased as population in the developing world is increasing. It is estimated that at least 20 million children under the age of 5 yr in Africa alone suffer from marasmus or kwashiorkor, which results in edemas and muscle wasting. The only way to overcome this problem is to improve the provision of foods that are rich in digestible AA. Two reports from the Food and Agriculture Organization of the United Nations (FAO) that include guidelines for evaluating food proteins were published in 2013 and 2014, respectively. The reports recommend that the protein quality of human foods be evaluated using a system called digestible indispensable amino acid scores (DIAAS). The 2 reports also recommend that because it is difficult and uneconomical to generate DIAAS values in humans, the best alternative is to determine these values using pigs as models for humans. Values for DIAAS are calculated from values for standardized ileal digestibility of AA and the 2014 report from FAO specified details on how to determine DIAAS values using the pig as the model. Following the publication of the 2 reports, DIAAS values in 21 foods used in human nutrition have been determined in our laboratory. Results indicated that in 8 raw cereal grains, DIAAS values range from 29 in sorghum to 77 in dehulled oats with maize, wheat, rye, rice, and barley being intermediate. Not surprisingly, Lys is the first limiting AA in all cereal grains. In contrast, DIAAS values in casein, milk protein concentrate, skim milk powder, whey protein concentrate, and whey protein isolate are between 124 and 139. The sulfur-containing AA are the first limiting AA in casein, milk protein concentrate, and skim milk powder, whereas His is the first limiting AA in whey proteins. Results also indicate that soy flour and soy protein isolates have DIAAS values close to 100, whereas pea protein concentrate has a DIASS value of 73. The sulfur-containing AA are the first limiting AA in both soy and pea protein. It is concluded that the pig can serve as a suitable model to generate DIAAS values for human foods, but there is a need to generate values in many more foods and also to determine effects of food processing on DIAAS values.

Key Words: amino acid digestibility, humans, pigs

DAVID SCHINGOETHE SYMPOSIUM

046 Modifying the composition of milk to increase marketability. D. J. Schingoethe*, *South Dakota State University, Brookings*.

Milk is nature's most nearly perfect food but we can improve it. Some people may consider that dairy products should contain less SFA, which, to a point, can be accomplished by feeding unsaturated fat sources such as heated soybeans. This will increase the proportion of unsaturated fatty acids and may allow, for example, the making of a softer butter at refrigerated temperatures without losing the desired butter flavor. Feeding an unsaturated fat, especially when high in linoleic acid (C18:2), can also increase the proportion of the healthful fatty acid *cis*-9, *trans*-11 CLA; adding a small amount of fish oil with the unsaturated fat source can increase the CLA content even more. One must be cautious to not feed too much fish oil or other unsaturated fatty acid sources so as to cause milk fat depression via an increase in *trans*-10, *cis*-12 CLA. On the protein side, caseins are the major proteins in milk, accounting for 75 to 85% of the protein in bovine milk, and are the proteins present in cheese, the main method of marketing dairy products in the United States today. Certain caseins such as κ-casein, especially the BB genetic variant, are closely related to the casein content of milk and increase milk protein yield and percentage and total cheese yield. The genetic incidence of κ-casein BB is 80 to 85% in Jerseys versus 3 to 4% in Holsteins. Some Holstein milk contains a_{s1}-*A*-casein, which is related to poorer cheese yields and cheese quality. The whey proteins are some of the highest biological value proteins available. A major marketing growth area is whey protein concentrates and isolates. These are promoted as bodybuilding supple-

ments used to increase dietary protein intake, often with the goal of maximizing muscle hypertrophy. The main whey proteins are α-lactalbumin (2 to 5% of all milk proteins), which is the specifier protein in lactose synthesis, and β-lactoglobulin (7 to 10% of total protein in ruminant milk). Although α-lactalbumin is important in maximizing milk production because lactose synthesis, the major osmotic constituent of milk, is the main determinant of milk production, β-lactoglobulin is found in ruminant milks but not in the milks from some other species and sometimes causes allergy reactions in some people. The marketing of various milk components will become increasingly important in the future.

Key Words: marketability, milk composition

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047 The history, mechanism, and modification of milk fat synthesis in rum inants. K. J. Harvatine*, *Penn State University, State College, PA*.

Milk fat is economically valuable and is important to many dairy products. Diet-induced milk fat depression (MFD) was first described over a century ago and remains a common problem observed under both intensive and extensive management. For decades, theories proposing a shortage of substrate for milk fat synthesis were popular but failed to withstand rigorous mechanistic investigation. The biohydrogenation theory 15 yr ago established that MFD is caused by an inhibition of mammary synthesis of milk fat by specific fatty acids produced as intermediates in ruminal biohydrogenation. During MFD, lipogenic capacity and transcription of key lipid synthesis genes in the mammary gland are downregulated in a coordinated manner. Mechanistic work has established that expression of sterol response element-binding protein 1 (SREBP1) and Spot 14 during MFD. Molecular investigation in multiple research groups provides strong evidence for SREBP1 as a central signaling pathway in the regulation of mammary fatty acid synthesis. In addition, SREBP1c and Spot 14 knockout mice exhibit reduced milk fat similar to the magnitude and pattern of MFD in the cow. Application of molecular biology approaches has provided the latest chapter in the regulation of milk fat synthesis. Although our understanding of the causative factors and mechanism has made great strides, diet-induced MFD remains an issue because of the complexity of rumen fermentation and the need to feed high-energy diets.

Key Words: conjugated linoleic acid, milk fat depression

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048 Milk composition and synthesis in dairy goats and sheep. M. Rovai[1,*], G. Caja[2], [1]*South Dakota State University, Brookings,* [2]*Group of Ruminant Research (G2R), Universitat Autonoma de Barcelona, Bellaterra, Barcelona, Spain*.

Milk and dairy products from sheep and goats are of relevant economic importance worldwide and their demands are continuously increasing due to nutritional, functional, ethnical, and gourmet reasons. Both species markedly differ in milk composition and mammary gland secretion process, which modifies the characteristics of their milk and the organoleptic traits of the produced dairy products. On average, ewe's milk is richer in fat and protein than does' milk, their secretion process being mainly merocrine and apocrine, respectively, which are responsible for the shedding of cytoplasmic particles and for the somatic cell counts in the milk, usually being greater in goats than in sheep. Moreover, the cisternal udder compartment is proportionally larger in goats than in sheep, requiring modifications in the milking machine settings and milking routines and varying their tolerance to extended milking intervals. Effects of genetics (i.e., breed and selection) and feeding (i.e., use of high concentrate diets and supplementation) on milk composition play an important role because sheep and goat milk is mostly transformed into dairy products. Genetic selection, especially in dairy goats, resulted in vast improvements in milk yield and lactation length but, in most cases, was accompanied by decreased milk composition and higher risk of fat–protein contents inversion. Milk protein content is hard to modify in both sheep and goat, with the casein being regulated by the same genes (CN locus) in both species, although goats show a greater degree of polymorphisms, which are markedly related to curd and cheese traits (i.e., α_{S1}-casein and κ-casein). An interaction between casein genotype and protein content of the diet has been reported in dairy goats. On the contrary, milk fat content rapidly increases and fatty acid profile varies after fat supplementation (e.g., oilseeds, calcium soaps, and vegetal oils) in sheep and goats, with low or not significant effects on milk protein. Feeding fresh forages and vegetal oils to sheep and goats markedly increase milk *c*9, *t*11 CLA, the effect being not significant when whole oilseeds are fed. Use of *t*10, *c*12 CLA reduces milk fat synthesis and increases milk yield in lactating goats and sheep, without altering milk protein and lactose contents. Although sheep and goats are moderately tolerant to harsh environments, milk fat and protein contents decrease markedly by effect of heat stress, which also impairs curd formation and cheese yielding.

Key Words: goat, lactation physiology, sheep

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049 Physiological and molecular mechanisms associated with performance, immunometabolic status, and liver function in transition dairy cows fed rumen-protected methionine or choline. Z. Zhou[1,*], M. Vailati Riboni[1], O. Bulgari[1], E. Trevisi[2], T. A. Garrow[1], J. K. Drackley[1], P. Cardoso[1], D. N. Luchini[3], J. J. Loor[1], [1]*University of Illinois, Urbana,* [2]*Università Cattolica del Sacro Cuore, Piacenza, Italy,* [3]*Adisseo S.A.S., Alpharetta, GA*.

The mechanisms underlying benefits of rumen-protected methyl donor supplementation during the transition period are largely unknown. Objectives were to evaluate performance,

immunometabolic status, liver function, and the underlying mechanisms in response to rumen-protected methionine (MET) or choline (CHO) supplementation. Eighty-one multiparous Holstein cows were used in a randomized complete block design with 2 × 2 factorial arrangement of MET (Smartamine M; Adisseo NA) and CHO (ReaShure; Balchem Inc.) level (with or without). Treatments were control (CON) with no MET or CHO, CON + MET (SMA), CON + CHO (REA), and CON + MET + CHO (MIX). From −50 to −21 d before expected calving, all cows received the same diet (1.24 Mcal/kg DM). From −21 d to calving, cows received the same basal close-up diet (1.54 Mcal/kg DM) and were randomly assigned to treatments (CON, SMA, REA, or MIX). From calving to 30 d in milk, cows were on the same postpartal diet (1.69 Mcal/kg DM) and continued to receive the same treatments through 30 d in milk. Methionine supplementation was adjusted daily at 0.08% of diet DM and CHO was supplemented at 60 g·cow^{-1}·d^{-1}. Blood (−10, 4, 8, 20, and 30 d) and liver (−10, 7, 21, and 30 d) samples were harvested for biomarker and molecular analyses. Methionine supplementation led to greater DMI during close up ($P = 0.01$) and the first 30 d postpartum ($P = 0.02$). Milk yield ($P = 0.03$) and milk protein percent ($P < 0.01$) also were greater in MET-supplemented cows compared with CHO-supplemented cows. The greater overall plasma albumin concentration ($P = 0.04$), blood neutrophil phagocytosis capacity ($P = 0.01$), and neutrophil oxidative burst ($P = 0.03$) in MET-supplemented cows underscored a better liver function and immune status. In addition, the greater concentrations of reduced and total ($P = 0.01$) glutathione in liver tissue indicated a lower degree of oxidative stress in cows fed MET compared with cows fed CHO. The similar ($P > 0.05$) activity and mRNA expression of hepatic betaine homocysteine *S*-methyltransferase and the lower ($P = 0.04$) MET synthase activity in CHO-supplemented cows indicated little regeneration of MET from supplemental CHO. In contrast, the greater ($P < 0.01$) phosphatidylethanolamine *N*-methyltransferase mRNA expression in response to MET indicates increased CHO synthesis from supplemental MET. Overall, results indicate that MET supplementation improves performance of transition cows through a combination of better immunometabolic status and a reduction in oxidative stress; insufficient regeneration of MET may be one reason for the lack of effect with supplemental CHO.

Key Words: enzyme activity, methyl donor, oxidative stress

050 Control of bovine pyruvate carboxylase expression by saturated and unsaturated fatty acids and impact on fatty acid metabolism. K. E. Boesche*, S. L. Koser, S. S. Donkin, *Purdue University, West Lafayette, IN*.

Metabolic fates of fatty acids in tissue may be influenced by extracellular fatty acid concentration and profile. Previous work demonstrates an ability of C18:3 *n*-3 *cis* to ameliorate C16:0- or C18:0-induced depression of pyruvate carboxylase (PC) mRNA expression. Pyruvate carboxylase catalyzes oxaloacetate synthesis and connects gluconeogenesis from lactate and fatty acid metabolism. Our objective was to determine the effects of a copresence of saturated and unsaturated fatty acids on cellular partitioning of [1-^{14}C]C16:0 metabolism to CO_2 or acid-soluble products (ASP) in Madin–Darby bovine kidney cells and the role of PC in this relationship. We hypothesized that the ratio of saturated to unsaturated fatty acid pretreatments regulates [1-^{14}C]C16:0 partitioning to CO_2 or ASP. Cells were exposed for 21 h pretreatments to either individual fatty acids, C16:0, C18:0, C18:1 *n*-9 *cis*, or C18:3 *n*-3 *cis*, or to fatty acid combinations in 10:90, 25:75, 50:50, 75:25, or 90:10 ratios for combinations of C16:0:C18:3 *n*-3 *cis*, C18:0:C18:3 *n*-3 *cis*, or C18:1 *n*-9 *cis*:C18:3 *n*-3 *cis*. Total pretreatment fatty acid concentration was 1.0 m*M*. Following pretreatment, cells were incubated in the presence of 1.0 m*M* [1-^{14}C]C16:0 for 3 h to determine the rate of metabolism to CO_2 and ASP per hour per microgram DNA. Pretreatments of either C16:0 or C18:0 alone significantly ($P < 0.01$) depressed subsequent oxidation of [1-^{14}C]C16:0 to ASP by 62.7 and 41.2%, respectively, compared with C18:3 *n*-3 *cis* pretreatments. Similar patterns were observed for [1-^{14}C]C16:0 oxidation to CO_2. Expression of PC mRNA significantly decreased ($P < 0.05$) with exposure to either C16:0 or C18:0 compared with either C18:3 *n*-3 *cis* exposure or control. Expression of cytosolic phosphoenolpyruvate carboxykinase (PCK1) mRNA followed a similar pattern. Pearson's coefficient correlations were determined for PC mRNA expression and rate of [1-^{14}C]C16:0 metabolism to CO_2 or ASP and for PCK1 mRNA expression and rate of [1-^{14}C]C16:0 metabolism to CO_2 or ASP. Production of CO_2 from [1-^{14}C]C16:0 positively correlated ($r = 0.63$, $P < 0.05$) with PC expression, whereas ASP production from [1-^{14}C]C16:0 only tended to correlate ($r = 0.51$, $0.05 < P < 0.10$) with PC mRNA expression. Production of CO_2 or ASP from [1-^{14}C]C16:0 both positively correlated ($r = 0.80$ and $r = 0.69$, respectively; $P < 0.05$) with PCK1 expression. Results show a regulation of fatty acid metabolism in response to saturated and unsaturated fatty acid pretreatments. Cellular oxidative capacity can help determine the response to physiological factors, including fatty acids, which increase during the metabolically stressful transition period in dairy cows.

Key Words: fatty acid oxidation, ketogenesis, pyruvate carboxylase

051 Postpartum protein nutrition for dairy cows. W. D. Weich[1,*], K. F. Kalscheur[2], D. P. Casper[1], [1]*South Dakota State University, Brookings,* [2]*USDA-ARS Dairy Forage Research Center, Madison, WI*.

Dietary recommendations regarding MP and AA nutrition for dairy cows in the immediate postpartum period have not been completely defined. A state of negative protein balance pres-

ent during this period, in which tissue AA are mobilized to support milk protein synthesis and gluconeogenesis, complicates estimates for supplying optimal amounts of MP. Efforts made in attempting to formulate postfresh diets using MP methods or estimating MP supplies from previous postpartum protein nutrition research diets have demonstrated inconsistent responses when increasing MP amounts during the immediate postpartum period. Potential benefits when altering MP fractions to optimize transition to the lactation diet have not been explored. Previous research related to early-lactation protein feeding strategies suggests that offering greater concentrations or amounts of RUP may be beneficial to enhancement of production and health through meeting MP demands during periods of depressed DMI while lessening circulating plasma ammonia concentrations. However, the viability of this feeding strategy during the postfresh period on maintaining health and ruminal adaptation to the lactation diet has not been evaluated. Research conducted by our group was developed to contribute to the pool of data supporting optimal MP feeding strategies for postfresh dairy cows. Theoretical MP, microbial protein and RUP, contributions were altered between 2 research diets through selection of various protein ingredients to create a control diet and a higher RUP diet fed to cows during the postpartum segment of the transition period. Model-predicted total MP estimates using poststudy DMI values were similar between treatments as were microbial and RUP estimates within the total MP supplied. Dietary RDP balance was significantly less for cows fed greater amounts of RUP. Results conclude that treatments had similar effects on means for DMI, milk production, and rumen fermentation end products; however, milk protein concentration was negatively affected for cows fed diets formulated with greater concentrations of RUP feed sources. Furthermore, after wk 4, animal performance from cows fed greater RUP tended to be adversely affected, suggesting that adequate RDP may not have been supplied to maximize rumen function. In addition, greater amounts of delivered RUP may have negatively affected DMI as intakes approached peak amounts.

Key Words: amino acid, postpartum, protein, transition cow

EQUINE

052 Equine welfare in a competitive setting–What can ten-plus years of research by the equitation science community tell us? (And what critical pieces are still missing?). C. R. Heleski*, *Michigan State University, East Lansing*.

"Equitation science promotes an objective, evidence-based understanding of the welfare of horses during training and competition by applying valid, quantitative scientific methods that can identify what training techniques are ineffective or may result in equine suffering" (http://www.equitationscience.com/). The relatively young field of equitation science has yielded many important findings in terms of equine welfare in a competitive setting; for example, König von Borstel and others performed a meta-analysis of 55 studies related to hyperflexing horses' necks (e.g., rollkur). In 88% of the studies, the hyperflexed neck posture negatively impacted welfare. McGreevy and others have performed several studies related to whip use in Australian race horses. High-speed photography allowed them to see how much skin and muscle displacement takes place during a whip strike, and postrace thermography allowed them to see heat generated from whip strike areas. This research group did not find increased whip strikes relating to enhanced speed. This echoes a finding by Waite and others that showed that barrel racing horses did not go faster when kicked more or struck more often with a riding aid. Numerous studies from equitation science have confirmed that the correct application of learning theory will enhance equine learning and will likely improve equine welfare. This has been applied to trailer loading, learning to cross over/encounter a novel object, tolerating certain veterinary procedures, etc. Conversely, researchers have confirmed that poorly timed punishment or attempting to train while the horse is fearful creates further problems. Wemelsfelder has now collaborated with a number of researchers to provide strength to the value of qualitative behavioral assessment. More studies are needed, particularly across competition disciplines, but the foundation has been laid for equine behaviorists to assess facial expressions and body language signals that can help us to know the emotional state of the horse. As this field matures, an increasing number of studies are presenting both physiological data (e.g., heart rate, heart rate variability, salivary cortisol) and behavioral data (e.g., frequency of behaviors exhibited, duration of behavioral states). In spite of logistical challenges, more research is needed from actual competition venues and with all levels of competing equine athletes.

Key Words: equine behavior, equine welfare, equitation science

053 Equine welfare in a competitive setting: The human role. K. L. Waite*, *Michigan State University, East Lansing*.

Equine welfare in a competitive setting is an issue critical to the horse industry. Social media shines an even brighter light on both the positive and negative aspects of animal welfare in conjunction with such activities. Although the number and scope of studies of competitive equestrian activity is limited, the general areas of concern in equestrian sport parallel those in more traditional sports. Skelly and others conducted a survey at a Michigan Horse Show Ethics Extension workshop that determined that the top 5 ethical concerns pertaining to horse shows were matters of sportsmanship, horse welfare is-

sues, violations of rules and regulations, concerns about fair judging, and parenting issues. Animal scientists are tirelessly working in the field of animal behavior and welfare to inform the literature with respect to the impact of competitive activity on animals, with equitation science specifically focusing on equines. Fewer studies, however, have taken into account the actions and motivations of the humans who put animals into competitive environments. Waite, for example, found no relationship between the use of aggressive riding techniques and final run time in youth barrel racing, whereas Voigt used Bandura's social cognitive theory to examine human perspectives toward show horse welfare within cognitive, behavioral, and environmental contexts. By asking research questions designed to better understand the human influence in competitive equestrian activity, we may more effectively influence change where change is needed. Understanding, addressing, and resolving animal welfare issues requires a multifaceted approach including animal science–based teaching, research, and extension efforts but also using psychology, social science, education, and other disciplines. This presentation will share current research with respect to the human impact on animal well-being and competitive equestrian activity, pose additional research questions, and share strategies for addressing these complex issues.

Key Words: competitive, equine, well-being

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054 Perceptions of equine well-being in South Dakota.

H. K. Carroll*, R. C. Bott, S. L. Mastellar, L. R. McNeill, G. D. Djira, *South Dakota State University, Brookings*.

South Dakota is a rural state with a high number of equids for its human population. In South Dakota, the status of equid well-being is relatively unknown. The objectives of the current study were to 1) gain understanding about the current perceptions of animal well-being in South Dakota with an emphasis on horses and other equids, 2) determine the level of care equids are reportedly receiving and the perceived challenges to equine well-being in South Dakota, and 3) determine if people from diverse geographical locations (east or west of the Missouri River) have similar views on the well-being of equids in South Dakota. Vast geographical differences and population densities exist across South Dakota, thus identifying varying viewpoints assists future educational efforts on animal well-being topics. Members of the South Dakota equid industry participated in our survey via hard copy at equine events, mailings, or a web-based questionnaire distributed through extension websites and equine organizations. Most survey questions were designed using a Likert scale: strongly disagree, disagree, undecided, agree, and strongly agree. Survey completion rate was 82% with a total of 142 responses from South Dakota. The sample population was 62% female and relatively young, with 60% of our sample between 18 and 44 yr old. Most respondents (87%) were from east of the Missouri River. The respondents were in agreement (76%) that the current level of equid well-being in South Dakota is sufficient, yet 75% of respondents strongly agreed that there can be improvements. A majority of survey respondents agreed or strongly agreed that the high annual cost of horse care (81%), poor horsemanship (67%), dental problems (66%), and whether the caretaker understands basic equine care (66%) were considered current challenges for the equid population of South Dakota. There was a significant association between where a respondent lives (western or eastern South Dakota) and their level of agreement with 3 statements: 1) a caretaker's misunderstanding could contribute to a lack of well-being ($P = 0.0423$), 2) neglect of basic physical needs was a current challenge to South Dakota equines ($P = 0.0443$), and 3) the low market value of horses has allowed people to acquire and/or retain more horses than available resources support ($P = 0.0361$). The results of this survey on perceptions of equid well-being provided a benchmark to gauge well-being and helps give direction for future educational needs to be addressed that can continue to improve equid care.

Key Words: animal welfare, equid care, equine well-being

EXTENSION– BEEF AND SMALL RUMINANT

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055 Using corn coproducts in postpartum diets of beef cows to optimize reproductive performance.

E. G. Taylor*, R. P. Lemenager, K. R. Stewart, *Purdue University, West Lafayette, IN*.

Primiparous and multiparous Angus–Simmental cows (n = 48; BW = 537 kg ± 42.5 and BCS = 5 ± 0.41) were used in a complete randomized block design to evaluate the effects of feeding distiller's dried grains with solubles (DDGS) as a primary source of dietary energy, which resulted in varying levels of protein during early lactation on cow BW, body condition, and reproductive performance. All cows were placed on study within 20 d of calving. Cows were blocked by calf birth weight, cow weight, BCS, and age and randomly assigned to 1 of 3 treatments: 1) silage-based total mixed ration (TMR; CON), 2) TMR with 2.5 kg/d DM DDGS (MID), or 3) TMR with 4.9 kg/d DM DDGS (HIGH). All diets were formulated to be isocaloric and either meet or exceed all other nutrient requirements. Postpartum ADG was targeted at 0.22 kg/d. Blood samples were collected at 7-d intervals from trial initiation until estrous synchronization for determination of plasma progesterone concentration as an indicator of resumption of cyclicity. Blood samples were also collected at 21-d intervals from trial initiation until estrous synchronization for plasma urea nitrogen (PUN). A 5-d Co-Synch + controlled internal drug release protocol was used and cows were bred by timed AI (TAI). Diameter of the largest antral follicle was

determined at TAI via ultrasonography. Bulls were placed with cows 10 d after TAI for the remainder of the breeding season. Pregnancy diagnosis was accomplished via ultrasonography 39 and 104 d after TAI, respectively, for TAI and overall breeding season pregnancy. Data were analyzed using the GLIMMIX, MIXED, and GLM procedures of SAS (SAS Inst. Inc., Cary, NC). Final BW ($P \geq 0.44$) and BCS ($P \geq 0.42$) were similar among treatments. Resumption of cyclicity in cows ($P = 1$), dominate follicle diameter ($P = 0.37$), and season long pregnancy rate ($P = 0.99$) were not different between treatments. No difference ($P = 0.72$) in TAI conception rates were seen between cows fed MID (56.3%) and CON (62.5%) treatments. However, TAI conception rate in the HIGH cows (87.5%; $P = 0.068$) was higher and approached significance compared with CON and MID cows. Differences in PUN concentration were observed between all treatments ($P \leq 0.002$) with HIGH being the highest, MID intermediate, and CON lowest. In summary, feeding high levels of DDGS to beef cows during early lactation has a positive effect on TAI conception rate, which can potentially enhance cow herd genetic progress and producer profitability.

Key Words: beef, heifer development, lactational programming

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056 Cultural energy analysis of cool- and warm-season grass pasturing systems into cattle finishing programs.

H. Koknaroglu[1,*], O. Koskan[1], R. A. Edler[2], M. P. Hoffman[2], *[1]Suleyman Demirel University, Isparta, Turkey, [2]Iowa State University, Ames*.

A 4-yr study integrating pasture and drylot feeding systems was used to assess cultural energy analysis of cattle production systems. Each year, 116 fall-born Hereford and Angus crossbred calves of similar genotypes were used. The calves were obtained April 15 following weaning and a preconditioning program. Following a 2-wk acclimation period in a drylot on ground midbloom alfalfa hay, the calves were assigned to treatments by weight and color pattern. Treatments were 1) placing calves on bromegrass pasture until mid October, at which time they were removed and finished in a drylot (OCT); 2) placing calves on bromegrass pasture until approximately July 1, at which time they were moved to a drylot for finishing; 3) placing calves on bromegrass pasture until mid June, at which time they were moved to warm-season pastures until being returned to bromegrass pasture from mid August until sometime in October when they were placed in a drylot for finishing (WARM); and 4) placing 28 steers directly into a drylot at the start of the tests (FEEDLOT). The bromegrass pasture consisted of 24 paddocks, each 1.7 acres in size. Each grazing treatment of 28 steers (except for 32 steers placed on warm-grass pastures) was rotated among paddocks at 3- to 4-d intervals early in the season and at about 2-d intervals later in the season. An 82% concentrate diet containing whole shelled corn, ground alfalfa hay, and a protein–vitamin mineral supplement with ionophores and molasses was provided ad libitum daily in the drylot. On pasture, calves were provided supplement blocks containing ionophores. Pens of cattle were harvested at approximately 568 kg. Cultural energy used for pasture establishment, feed consumption, and maintenance were calculated using the actual inputs and corresponding energy values from the literature. The FEEDLOT cattle had higher and OCT cattle had lower total cultural energy expenditures than other treatments ($P < 0.01$). Feed energy made up more than half of the total cultural energy and was highest for FEEDLOT cattle and was lowest for OCT cattle ($P < 0.01$). Energy expended per kilogram live weight gain was higher for FEEDLOT cattle ($P < 0.01$). The energy output ratio, defined by kilocalories input/kilocalories output, was better for the OCT treatment followed by the WARM treatment ($P < 0.01$). Results show that pasturing cattle is an effective way of reducing cultural energy expenditure and that grazing cool-season grass was better suited to the concept of sustainable agriculture.

Key Words: cultural energy, feedlot, pasture, sustainability

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057 Cultural energy analyses of climatologically suitable places in Turkey for feedlot cattle production determined by using the comprehensive climate index model.

H. Koknaroglu[1,*], J. A. Harrington Jr.[2], T. L. Mader[3], *[1]Suleyman Demirel University, Isparta, Turkey, [2]Kansas State University, Manhattan, [3]Mader Consulting, LLC, Gretna, NE*.

The objective of this study was to conduct cultural energy analyses on feedlot cattle production in Turkey. The comprehensive climate index (CCI) model was used to predict DMI, ADG, and feed efficiency of feedlot cattle in 15 locations in Turkey. The CCI enables one to quantify beef cattle performance for a number of breeds based on environmental conditions (temperature, relative humidity, wind speed, and solar radiation) at any time in the year. Because mostly dairy breed calves are placed into the feedlot in Turkey, the Holstein (dairy breed) option in the CCI was chosen to calculate the maintenance energy requirement. Based on previous feedlot feeding studies conducted in Turkey, it was assumed that calves would be placed on feed at 250 kg and be marketed at 520 kg and that the diet would have 2600 kcal/kg metabolic energy and would have DMI of 2.31% of the BW. It was assumed that cattle would receive 2 kg/d straw and that the concentrate mixture would consist of 52.65% barley, 26% corn, 19% cotton seed meal, 1.5% limestone, 0.25% vitamins, 0.5% salt, and 0.1% minerals. Cultural energy inputs were calculated by multiplying the amount of inputs and their corresponding cultural energy based on values from existing literature. Cultural energy used for feed was derived from DMI of cattle and corresponding values for each feed ingredient. Transportation energy was also included in the analysis, including costs for shipping calves from animal market to the farm, shipping yearlings to

slaughterhouse, and shipping feed ingredients to the farm. Cultural energy expended for feed made up more than half of the total cultural energy and differed among cities ($P < 0.05$). Cultural energy for feed was highest for the coldest places and lowest for hot locations. Cultural energy of transportation constituted the second highest cultural energy expenditure. Cultural energy expended per kilogram live weight gain (defined as total cultural energy expended divided by kg live weight gain) was highest for the coldest location and lowest for relatively hotter cities ($P < 0.05$). Cultural energy use efficiency (defined by kcal input/kcal output) followed the feed efficiency ranking with cattle having better feed efficiency also have better cultural energy use efficiency. Results showed that cattle having higher ADG did not mean that they would also have better cultural energy use efficiency.

Key Words: beef cattle, comprehensive climate index, cultural energy, feedlot

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058 Determination of suitable sample size and number of simulation for predicting dry matter intake of feedlot cattle. O. Koskan[1,*], H. Koknaroglu[1], D. D. Loy[2], M. P. Hoffman[2], *[1]Suleyman Demirel University, Isparta, Turkey, [2]Iowa State University, Ames*.

Close-out information, submitted by Iowa cattle producers to the Iowa State University Feedlot Performance and Cost Monitoring Program, was used to develop a suitable sample size and number of simulations for predicting DMI in feedlot cattle. Close-out information consisting of 3452 pens of cattle included information on start and end dates, cattle per pen, sex, housing type, days on feed, initial and sale weight, feed conversion (FC), proportion of concentrate, ADG, percent death loss, feed cost and total cost per 45.35-kg gain, break-even sale price, nonfeed variable cost, nonfeed fixed cost, and corn price. Dry matter intake was not provided but was calculated as DMI = ADG × FC. The average number of cattle per pen was 147 and the number of cattle fed was 507,444. Because the number of cattle fed was enormous, it was assumed that this could represent the population. To determine a suitable sample size and number of simulations, different sample sizes (3, 5, 10, 15, 20, 30, 50, 70, and 100) and different number of simulations (1000, 3000, 5000, and 10,000) combinations were run. Samples were chosen as sample with replacement among 3452 pens. This sampling procedure was performed 1000, 3000, 5000, and 10,000 times. Results showed that a sample size of 15 pens and above gave better results than smaller sample sizes. As the number of sample size increased above 15, results became more dependable, but considering the time and money constraints, it is advised to have a sample size of 15. The optimum number of simulations was found to be between 3000 and 5000 by looking at the distribution shape, SEM, and the similarity of DMI to actual DMI. When a simulation was run for 10,000, distribution shape, SEM, and the similarity of DMI to actual DMI were nearly perfect. However, considering the time constraint and the advanced computers needed to run the large number of simulations, it is advised to have between 3000 and 5000 simulations.

Key Words: dry matter intake, feedlot, sampling, simulation

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059 The effect of age, plane of nutrition, and progesterone pretreatment on lambing rate in nulliparous females bred during the breeding season. A. K. Redhead*, A. K. Adebiyi, C. D. Paul, E. N. Keller, K. J. Powell, M. Knights, *West Virginia University, Morgantown*.

Replacement ewe lambs make up approximately 30% of the breeding flock, and successful breeding of ewe lambs at 7 to 9 mo of age can increase the lifetime productivity and profitability. However, the lambing rate of ewe lambs is 35% lower than their adult flock mates. A 2 × 2 × 2 factorial arrangement of treatment study was used to determine the effect of age, plane of nutrition, and progesterone pretreatment on fertility of replacement ewes. Young (5.45 ± 0.09 mo) and old (8.75 ± 0.19 mo) females ($N = 110$) were assigned to receive a low plane of nutrition ($n = 57$; LP) or high plane of nutrition ($n = 53$; HP; 0.23 or 0.68 kg/d of a 15% CP and 65% TDN grain concentrate, respectively) and free access to average quality forage for 2 mo before the beginning of the breeding season. Before breeding, females in each nutrition plane were either pretreated with progesterone containing controlled internal drug release devices for 5 d or introduced to rams only at a ram-to-female ratio of 1:25 for a 35-d breeding period. Analysis of variance was conducted using the GLM procedures of SAS (SAS Inst. Inc., Cary, NC), and the least squares means were computed on reproductive performance variables. Older ewe lambs had a higher estrus response ($P = 0.04$; 81.9 ± 7.5 vs. 61 ± 7.3%) and conception rate ($P = 0.04$; 83.6 ± 7.8 vs. 60 ± 8.9%) and tended to have a higher pregnancy rate to first service ($P = 0.09$; 91.4 ± 7.5 vs. 74.3 ± 7.3%) than young females. Females receiving progesterone pretreatment had a higher estrus response ($P = 0.001$; 81 ± 5.9 vs. 61 ± 6.4%) and an earlier lambing day and shorter duration from ram introduction to lambing (7.66 ± 1.27 vs. 13.2 ± 1.30 d [$P = 0.0021$] and 151.7 ± 1.32 vs. 155.8 ± 1.38 d [$P = 0.0216$], respectively) and tended to have a higher pregnancy rate to second service ($P = 0.06$; 92.8 ± 4.9 vs. 80 ± 5.3%). Prolificacy and overall lambing rate was higher in females receiving the HP diet than those receiving the LP diet (1.57 ± 0.09 vs. 1.01 ± 0.08 [$P = < 0.001$] and 1.10 ± 0.12 vs. 0.71 ± 0.11 [$P = 0.0272$], respectively), but prolificacy and lambing rate was not affected by age and progesterone pretreatment. In conclusion, a HP before breeding increased prolificacy and lambing rate in nulliparous ewes, but a similar effect was not observed by progesterone pretreatment or by increasing age at breeding.

Key Words: breeding performance, ewe lambs, fertility, lambing rate, prolificacy

060 Evaluating results of prebreeding reproductive examinations in yearling and mature beef bulls via the BullTest data reporting system.
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Over a 2-yr period, data were collected to summarize incidence and reasons for failure of reproductive soundness examinations in yearling and mature beef bulls. Upon completion of examinations, participating veterinarians completed the BullTest card by indicating the number of yearling and mature bulls evaluated and the number of bulls in each age class that failed the examination. Examinations were further classified by indicating number of bulls failing for each of the following reasons: semen motility, semen morphology, excess white blood cells present in ejaculate, penile injury/defects, wart proliferation, feet and leg conformation, scrotal circumference, and "other." In addition, practitioners indicated the type of examination conducted: simple semen exam or full breeding soundness exam, whether the test was for a breeding herd or production sale, and whether the test was the initial evaluation of bulls or a retest. Data were reported by 5 veterinary clinics and included 14,698 bulls in 1374 groups. The number of bulls reported in each group ranged from 1 to 228 (mean 10.7 ± 0.43, median 6). For each group, the proportion of bulls failing examination and the proportion of bulls failing for each specific reason were calculated. The overall failure rate for groups of yearling bulls (22.1 ± 1.2%) was greater ($P < 0.01$) than that of mature bulls (11.6 ± 0.8%). A greater ($P < 0.01$) proportion of yearling bulls that were presented for retesting (39.5 ± 3.6%) failed examinations compared with those presented for their initial examination (18.2 ± 1.8%). Similarly, a greater ($P < 0.01$) proportion of mature bulls that were presented for retesting (38.6 ± 2.7%) failed examinations compared with those presented for their initial examination (9.4 ± 0.7%). Failure rates were similar ($P = 0.62$) among groups of yearling bulls tested as part of a breeding herd (20.9 ± 18%) or production sale (23.9 ± 2.6%). A greater ($P \leq 0.02$) proportion of yearling bull failures were related to semen morphology or penile warts compared with mature bulls, whereas a greater ($P < 0.01$) proportion of mature bull failures were related to other penile injuries/defects or issues with feet and leg conformation. The BullTest system provided an excellent platform to summarize results of prebreeding reproductive evaluations in beef bulls.

Key Words: breeding soundness examinations, bulls, reproductive management

061 Perceptions of crop consultants and producers in Nebraska on grazing corn residue.
J. L. Cox[1,*], K. M. Ulmer[1], M. Rakkar[2], L. Franzen-Castle[3], H. Blanco-Canqui[2], M. E. Drewnoski[1], J. C. MacDonald[1], R. J. Rasby[1], *[1]Department of Animal Science, University of Nebraska, Lincoln, [2]Department of Agronomy and Horticulture, University of Nebraska, Lincoln, [3]Department of Nutrition and Health Sciences, University of Nebraska, Lincoln*.

This study was designed to better understand perceptions and concerns of crop consultants and producers in Nebraska regarding grazing corn residue. Survey participants were crop consultants (234/940 = 25% return rate) and crop producers (130/545 = 24% return rate). Online survey software (Qualtrics) was used to create, distribute, and store data from the surveys, which were distributed using an electronic mailing list of consultants and producers developed by the University of Nebraska– Lincoln extension educators. The survey indicated that 76% of consultants influenced ≥ 4,000 acres of sprinkler-irrigated and rain-fed cropland with about 50% under no-till management. Seventy percent of producers farmed between 81 and 1618 ha of sprinkler-irrigated and rain-fed cropland with about 70% under no-till management. Regarding grazing practices, 82% of consultants recommended grazing corn residue but only 52% of producers allowed corn residue grazing. Thirty-seven percent of producers did not allow grazing due to concerns of soil compaction, inconvenience (lack of water, fencing, and land/equipment damage), and lack of access to livestock for grazing. In regards to the impact of grazing on subsequent corn and soybean yields, about 50% of producers stated that grazing had "no impact" and about 33% stated that grazing increased yield. Producers that allowed corn residue grazing perceived that grazing residue increased subsequent corn ($P < 0.01$) and soybean ($P = 0.02$) yield more than producers that did not allow grazing. From a question that allowed respondents to select "all that apply," 56% of consultants and 44% of producers reported receiving information related to yield and corn residue grazing from their own observation. Forty-eight percent of consultants and only 25% of producers received information regarding yield and corn residue grazing from university extension programs. We hypothesized that consultants would recommend against grazing corn residue, but the survey results suggested otherwise. Almost 40% of producers were not allowing grazing despite the majority of consultants recommending it. Overall, the perceptions of consultants and producers were positive toward grazing residue and its impacts on subsequent grain yields. There was a large portion of consultants and producers making management decisions based on their own observation rather than based on research data. Hence, this survey suggests the need for university extension educators and researchers to more effectively disseminate research results to producers and other

clientele regarding this management strategy.

Key Words: crop yield, extension education, grazing corn residue, survey

062 Determination of climatologically suitable places in the Midwest for feedlot cattle production by using the comprehensive climate index model.

H. Koknaroglu[1,*], J. A. Harrington Jr.[2], T. L. Mader[3], *[1]Suleyman Demirel University, Isparta, Turkey, [2]Kansas State University, Manhattan, [3]Mader Consulting, LLC, Gretna, NE*.

The objective of this study was to determine climatologically suitable places to raise feedlot cattle in the Midwest. Hourly average temperature, relative humidity, and wind speed values for 22 locations (Des Moines, Mason City, Sioux City, Waterloo, Concordia, Dodge City, Goodland, Russell, Topeka, Wichita, Columbia, Kansas City, KCI, Springfield, St. Louis, Grand Island, Lincoln, Norfolk, North Platte, Omaha, Scottsbluff, and Valentine), spanning the last 10 yr, were obtained. Daily solar radiation values could not be obtained from the weather stations and were calculated based on a formula that takes hemisphere, latitude, and day of the year into account. The comprehensive climate index (CCI) model was used to predict DMI, ADG, and feed efficiency of feedlot cattle. The CCI enables one to quantify beef cattle performance for a number of breeds based on environmental conditions (temperature, relative humidity, wind speed, and solar radiation) at any time in the year. Because mostly beef cattle breed calves are placed into the feedlot in the Midwest, the British (beef breed) option in CCI was chosen to calculate the maintenance energy requirement of cattle. It was assumed that calves would be placed on feed at 340 kg and be marketed at 613 kg and that diets would have 3200 kcal/kg metabolic energy and would have DMI of 2.10% of the BW. Results comparing the 22 locations showed that Mason City had the highest and Columbia had the lowest DMI ($P < 0.05$). Cattle raised in Kansas and Missouri had lower DMI than those raised in Iowa and Nebraska. Cattle had ADG ranging from 1.74 to 1.69 kg/d; Scottsbluff and Goodland had the highest ADG and Columbia had the lowest ADG ($P < 0.05$). As it is observed in DMI, cattle raised in south latitudes had lower ADG than those raised in northern latitudes. Springfield and Wichita had better feed efficiency than other locations, and Mason City had the worst feed efficiency. Cattle raised in Kansas and Missouri had better feed efficiency than those raised in Iowa and Nebraska ($P < 0.05$). Results showed that there are differences in terms of performance of cattle raised in different locations in the Midwest and this should be taken into consideration for economical beef production.

Key Words: comprehensive climate index, feedlot, performance

063 Breed and gender interact to affect the sale price of beef calves sold through video auctions from 2010 through 2014.

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The objective of this study was to quantify the effect of the potential interaction of breed and gender on the sale price of beef calves marketed through video auctions while adjusting for all other factors that significantly influenced price. Information on descriptive characteristics of lots of beef calves were obtained from a livestock video auction service. Data were available on 20,007 lots of steer calves and 13,804 lots of heifer calves (2106,181 total steer calves and 1239,645 total heifer calves) that sold in 116 video auctions from 2010 through 2014. All lot characteristics that could be accurately quantified or categorized were used to develop a multiple regression model that evaluated the effects of independent factors on the sale price using a backward selection procedure. A value of $P < 0.05$ was used to maintain a factor in the final model. Breed description of the calves in the lots was 1 of 19 factors included in the original model and was characterized into 6 groups: English, English crosses (EX), English–Continental crosses (ECX), Black Angus sired out of dams with no Brahman influence (AN), Red Angus sired out of dams with no Brahman influence (AR), and Brahman influenced (BR). Breed and gender of the lot interacted ($P < 0.0001$) to affect the sale price of calves. Lots of AR and AN steer calves had similar sale prices ($P = 0.9540$; \$379.08 and \$378.14 per 100 kg BW, respectively) and sold for significantly higher prices than all other steer breed groups. English cross and ECX steer lots had similar sale prices ($P = 0.2588$; \$376.24 and \$374.92 per 100 kg BW, respectively) but were greater ($P < 0.05$) than BR steer calves (\$365.61 per 100 kg BW). Among heifer calves, lots of AR heifers sold for the highest price ($P < 0.05$; \$356.02 per 100 kg BW). The AN heifer calves sold for the second highest price at \$345.95 per 100 kg BW, and this price was greater ($P < 0.05$) compared with ECX (\$341.50 per 100 kg BW) and EX heifers (\$341.14 per 100 kg BW). Brahman-influenced heifer calves sold for the lowest ($P < 0.05$) price at \$334.64 per 100 kg BW compared with heifers of all other breed descriptions. Breed and gender composition of the lots of beef calves interacted to affect the sale price of calves selling through video auctions. The value of the specific breed composition of beef calves is influenced by gender and may be related to buyers purchasing certain breeds of heifer calves as replacements for the breeding herd.

Key Words: beef calves, breed, gender

064 Evaluation of distillers' grains components singly or in combination for finishing calf feds.

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A finishing study was conducted to determine the value of the fiber, protein, fat, and solubles components from wet distillers' grains with solubles (WDGS) alone or in combination for feedlot cattle in comparison with WDGS diets. Six hundred calf-fed steers (309 kg [SD 18]) were used in a randomized block design with 10 treatments and 6 replications per treatment. Diets were formulated to contain the same amount of fat, fiber, or protein as in WDGS. The control diet had a 1:1 mix of dry-rolled corn:high-moisture corn with 4% sorghum silage, 3.5% grass hay, and 5% supplement. The WDGS20 and WDGS40 diets had 20 and 40% of WDGS replacing corn, respectively. The Fiber20 and Fiber40 diets contained corn bran at 7 and 14%, respectively, and solvent extracted germ meal at 1.5 and 3%, respectively, replacing corn to mimic the fiber in the WDGS20 and WDGS40 diets. Protein was then added to the fiber diet in the form of corn gluten meal at 17.5% replacing corn to mimic the CP in the WDGS40 diet. Whole fat germ was then added to the fiber and protein diet to mimic the fat portion at 7.5% inclusion. Lastly, condensed distillers' solubles were added to the fiber, fiber plus protein, and the fiber plus protein and fat diets at 8% to evaluate its contribution to energy. The control diet was found to be similar to the Fiber20 and Fiber40 diets. As WDGS replaced corn in the diet, G:F quadratically increased ($P = 0.02$). Feeding WDGS resulted in greater G:F when compared with the cattle fed the Fiber20 and Fiber40 diets ($P < 0.01$). The addition of protein to the fiber diets improved G:F along with the inclusion of fat to the protein plus fiber diets ($P < 0.01$).With the solubles inclusion, ADG increased ($P < 0.01$). The addition of protein to the fiber diet and the addition of fat to the fiber and protein diet added 47 and 2%, respectively, to the feeding value when compared with the corn control. The diet intended to reconstruct WDGS40 from fiber, protein, fat, and solubles gave similar performance for G:F ($P \geq 0.83$). However, WDGS40 cattle had greater fat ($P = 0.05$) and tended to have greater marbling ($P = 0.17$). The combination of the individual components mimics the feeding value of WDGS with the largest contributor being protein.

Key Words: fiber, protein, wet distillers' grains

EXTENSION– DAIRY

065 A study to examine the relationship between uterine pathology and depletion of oxytetracycline in plasma and milk after intrauterine infusion.

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Metritis is a frequent problem in postpartum dairy cows. Intrauterine therapy with oxytetracycline (OTC) is often used to improve therapeutic outcomes, although efficacy data supporting this therapy are ambiguous. Several manuscripts describe the depletion of OTC from milk following intrauterine therapy. However, none of these studies have correlated uterine severity scores with milk OTC concentrations using highly sensitive detection systems. Our objective was to do this to test the hypothesis that cows with more severe uterine severity would have higher OTC residues in milk following intrauterine therapy. Thirty-two cows received a single treatment of 4 g of OTC via intrauterine infusion. Blood and milk samples were collected before intrauterine therapy and throughout the trial period of 96 h after infusion. Uterine severity scores were assigned at initiation of therapy and every 24 h throughout the remainder of the trial. Plasma and milk samples were analyzed for OTC concentrations using liquid chromatography coupled with mass spectrometry. Following treatment, OTC rapidly diffused from the uterus to plasma and from plasma to milk. Maximum concentration in plasma and milk occurred within 24 h following intrauterine infusion and 18 of the cows still had detectable levels of OTC in milk 4 d after intrauterine infusion. Greater uterine severity score at the initiation of treatment showed a significant positively correlation with higher milk OTC concentration at the second milking following treatment ($R^2 = 0.46$, $P = 0.01$) but there was no correlation between initial uterine severity score and OTC concentration at the conclusion of the study ($R^2 = -0.06$, $P = 0.75$). In the United States, intrauterine administration of OTC is considered to be an extra-label therapy. The use of uterine severity score can be used to predict OTC concentration in the first day following therapy but should not be used as a predictor of OTC concentrations 96 h after treatment. Dairy producers should consult with their veterinarian to develop strategies that will prevent the presence of violative residues of OTC in bulk tank milk following intrauterine therapy.

Key Words: bovine metritis, drug residues

066 Midwest dairy processing needs, trends, and changes. V. V. Mistry*, *South Dakota State University, Brookings*.

The general trend in the U.S. dairy industry over the years has been that of consolidation, and this has been reflected in the Midwest as well. The total number of dairy farms in the United States has dropped approximately 668% since 1980. The whole-herd buyout program that began in 1985 to reduce the milk supply in the country and improve prices resulted in a drop in cow numbers by approximately 1 million in just 5 yr. Subsequently, in the previous 2 decades, there has been a general increase in the demand for milk products, presenting opportunities for the dairy industry. Although there have been definite differences in demand for specific products, the general trends reflect an increase. A recent study by Bliming and Associates, Inc., "Path Forward," sponsored by the Midwest Dairy Association, has shown that the Midwest has the potential to capitalize on the growing domestic and global dairy demand opportunities. According to this study, the region's existing land and water infrastructure, business climate, and capital resource availability are the key ingredients that will help support the anticipated dairy market growth of 15% by 2022. Much of this growth has already been occurring in some parts of the Midwest. For example, in South Dakota, after a decline in dairy farm numbers in the period following 1985 from 4400 to 273 in 2013 and a record low of 79,000 cows in 2004, the cow numbers have increased to 107,000 and are expected to grow further in response to anticipated processing growth and demand for products. In 2013, there were 8 cheese plants, which include 2 large cheese and whey processors, a drying facility, and several others. In response to the positive growth opportunities, a new $100 million cheese plant was built in the state in 2014. Two existing cheese plants have also undergone substantial expansions in cheese- and whey-processing capabilities. The state ranks eighth in cheese production and accounts for approximately 24% of all cheese produced. These plants collectively manufacture natural commodity cheeses that are exported outside of the Midwest and used as table cheeses or for further processing. Other products such as dried whey ingredients, including lactose, are also manufactured, largely for export. To support this growing industry, there is a strong need for dairy graduates. The check-off funds–sponsored Midwest Dairy Foods Research Center supports the processing industry through cutting edge dairy products research.

Key Words: dairy education and research, dairy processing, Midwest

067 Organic pasture versus conventional dairying–Is there a difference in sustainability? B. J. Heins*, *University of Minnesota West Central Research and Outreach Center, Morris*.

Organic is a production system that is managed to respond to site-specific conditions by integrating cultural, biological, and mechanical practices that foster cycling of resources, promote ecological balance, and conserve biodiversity. The number of organic dairy producers in the Upper Midwest continues to grow. Over an 8-yr period from 2000 to 2008, the number of organic farms grew by 42% Despite the slow-moving economy over the past several years, consumers continue to purchase organic dairy products. Organic milk can cost considerably more than conventional milk. Disease frequencies were examined on organic and conventional herds in Minnesota. Lameness prevalence and Johne's disease presence on the farm between similar-sized organic and conventional farms and bulk tank bacteria count were not substantially different among farm types. Furthermore, organic farms had higher gastrointestinal parasite egg counts than conventional dairy farms. For Minnesota, organic dairy herds in 2014 had 4881 kg less production than conventional dairy herds; however, the lower production was a result of lower inputs for cows (i.e., feeding less grain). Additionally, organic herds in Minnesota had less feed cost and less total costs per cow than conventional herds. Organic herds had less feed costs because they were fed less grain whereas conventional herds had high grain prices and high prices on protein and vitamins and minerals. Organic herds in Minnesota also had less veterinary costs ($78.94 less per cow) than conventional herds. The bottom line is that organic dairy herds in Minnesota during the last 5 yr had more net income per cow (+$13.65) than conventional herds. Some challenges of organic dairy production include fewer health products allowed, higher costs of feed, less research information available on organic dairy production, high costs of certification, and the extensive paperwork and records that must be maintained on all aspects of the farm. Despite the challenges, organic dairy production may be more profitable that conventional dairy production. Regardless whether organic or conventional, dairy producers must have the best management practices that will positively impact the profitability of their dairy operations.

Key Words: conventional dairy, organic dairy, sustainability

068 Field observations of automated dairy calf feeding systems in the Upper Midwest. N. B. Litherland*, A. M. Hoskins, *Vita Plus Corporation, Madison, WI*.

Calf nutrition and management play significant roles in determining the success of calves in automated calf feeding systems (ACFS). There is considerable variation in ACFS design, operation, and outcome throughout the Upper Mid-

west, and producers with greatest success with ACFS apply the following principles: excellent maternity and colostrum management; backgrounding calves in individual pens for at least 4 feedings; preventing calves from under- or overconsuming milk; encouraging starter grain and water intake; and maintaining environmental quality including air, bedding, and equipment sanitation. Producers raising calves in ACFS are feeding greater amounts of pasteurized whole milk and milk replacer than in convention individual housing systems. Maintenance requirements for energy and protein appear to be greater in group vs. individual systems. Backgrounding allows producers to make sure calves are consuming adequate amounts of milk and are provided with supplemental heat for the first few days during winter months before moving to the ACFS. Moving calves into ACFS pens when they are close to their next regularly scheduled meal will facilitate faster adaptation to the ACFS. Average birth BW of Holstein heifers averages 38.6 kg, so developing small and large calf feeding programs using average birth BW to assign calves has some merit. An example feeding curve with whole milk or milk replacer mixed at 130 to 150 g/L is 6 L/d from d 1 to 14, 9 L/d from d 15 to 40, 5 L/d from d 41 to 48, and 5 to 0 L/d from d 49 to 56. Set minimum meal size of 1.5 L to allow calves to feel satiated and minimize aberrant oral behaviors. Set maximum meal size of 3.0 L/meal, so the calf feels full, but not an excessive volume to restrict starter intake. Calves typically average 2.5 to 4.5 meals/d. Start the weaning process early enough so that calves are completely weaned for 7 d before moving out of the nursery. Offer starter grain in troughs inside the calf pen with at least 20 cm of bunk space per calf. Calves will drink more water if it is clean and warm (37°C). Floor drainage and frequent bedding is absolutely critical to success in ACFS barns. Elevated moisture in bedding reduces air quality and insulating properties of bedding, increasing risk of respiratory disease. Add floor drains throughout the pen to capture and drain moisture. Groove concrete with a slope toward drains to increase moisture drainage.

Key Words: automated calf feeder, dairy calf, group housing

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069 Key factors affecting automated milking system performance. J. A. Salfer[1,*], M. I. Endres[2], *[1]University of Minnesota, St. Cloud, [2]University of Minnesota, Saint Paul.*

Automatic or robotic milking systems (AMS) are being adopted by dairy producers in the upper Midwest at a relatively fast rate. AMS allow farmers to milk more cows with less labor and have an improved lifestyle. We collected data from 52 AMS dairy farms in Minnesota and Wisconsin to describe characteristics of AMS systems and to investigate factors that may influence AMS efficiency. Farms were visited once to collect information, and daily data from the AMS was remotely collected for approximately 18 mo. Farms had 2.6 ± 1.6 AMS/farm with a range of 1 to 8 AMS/farm. These data showed that, on average, cows were milked 2.6 ± 0.3 times per day, produced 32.3 ± 6.8 kg of milk per day, and consumed 5.03 ± 0.95 kg of concentrate in the AMS per day. Free flow systems fed more concentrate through the AMS than guided flow systems. A survey of nutritionists working with these farms showed that in free flow herds the partial mixed ration (PMR) was balanced for milk production levels of 4.5 to 13.6 kg less than the herd's average production. For guided flow herds, the PMR was balanced for 4.1 to 9.1 kg less than the average of the herd. Feeding management is suggested to be one of the major factors for success in AMS. Nutritionists ranked palatability of the pellet and consistency of the PMR as two keys for feeding success. The number of cows per robot box was 70.3 ± 14.1, and it was greater for guided flow compared to free flow farms. Milking speed was 2.24 ± 0.40 L/min, and total milk yield per robot unit was 1843.5 ± 490.9 L/day. Total daily milk yield per robot has been suggested to be an important characteristic to assess the efficiency of AMS. An analysis showed that the factors most strongly associated with yield per robot ($P < 0.001$) were milk per cow per day ($r = 0.81$) and average milking speed ($r = 0.76$). Other factors moderately associated ($P < 0.001$) with yield per robot were average concentrate consumed per day ($r = 0.31$) and exit length from the AMS ($r = 0.32$). Further multilevel regression analysis will provide a clearer picture of factors influencing efficiency of AMS in the United States.

Key Words: automatic milking system, dairy cattle, robot

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070 Effects of milk replacer feeding regimen to the pre-ruminant calf on crude protein utilization, digestibility, and growth. C. E. Chapman*, *University of New Hampshire, Durham.*

Traditionally, conventional calf feeding programs have restricted the amount of milk replacer (MR) fed during the preweaning period in an effort to encourage more solid feed intake, minimize the cost of feeding and management, and reduce the potential for diarrhea. More recently, studies have concentrated on ways to improve average daily gain (ADG) in preweaned calves and have demonstrated that calves consuming greater amounts of milk solids, as well as higher protein concentrations in MR, have higher dry matter intakes (DMI), resulting in greater ADG and skeletal measurements. However, these calves consumed less solid feed, which can lead to more stress during weaning and less rumen development, which opposes the goals of the conventional programs described above. These accelerated calf feeding programs capitalize on the rapid and efficient early lean growth potential of calves by allowing for increased body protein deposition without excessive fattening. Feeding programs have been developed that are intermediate in nature to accelerated and conventional programs. These programs result in lesser slumps in growth around weaning

and fewer digestive setbacks than those of more accelerated feeding programs. A study conducted at the University of New Hampshire used calves assigned to 1 of 3 treatments: 1) 454 g of a conventional MR (CON; 20% crude protein (CP), 20% fat), 2) 680 g of a moderately high protein MR (MOD; 26% CP, 17% fat), or 3) 908 g of a moderately high protein MR (AGG; 26% CP, 17% fat). All calves were fed ad libitum starter and water. Calves fed MOD and AGG had greater ADG and feed efficiencies compared to CON calves and similar but lower nitrogen efficiency than CON calves (45.5% vs. 52.7%; $P < 0.05$). This could be due to MOD- and AGG-fed calves having greater urine volume and, thereby, greater urine nitrogen output compared to CON calves (17.6 g/d vs. 12.1 g/d; $P < 0.05$). A similar study conducted at the Nurture Research Center (Provimi) showed that calves fed AGG had lower digestibility of nutrients postweaning, which indicates that postweaning digestion is lower than optimal and contributes to lower postweaning growth in calves fed AGG compared to conventional or MOD programs. In conclusion, calves fed AGG had improved feed efficiency and increased ADG but had reduced starter intake and lower nitrogen efficiency during the preweaning period, as well as reduced digestibility of nutrients during the postweaning period.

Key Words: calf, milk replacer, protein

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071 Potential body site reservoirs for coagulase negative staphylococcal intramammary infection in heifers.

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Coagulase negative staphylococcal (CNS) species are a common cause of subclinical mastitis in dairy heifers. The relationship between body site colonization and intramammary infection (IMI) in heifers is not well understood. The objective of this study was to determine if specific body sites were colonized with the same CNS species and strain type that were causing CNS IMIs in heifers at calving. Primiparous heifers ($n = 100$) at the University of Missouri Dairy were studied. Pre-calving samples were collected approximately 14 d before the expected calving date and included mammary quarter secretions and body site swabbing samples from teats, muzzle, perineum, and inguinal region. Swabbing samples were collected using sterilized electrostatic dusters. At calving, mammary quarter foremilk samples were collected twice, at approximately 3 to 5 and 7 to 9 d postpartum, for culture and somatic cell counting. Swabbing samples were mixed with sterile saline and plated on mannitol salt agar. At 24 h, plates were read, and up to 10 staphylococcal colonies, including at least one of each morphologically distinct type, were saved for characterization. For mammary secretions and milk, 10 μL was plated onto blood agar and primary identification was determined according to the National Mastitis Council guidelines. All staphylococcal isolates were speciated using *rpoB* gene sequencing and/or matrix-assisted laser desorption ionization–time of flight mass spectrometry. Strain typing was done using pulsed-field gel electrophoresis (PFGE). The most common CNS species identified in both prepartum and postpartum mammary secretions was *Staphylococcus chromogenes*. Other common species identified were *S. agnetis* and *S. simulans*. A total of 2357 staphylococcal isolates were recovered from body site samples, and 58% (1360/2357) of these isolates have been speciated. After removing species that were represented more than once per body site sample per heifer, a total of 459 isolates have been characterized. The most commonly identified species from body site samples were *S. chromogenes*, *S. haemolyticus*, and *S. xylosus*. To date, PFGE strain typing has been completed on all *S. chromogenes* isolates from five heifers. Multiple strains of *S. chromogenes* have been identified on all five heifers. *Staphylococcus chromogenes* strains isolated from the mammary gland were found to be 100% similar to a teat skin isolate on 3/5 heifers, to an inguinal isolate on 1/5 heifers, and to a teat skin and inguinal isolate on 1/5 heifers. Final results of this study will further the understanding of the epidemiology of CNS infections in dairy heifers and facilitate future studies aimed at control and prevention of CNS IMI.

Key Words: heifer, mastitis, *Staphylococcus*

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072 Strategies for programming the lactation.

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While the transition period is brief (3 wk before to 3 wk after calving), it is a critical window wherein the relative success of a dairy cow compared with her herdmates is often determined. For example, disease events—such as mastitis, metritis, or metabolic disorders—in the first 3 wk of lactation can program the cow for decreased milk production for a significant proportion of the lactation if they occur. Conversely, it may be possible to program a cow for higher levels of milk production across a lactation. The gender of the calf that is born can influence 305-d milk yield for the ensuing lactation. When 2.39 million lactation records from 1.49 million Holstein dairy cows were analyzed, we demonstrated that cows that gave birth to heifer calves produced greater 305-d milk yields compared to those who gave birth to bull calves. When a subset of these lactation records was analyzed, we found that cows that gave birth to heifer calves in their first lactation had an advantage of approximately 445 kg of milk over the first 2 lactations. Administration of nonsteroidal anti-inflammatory drugs (NSAID) beginning 12 to 36 h following calving also increases 305-d milk production under some circumstances despite the brief administration period. Dairy cattle from a commercial dairy herd in at least their second lactation were randomly assigned to 3 treatments: CON (control; control bolus on d 1 and water drenches on d 1 to 3), MEL (bolus of 675 mg of meloxicam on d 1 and water drenches on d 1 to 3), or SAL (control bolus on d 1 and drenches of 125 g of sodium salicylate on d 1 to 3). Cows who received either

NSAID treatment (MEL or SAL) produced greater volumes of milk on a daily basis beginning at approximately the ninth week of lactation, resulting in greater 305-d milk yield. When dairy cattle on a research dairy in their second lactation and greater received the same SAL treatment in a follow-up study, milk yield did not follow the same response; however, there appeared to be a long-term programming effect on some physiological measurements, and this result was particularly apparent in cows in their third lactation and greater. Overall, these results indicate that, in addition to the prevention of diseases, opportunities are available for both producers and researchers to program increased milk production in a lactation and improve profitability.

Key Words: calf gender, nonsteroidal anti-inflammatory drugs, transition dairy cow

EXTENSION- SWINE

073 Impact of piglet birth weight increase on survivability and days to market, a simulation model. J. Jourquin[1,*], J. Morales[2], C. D. Bokenkroger[3], *[1]Elanco, Antwerpen, Belgium, [2]PigCHAMP Pro Europa, Segovia, Spain, [3]Elanco Animal Health, Greenfield, IN.*

As a result of high prolificacy in sows, piglet birth weight is decreasing by 25 to 35 g per extra pig in the litter while its variability is increasing. Piglets under a birth weight threshold of 1.13 kg are pigs at risk. They have low survival chances and need more days to market. The objective of the simulation model was to determine the impact of individual birth weight increase on survivability and days to 100 kg. From 3 farms located in Spain, 2331 piglets from 178 litters were followed from birth to slaughter or moment of death. Litter parameters were collected. The pigs were weighed at birth, weaning, end of nursery, end of growing, and on the day before the first pigs of the batch went to slaughter. If the pig died, the date, weight, and cause were recorded. The pigs were categorized in increasing birth weight classes of 100 g. For each class, frequency, mortality, and days to 100 kg were calculated. To each birth weight class, 100, 150 or 200 g was added, and the mortality and days to 100 kg were recalculated. Litter size was 14.3 total born and 13.1 live born. The average birth weight was 1.46 kg. Eighty-three percent of the pigs made it to harvest. By increasing the birth weight class by 100, 150, and 200 g, the survival rate would increase to 85.6, 86.6, and 87.6%, respectively, or 0.34, 0.47, or 0.60 piglets per litter. The litter weight at birth would increase from 19.2 to 20.5, 21.1, and 21.8 kg, respectively. Time to reach 100 kg would decrease from 178.7 d to 176.1, 174.5, and 172.9 d, respectively. Preweaning survival chances of pigs at risk (< 1.13 kg) are low (58%) compared to the other piglets (92%). By increasing the birth weight of the piglets proportionally, survivability increases are more pronounced in the low birth weight range, and this could potentially bring the average growth rate down. However, in the model, the time to market still decreased marginally. As a result, more pigs would reach the market without a negative impact on time to market. The model used suggests that increasing birth weight proportionally has a positive impact on survivability without having a negative impact on the number of full value pigs to slaughter.

Key Words: birth weight, days to market, survivability

074 Birth weight threshold for identifying piglets at-risk for preweaning mortality. J. A. Feldpausch[1,*], J. Jourquin[2], J. R. Bergstrom[3], C. D. Bokenkroger[4], J. L. Nelssen[1], M. J. Ritter[4], D. L. Davis[1], J. M. Gonzalez[1], *[1]Kansas State University, Manhattan, [2]Elanco, Antwerpen, Belgium, [3]DSM Nutritional Products, Parsippany, NJ, [4]Elanco Animal Health, Greenfield, IN.*

The association of piglet birth weight (BtW) with early-life mortality risk is strongly supported by research of numerous studies reporting decreased preweaning piglet mortality as individual piglet BtW increases. The purpose of the present analysis was to identify a BtW threshold associated with reduced odds of preweaning survival. Observations from 2 studies with a total of 4068 piglets originating from 394 litters on 4 different commercial farms (3 European, 1 U.S.) were compiled for meta-analysis. Overall preweaning mortality rate across all farms was 12.2%. Data used in the analysis was weight of piglets within 24 h of birth and their corresponding survival outcome (dead or live) by weaning at 3 to 4 wk of age. A mixed effects logistic regression model was fit to estimate the probability of preweaning mortality based on BtW. A random effect of study was included to account for overall differences in mortality between the 2 studies. A piecewise linear predictor was selected to best represent the drastic decrease in preweaning mortality found as BtW increased in the range of 0.5 to 1.0 kg and the less extreme change in preweaning mortality observed for changes in weight above 1.0 kg. The model change point was determined by comparing model fit for BtW ranging from 0.5 kg to 2.0 kg based on maximizing the likelihood. A linear predictor equation was also generated to estimate the associated preweaning mortality probability associated with every 50 g of piglet BtW. Results indicated a 1.11 kg BtW change point in the log odds of piglet preweaning mortality, thus, implicating that every incremental change in BtW below 1.11 kg has a greater impact on mortality risk than incremental changes in BtW above 1.11 kg. Among the farms in this analysis, 14.9% of all piglets had BtW < 1.11 kg. These findings imply that interventions targeted at increasing the BtW of piglets having BtW less than 1.11 kg have tremendous potential to improve piglet preweaning survivability. A large percentage of the neonatal pig population falls below this weight thresh-

old, and postnatal management strategies to decrease neonatal mortality should be directed toward these at-risk piglets.

Key Words: birth weight, piglet, preweaning mortality

075 Early predictors of puberty in gilts.

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The objective of the study was to determine the impact of growth and body composition traits on puberty attainment. Multigenerational records were compiled from PIC Landrace × Large White composite gilts (n = 1573) reared at the NCDA Tidewater Research Station. Females were housed in a curtain-sided building with fully slatted floors and natural ventilation. Sprinklers activated when temperatures reached 27°C. Gilts were placed in pens of 15 (0.84 m^2 per pig). At 130 d of age, each group of gilts was exposed to mature boars for 7 min daily, and estrous behavior was recorded. Estrous detection continued for 90 d. Puberty was defined as first observed standing reflex in the presence of a boar. Traits measured included: birth weight (BWT), weaning weight adjusted to 21 d of age (WWT), backfat depth (BF), loin eye area (LEA), ADG, age at puberty, and whether a gilt obtained puberty (PUB). Backfat and LEA were adjusted to 114 kg. Statistical analysis was performed in SAS using PROC LOGISTIC for categorical variables (PUB) and PROC GLMSELECT for continuous traits (age at puberty). Fixed effects of year and age at boar exposure were included in all models. Average BWT, WWT, BF, LEA, ADG, age at puberty, and PUB were 1.04 kg, 5.0 kg, 1.72 cm, 43.8 cm^2, 622 g, 191 d, and 66% pubertal, respectively. Both BWT and WWT had quadratic associations ($P < 0.01$) with PUB, with low BWT and WWT being detrimental. Greater BF and ADG improved ($P < 0.01$) PUB. Yet LEA did not impact ($P > 0.05$) PUB. Birth weight and WWT were not correlated ($P > 0.05$) with age at puberty. Greater ADG, thicker BF, and smaller LEA were associated ($P < 0.05$) with a younger age at puberty. The proportion of variation explained by each model is shown in Table 075. Of the traits measured, ADG and BF explained the most variation in PUB and age at puberty, respectively. Results indicate developing management strategies to improve gilt growth rate may increase gilt retention.

Key Words: gilt, growth, puberty

Table 075. The proportion of variation explained in PUB and age at puberty

		PUB		Age at puberty	
Trait	No. of gilts	Base model R^2	R^2 with trait	Base model R^2	R^2 with trait
BWT	1573	0.062	0.097	0.046	NS
WWT	1293	0.065	0.078	0.046	NS
BF	1120	0.087	0.123	0.046	0.102
LEA	1120	0.087	NS	0.046	0.052
ADG	1120	0.087	0.195	0.046	0.084

NS = ($P > 0.05$).

076 Using boar feeding patterns and classification trees to predict performance.

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Using feeding patterns to predict performance could allow producers to better sort animals in the finisher to optimize production efficiency. Selecting the correct animals for each market cut is important to maximize the profit from a finishing group. The objective of this study was to examine the predictive ability of a boar's feeding patterns on his growth and feed efficiency performance. Individual feed intake records from 2582 Yorkshire, 2275 Landrace, and 5267 Duroc boars were collected at a single finishing site using Osborne Feed Intake Recording Equipment (FIRE™). Pigs were tested from 11 wk of age to 23 wk of age. Feed intake was recorded every other week on each pig during the 12-wk testing period. The randomForest package in R was used to create 1000 classification trees using feeding patterns to sort boars by quartile for feed intake, feed efficiency (gain/feed), and growth rate in the finisher. The feeding patterns used in this analysis included average number of visits to the feeder per day, average time spent in the feeder per day, feed consumed per visit, the skewness, kurtosis, 95th quantile, and fifth quantile of the feed consumed per visit, and the skewness, kurtosis, 95th quantile, and fifth quantile of the time spent in the feeder per visit. The out-of-bag error rate for feed intake was 37%, 37%, and 36% for Yorkshire, Landrace, and Duroc boars, respectively. Similar out-of-bag error rates were found for feed efficiency and growth rate (62% and 53% for Yorkshire, 58% and 56% for Landrace, and 61% and 53% for Duroc). The feeding pattern variable with the largest mean decrease in accuracy for feed intake was average number of visits to feeder per day for Yorkshire and average feed consumed per visit for Landrace and Duroc. The variable with the largest mean decrease in accuracy for feed efficiency was average feed consumed per visit for Yorkshire and Landrace and average time spent in the feeder per day for Duroc. For growth rate, the variable with the largest mean decrease in accuracy was average feed consumed per visit for Yorkshire and Duroc, and 95th quantile for feed consumed per visit for Landrace. The feeding patterns examined in this study appear to provide little aid in predicting feed intake, feed efficiency, and growth rate in boars; more research should be done to determine if there are other feeding patterns that are more predictive.

Key Words: feed intake, growth, swine

077 *Enterobacteriaceae* counts from livestock truck wash stations offering different service levels located in Iowa. A. M. Danielson[1,*], S. Azarpajouh[1], R. B. Baker[2], C. J. Rademacher[3], J. S. Dickson[1], A. K. Johnson[4], L. A. Karriker[3], T. T. Bigelow[5], K. J. Stalder[1], *[1]Department of Animal Science, Iowa State University, Ames, [2]Department of Vet Diagnostic and Production Animal Medicine, Iowa State University, Ames, [3]Swine Medicine Education Center, Department of Vet Diagnostic & Production Animal Medicine, Ames, IA, [4]Iowa State University, Ames, [5]USDA, APHIS, Des Moines, IA.*

The objective of this study was to determine the overall effectiveness of different washing services at livestock truck wash stations. Eighteen truck washes within Iowa were chosen to participate in *Enterobacteriaceae* count collection using drag swabs. Truck wash services offered were prewash (PW; $n = 78$), post wash with disinfectant (PostD; $n = 78$), and post wash without disinfectant (PostND; $n = 12$). Disinfectant type and application rate differed among several truck washes. In total, 168 drag swabs were collected for this study. Each swab was pre-moistened with double strength skim milk, a saturation medium that enables any particles collected during the swabbing process to be gathered and secured. For single deck trailers, samples were collected on both sides of the floor. On double deck trailers, both sides of the floor on the upper and lower decks were sampled. Collection occurred two times during the wash process, PW (before trailers were washed and scraped if applicable) and PostD or PostND (after trailers were washed and disinfected or not). Swabbing began at the front end of the trailer floor and followed along the designated side for the entire length of the trailer. Swabs were placed in filtered bags, and 10 mL of letheen broth was added. Swabs were processed in the stomacher for 60 s, and 1 mL was transferred from the filtered bag to 9 mL of buffered peptone water and vortexed. Further serial dilutions were made to 10^{-7}. The dilutions were plated onto *Enterobacteriaceae* Petrifilm. After incubating the plates at 37°C, bacteria populations were counted, multiplied by the appropriate dilution factor, and reported as log10 CFU/m^2. Data were analyzed using mixed model methods with a significance level of $P < 0.05$ and trailer as the experimental unit. The model included swab location and type of wash as fixed effects. Swab number was included as a random variable. Prewashed swabs had greater *Enterobacteriaceae* counts when compared with PostD or PostND (5.0 ± 0.4, 2.2 ± 0.4, and 2.7 ± 0.7 log10 CFU/m^2, respectively; $P < 0.05$). There was no difference in log10 CFU/m^2 between PostD and PostND ($P > 0.05$). Additionally, there was no difference in log10 CFU/m^2 between swab locations ($P > 0.05$). Results from this study suggest that current methods for washing trailers are effective in reducing *Enterobacteriaceae* counts. The lack of difference between PostD and PostND may be due to differences in the application rate of disinfectant between truck washes.

Key Words: biosecurity, trailer, truck wash

078 Probabilities of producing feed under nutrient threshold. L. Fab[1,*], D. Sol-Oriol[1], L. Blavi[1], M. Farrè[2], J. Gasa[1], *[1]Animal Nutrition and Welfare Service, Department of Animal and Food Science, Universitat Autònoma de Barcelona, Bellaterra, Spain, [2]Department of Mathematics, Universitat Autònoma de Barcelona, Bellaterra, Spain.*

Producing feeds precisely is tied to the variation of the actual composition of feed ingredients. The present study was performed to assess the impact of disregarded variability of feed ingredients at two situations: formulating with table values or medium-term average values. In the first place, samples from different batches of ingredients were collected along 5 mo (wheat = 134, corn = 133, barley = 128, wheat middlings = 55, soybean meal = 49, and rapeseed = 31) at a feed mill, and chemical composition was analyzed by NIRS while lysine (LYS) and metabolizable energy (ME) were estimated. Second, two similar diets (C and V), including those ingredients, were formulated for growing pigs (3175 kcal/kg, 15% CP and 0.9% LYS), first using ingredient information from reference tables (diet C, 30.0, 22.3, 20.8, 10.0, 6.6, and 6%, ingredients, respectively) and, second, formulated by using average nutrient values in the collection period (diet V, 30.0, 15.8, 26.6, 10.0, 8.4, and 6.0%, respectively). Simulating unconcern of ingredient variability, a resampling procedure was used to create 10^7 combinations of the 6 ingredients among collected samples. Those batch combinations were then applied to both diets (C and V) to calculate the nutrient content at each combination and diet (resultant feeds). This way, it was possible to estimate the probabilities of producing final feed batches over and below specific thresholds in both situations. Ingredient nutritional variability (coefficient of variation, CV %) was highest for crude fiber (2.6 to 18.3%), followed by crude protein (CP) (2.0 to 8.2%), LYS (2.1 to 5.7%), and ME (0.9 to 6.0%). Comparing between diets, V had a higher proportion of resultant feeds closer to nutrient specification than C. Regarding ME, the C diet showed that 28% of the feeds were below 3150 kcal/kg and 2% below 3120 kcal/kg, whereas for V formula only 7% were below 3150 kcal/kg. For the C diet, 31% showed CP content below 14%, and even 7% were below 13.7% CP, while V had a lower proportion under the same thresholds (0.1 and 0%). It is required to increase the threshold up to 14.5% CP to find a 7.8% under this requirement. Similarly, for LYS content, 18.7% of the resultant feeds were below 0.87% in the C diet whereas none were for V. Contrarily, the V diet showed 14% of the feeds above 0.92% LYS. In conclusion, ingredient variability affects the accuracy when producing feeds whether ingredient information for formulating is based on table values or using medium-term average values; nevertheless, those average values could increase the probabilities of producing feeds more precisely, between 19 and 31% depending on the nutrient.

Key Words: efficiency, feed ingredients, variability

079 Identification of the range of hock angles in replacement gilts. J. M. Mumm[1,*], K. J. Stalder[1], J. D. Stock[1], J. C. M. Dekkers[2], J. A. Calderon Diaz[1], *[1]Department of Animal Science, Iowa State University, Ames, [2]Iowa State University, Ames.*

Objective measurement of joint angles is becoming increasingly important for gilt selection and sow longevity. It has been reported that small hock angles are related to sow longevity, but the range of angles is unknown. The objective of this study was to identify the range for hock angles and possible differences in hock angulation within the entire gilt population divergently selected for residual feed intake (RFI) at Iowa State. Yorkshire gilts from the 10th generation of Iowa State University's RFI lines (low RFI, $n = 25$, and high RFI, $n = 27$) were moved to a pen where digital images (still pictures) of the gilts' profile (left or right) were captured while walking to measure hock angles while the leg moved forward and backward and while the gilt stood squarely. On average, 9 images were used per gilt. Hock angles were measured by tracing the front and back of the joint between the fibula/tibia and tarsals, with the anterior and posterior positions acting as the anchor. Gilts were classified as lame and non-lame. If lame, affected limb(s) were recorded and images for only the sound leg were used. Flank-to-flank measurement was recorded to estimate BW. Data were analyzed using mixed model methods with side (left or right), leg position (forward, standing, backward), RFI line, leg position × RFI line, and lameness classification included as fixed effects. Estimated BW was included as a linear covariate. Gilt was included as a random effect. Fifty percent of gilts were lame (70.4% and 28.0% from the high and low RFI lines, respectively); it is important to note that none of the animals were severely lame. There were no differences between left or right hock angles ($P > 0.05$) or between lameness classifications ($P > 0.05$). Additionally, BW was not a significant source of variation ($P > 0.05$). Hock angles differed between leg positions ($P < 0.0001$). Average hock angles were 141.7 ± 1.2, 133.4 ± 1.2, and 147.0 ± 1.16 degrees when the leg was positioned forward, standing, and backward, respectively. Low RFI gilts had wider hock angles when their leg was positioned backward than high RFI (151.3 vs. 142.71 ± 1.5 degrees; $P < 0.0001$). There was no difference between RFI lines when the leg was positioned forward or standing ($P > 0.05$). In conclusion, there is a measureable difference in hock angulation while the leg is in different positions. Although hock angles differed between leg position and RFI line, it's unclear if these differences are biologically important.

Key Words: feet and leg conformation, gilts, hock range

080 Evaluation of the inter-scorer reliability of body and leg conformation traits in replacement gilts. S. Azarpajouh[1,*], J. M. Mumm[1], J. A. Calderon-Diaz[2], *[1]Department of Animal Science, Iowa State University, Ames, [2]Iowa State University, Ames.*

Visual scoring systems are commonly used to select replacement gilts with the most desirable body and leg conformation traits. Although visual scorings are easy to implement, their reliability depends on the training and the experience of the observers. The objective of this study was to evaluate the agreement between two inexperienced scorers for body and leg conformation traits. Twenty-two Yorkshire gilts were visually scored once for body and leg conformation traits by two inexperienced scorers. Front and rear pasterns, hip structure, and rib shape were evaluated using 5-point scales, where 1 and 5 indicate the extreme phenotypes of the traits. Front and rear toe evenness and front and rear foot size were scored using 3-point scales. The scoring system was explained to the inexperienced scorers by a trained observer. Due to the low number of gilts receiving extreme values, conformation traits were reclassified as 1 = desirable conformation and 0 = suboptimal conformation. A kappa statistics test was used to measure the level of agreement between scorers. A moderate level of agreement, beyond that expected by chance, in the scores assigned to the rear pastern (kappa = 0.47; $P < 0.05$) and a substantial agreement in the scores assigned to the front pastern and hip structure (kappa = 0.64 and 0.79, respectively; $P < 0.05$) were observed. Scorers agreed 100% on the scores assigned to rear foot size and front toe evenness, but they did not agree on the scores assigned to the rear toe evenness (kappa = 0.18; $P > 0.05$). Although inexperienced with the scoring system, the two scorers showed a high level of agreement in the scores assigned to the majority of traits. The reason that scorers had a lower level of agreement on rear pastern score and that they did not agree in the score for rear toe evenness may be related to the fact that such body areas are more difficult to observe. It is possible that with more training, kappa statistics for such traits could improve.

Key Words: body and leg conformation traits, inter-scorer agreement, replacement gilts

081 Comparison of digestible amino acids databases: relationship between amino acid digestibility and concentration in swine. D. J. Bloxham*, M. J. Azain, G. M. Pesti, *University of Georgia, Athens.*

Databases comparing total amino acid (AA) profiles and standardized ileal AA digestibility (SID) values of 20 feedstuffs commonly fed to pigs from two sources, Evonik (Kennesaw, GA) and the Nutrient Requirements of Swine published by the National Research Council (NRC; Washington, DC) were used to observe AA concentration effects on digestibility values. Both databases reported SID swine values. The number

of AA values depends on the ingredient. The 20 feed ingredients were compared from each database and were analyzed using PROC CORR and GLM procedures of SAS (version 9.4; SAS Inst. Inc., Cary, NC). When both databases were compared in their entirety, there was a positive correlation of 0.362 for the Evonik database and 0.349 for the NRC database ($P < 0.0001$) with increasing total amino acids vs. SID digestibility. There were also differences between feed ingredients in the Evonik and NRC databases ($P < 0.0001$). There were differences in SID of animal and plant sources ($P < 0.001$). When only essential AA were compared, there were positive correlations of 0.353 and 0.455 for the Evonik and NRC databases, respectively ($P < 0.0001$), of total AA to SID digestibility. There was a trend for differences between plant and animal feed ingredients when essential AA were being compared ($P < 0.10$). Four essential AA were analyzed separately across feedstuff: Lys, Met, Trp, and Thr. Lysine in both databases had a correlation with increasing total lysine and increasing SID (0.556 and 0.618; $P < 0.01$) for the Evonik and NRC databases, respectively. Methionine also had increasing SID with total AA with a correlation of 0.577 and 0.666 ($P < 0.01$) for the Evonik and NRC databases, respectively. Methionine also had differences in SID in plant vs. animal sources ($P < 0.05$). Tryptophan had a correlation of 0.435 ($P < 0.06$) for the Evonik database, while the NRC database had a correlation for Trp of 0.544 ($P < 0.01$) of increasing SID with increasing total Trp. Threonine had a correlation of 0.390 ($P < 0.09$) for the Evonik database and 0.505 ($P < 0.05$) for the NRC database of total Thr vs. Thr SID digestibility. From this data, a predictor of AA digestibility is AA concentration of the feedstuff. The digestibility of AA in the feedstuff should be a property of the feed ingredient and not the concentration of AA in the feed ingredient. Differences in databases will change the cost of diet formulation. The database that is used to formulate amino acid profiles could affect the performance of the pig because of differences between databases.

Key Words: amino acid, concentration, digestibility

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082 Blood parameters as piglet health biomarkers in an experimental infection with *Salmonella* spp.

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Weaning is a critical period for commercial pigs, and very little is known about the potential use of traditional blood parameters (BP) to evaluate their response. The aim of this study was to evaluate the potential use of different BP as indicators in an experimentally controlled range of weaning distresses: piglets infected or not with *Salmonella*, aiming to provoke a dysregulation of electrolyte and acid-base balance, and treated or not with a probiotic combination of *Bifidobacterium* spp., aiming to ameliorate their outcome. Seventy-two piglets (28 d old) were divided into 4 groups in a 2 × 2 factorial design with animals daily treated or not with probiotic (10^9 CFU/g) and orally challenged or not with *Salmonella* Typhimurium (5×10^8 CFU) a week later. Four days after the challenge, blood samples of the middle-weight animal of the pen ($N = 24$) were collected for the following analysis: glucose (Glu), anionic interval (Anion Gap-AG), potassium (K^+), sodium (Na^+), chloride (Cl^-), hemoglobin (Hgb), hematocrit (Htc), pH, partial pressure of oxygen (PO2) and carbon dioxide (PCO2), base excess (BE_{ecf}), total carbon dioxide (TCO2), bicarbonate ($HCO3^-$), Zn, Fe, and Cu. Results corroborate the existence of marginal deficiencies of Zn at weaning (0.6 ± 0.05 mg/L vs. normal range of 0.7 to 1.5 mg/L). Plasmatic Zn showed positive correlation with weight gain more evident in non-challenged animals ($r = 0.73$; $P = 0.037$), and Cu had a negative correlation with bodyweight gain ($r = -0.67$; $P = 0.001$). Blood electrolytes decreased in animals with the lowest weight gain (124 vs. 138 mM, $P < 0.001$ for Na^+; 4.6 vs. 5.8 mM, $P < 0.001$ for K^+; 94 vs. 107 mM, $P = 0.110$ for Cl^-) where performance of the animals was compromised and clinical symptoms were more apparent. Acid-base balance parameters such as $HCO3^-$, TCO2, and BE_{ecf} were correlated with weight gain but only in the challenged animals ($r = -0.53$, $P = 0.031$; $r = -0.55$, $P = 0.028$; and $r = -0.51$, $P = 0.044$, respectively) suggesting metabolic acidosis depending on the level of *Salmonella* infection. Furthermore, Htc and Hgb concentrations increased with the challenge (14.7 vs. 22.9%; $P = 0.005$ for Htc and 5.0 vs. 7.8 g/dL, $P = 0.006$ for Hgb), decreased with the probiotic treatment (21.7 vs. 15.8%, $P = 0.030$ for Htc and 7.38 vs. 5.39 g/dL for Hgb, $P = 0.030$), and had negative correlations with weight gain ($r = -0.42$ and -0.41 for Htc and Hgb; $P = 0.048$). Overall, BP can be easy in-farm sensible indexes to assess performance and health, being potentially useful in experimental designs aimed to evaluate feed strategies in weanlings.

Key Words: blood biomarkers, *Salmonella*, weaning piglets

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083 Initial use of statistics to be used to quantify the magnitude errors in the sorting on three finishing barns.

Y. Que*, F. A. Cabezon, A. P. Schinckel, *Purdue University, West Lafayette, IN.*

The objectives were to use actual data to evaluate methods to quantify the amount of error in the estimated BW for market pigs and its impact on the mean and SD in carcass weight (CW) and sort loss. Data from three grow-finishing barns

of pigs were obtained which included harvest dates, CW, sort loss, date ractopamine (RAC) feeding was initiated, and pigs' birth dates. Pigs were sold in three cuts with multiple marketing days for each cut. The increased CW gain for RAC was estimated as 0.138, 0.112, 0.086, and 0.069 kg/d for each 7-d period of RAC feeding. The increase in BW gain was estimated as the increase in CW gain/0.95. Each pig's BW was estimated as $(CW/0.721)^{0.99394}$. BW data were fitted to a Michaelis-Menten (GMM) equation with the values for K and C fixed at 191.5 d and 2.221. The mean value for WF and pig-specific random effects were solved for. The BW was estimated for each pig at each marketing day using the GMM equation including each pig's random effect (deviation from the mean WF value). Three marketing error rates for BW were evaluated with no error (based on predicted BW's), actual and random sorting. Statistics were calculated, including mean and SD for BW and CW, sort loss, and percentage of pigs sold correctly, for each cut. The magnitude of the sorting errors was estimated as the pig's BW minus the cut-off BW for that day. The overall means for CW were 95.7, 100.9, and 91.2, and SDs of 7.6, 8.8, and 7.4 kg. With no error, the estimated means were 95.5, 100.7, and 91 kg with SDs of 4.6, 4.6, and 4.3 kg. The actual SDs of CW for the second cut were 6.6, 8.9, and 6.0 kg, without error estimated as 1.9, 1.5, and 1.8 kg. The mean CWs for the first cut were 3 to 4 kg greater and for the third cut 3 to 4 lesser with predicted accuracy versus actual sorting. The percentage of pigs sold correctly for the first two cuts were 56, 48, and 52% and difference in sort loss ($/pig) were 1.22, 5.74, and 0.56 for each barn. The level of accuracy in sorting pigs for market effects the distribution of CW and affects sort loss when the pigs have CWs close to the upper acceptable range. The accuracy of sorting pigs for market can be evaluated from currently available data.

Key Words: carcass weight variation, marketing, pork, sorting accuracy, sort loss

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084 Evaluation of statistics to be used to quantify the magnitude errors in the sorting of pigs for market via simulation. F. A. Cabezon, A. P. Schinckel*, Y. Que, *Purdue University, West Lafayette, IN.*

The BW growth curves for 25 4000-head finishing barns were simulated to (1) evaluate methods to quantify the errors in the estimation of BW for market pigs from available data, and (2) estimate the impact of sorting errors on the mean and variance in BW and carcass weight (CW). Two types of errors were evaluated, BW estimation error (BWEE) and percentage of pigs not evaluated (unseen). Four levels of BWEE with SDs of 0, 4, 6, and 8% of BW and four levels of unseen (0, 8, 16, and 24%) were simulated. Pigs were marketed in 3 cuts, 25% at 169, 25% at 179, and the remaining 50% at 193 d of age. The percentage of pigs sold correctly for each cut was determined. Two types of sorting errors, pig not marketed that should have been or pig marketed that should not have been were evaluated. The magnitude of the sorting errors was estimated as the pig's BW minus the cut-off BW for that day. The values of variables associated with the marketing simulations runs were fitted to a model including the fixed effects of marketing cut (CUT, first, second, or third), BWEE, unseen, their interactions, and random effect of replicate barn using the mixed procedure of SAS. Increased BWEE and unseen decreased ($P < 0.001$) the mean CWs of the first cut, had smaller impacts on the second cut, and increased ($P < 0.001$) the mean CWs for the third cut. The SDs for CW, percentages of pigs sold correctly and sort loss were affected ($P < 0.001$) by the main effects of CUT, BWEE, and unseen, and all possible interactions. The SDs for CW for the second cut increased from 2.69 kg with no error to 6.83 kg with 8% BWEE and 24% unseen. As the BWEE or unseen increased, the percentage of pigs sold correctly decreased, especially for the second cut. Statistics which quantify the accuracy of sorting are: (1) percentage of pigs sold correctly, (2) magnitude of the errors for pigs sold incorrectly, (3) distribution of the sorting errors (positive and negative values) for the first two cuts, and (4) the SDs for CW for pigs of the second cut. These statistics can estimated from currently available data to quantify the accuracy of sorting market pigs. Sort loss was not a consistent indicator of the accuracy of sorting.

Key Words: marketing, pig supply chain, pork, sort loss, stochastic model

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085 Analysis of lactation feed intakes for sows including data on environmental temperatures and humidity. F. A. Cabezon[1,*], A. P. Schinckel[1], B. T. Richert[1], K. R. Stewart[1], M. Gandarillas[2], W. A. Peralta[3], *[1]Purdue University, West Lafayette, IN, [2]Universidad Austral de Chile, Valdivia, Chile, [3]Agrìcola Super Ltda, Rancagua, Chile.*

Daily feed intakes of 565 lactation records were evaluated for sows of two genetic lines, PIC C-22 and L-42. Sows were fed ad libitum during the entire lactation period (Avg. = 20.9 d). Sows were fed a corn-soybean meal based diet (3.32 Mcal ME/kg) supplemented with either 0% or 0.3% betaine-HCl (70.7% betaine). The daily feed intake (DFI) data were fit to generalized Michaelis-Menten (GMM) functions of day of lactation. The GMM function has the form: $DFI_{i,t}$ (kg/d) = $DFI_0 + (DFI_A - DFI_0)(t/K)^C/[1 + (t/K)^C]$ where DFI_A is asymptotic daily feed intake, DFI_0 is predicted daily feed intake at Day 0, t is days of lactation, K is a parameter equal to the day of lactation at which one-half of the increase from DFI_0 to DFI_A is achieved, and C is a unitless parameter. The GMM function with two random effects for maximal daily feed intake (dfi_{Ai}) and intercept (dfi_{0i}), with K as a linear function of dfi_{0i}, provided the best fit to the daily feed intake ($R^2 = 0.474$). $DFI_{i,t}$ (kg/d) = $(4.12 + dfi_{0i}) + ((7.85 + dfi_{Ai}) - (4.12 + dfi_{Ai}))(t/(4.865 - (2.27\ dfi_{0i})))^{1.60}/[1 + (t/(4.865 - (2.27\ dfi_{0i}))^{1.60}]$. The addition of a single covariate including daily degree-hours above 24°C (DGH24) or daily maximum temperature (MaxT)

of the current day were significant ($P < 0.001$). Furthermore, the addition of a second covariate as the prior day DGH24 and MaxT to the single covariate models with current day DGH24 and MaxT were significant ($P < 0.001$). The addition of dewpoint to the model with a temperature covariate (DGH24 or MaxT) was not significant ($P > 0.51$). No genetic line differences were found for the random effects dfi_{0i} and dfi_{Ai}. Betaine supplemented sows had a 0.27 kg greater mean for the dfi_{Ai} random effect ($P = 0.004$). Parity by treatment interactions were significant for dfi_{Ai} ($P = 0.006$). Greater DFI was found at the end of lactation in betaine supplemented parity 1 and parity 2 sows ($P = 0.012$ and 0.005, respectively). Parity was significant for both random effects ($P < 0.001$). Parity 1 sows consumed 91.2% and 85.6% of DFIs compared to parity 2 and 3 to 5 sows, respectively. Sows were managed to allow greater maximal DFI, and variation in DFI in early lactation and variation for dfi_{0i} than previous studies. As temperature increased above 24°C, DFI decreased; however, humidity did not impact sow lactation DFI in this study.

Key Words: environment, feed intake, lactation, random effects, sow

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086 Alternative method to accurately predict the sows' body weight in early gestation. S. Lûpez-Vergè, L. Blavi*, D. Sol-Oriol, J. Gasa, *Animal Nutrition and Welfare Service, Department of Animal and Food Sciences, Universitat Autònoma de Barcelona, Bellaterra, Spain.*

When managing gestating sows, body weight (BW) increase and/or variation may be a better index of body reserves evolution than body condition score (BCS) itself. Measuring or accurately predicting BW during early gestation just before moving animals to the courtyards of gestation may be an easy method to better define the subsequent feeding program. To measure a sow's BW is a hard job since it requires a scale, and it is not currently implemented in commercial conditions. Instead, measures like heart girth (HG), flank to flank (FF), back fat thickness (BF), and muscle (MUSC) are potentially good predictors of BW. Furthermore, all of these measures are easy to collect (rather than weighing animals), especially when sows are individually placed the first 35 d of gestation. Our objective was to propose a method to correctly predict the sows' BW in the first month of pregnancy (instead of the use of the BCS) to define an adequate feeding program during gestation. A total of 110 Landrace × Large White (L×LD) sows were used. At Day 35 of gestation, all measures were done for each sow. For the HG and FF, we used a measuring tape (in cm); BF and MUSC were measured by ultrasound ecography (in mm). All data obtained were fitted to a multiple regression model (MLR) by using the REG procedure of SAS. Parity was included as a qualitative variable (1: parity from 1 to 2; 2: parity from 3 to 10). The variables BF and MUSC were found not significant so were removed from the model. The FF was also discarded since their correlation with BW was lower than that obtained with the HG; besides, the change in the R^2 of the model was negligible. The final equation was BW35d = −221.83 + 3.12*HG + 27.18*PARITY(2). The RMSE was 13.24 and R^2 was 0.92. The average BW was 233.9 kg, ranging from 134.5 to 320 kg. The range for the HG was 114 to 168 cm. To conclude, the HG is easy to obtain and was found to be a good predictor of sows' BW during the first 35 d of gestation. This BW prediction could help to better adjust the feeding program of the sows just before moving them to the courtyards of gestation rather than using BCS. Finally, a specific equation must be fitted taking into account the particular genetic line and populations of each farm.

Key Words: heart girth, prediction, regression

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087 Influence of Amaferm® Digest More® on swine lactation performance. S. J. Moeller*, M. B. Hess, *The Ohio State University, Columbus.*

The objective was to assess the influence of the dietary addition of *Aspergillus oryzae* (Amaferm® Digest More® at 45 g per head per day, delivering 5.5 g of Amaferm as a single daily top dress) on female and litter characteristics. Thirty three ($n = 16$ control-fed (C) and $n = 17$ Amaferm®-fed (AM)) commercial crossbred (Topigs® × PIC® Maternal; ~3/4 Yorkshire, ~1/4 Landrace) females were randomly allocated at Day 70 of their first gestation in two replicates (Rep 1, $n = 17$; Rep 2, $n = 16$) separated by 6 wk. Treatment allocation continued through confirmation of pregnancy status for the third litter, failure to mate in the predefined 10-d rebreeding window, or removal due to locomotion or well-being considerations. Of the 33 females allocated, 21 weaned a second litter ($n = 12/17$ AM, and $n = 9/16$ C), producing a total of 54 litters. Individual females served as an experimental unit. Treatment (AM and C) and parity (1 and 2) were fixed effects, and replicate was a random effect in mixed-model analyses, with LS Means adjusted for multiple comparisons. Linear covariates for number of piglets allowed to nurse (Avg. = 11.6 pigs) and age at weaning (Avg. = 19.4 d) were included in litter weight measures. Number of pigs born alive and litter birth weight were not different for treatment or parity; however, following cross-fostering to maintain equal opportunity, by d 7 there was a trend ($P = 0.06$) for females fed AM to be nursing more piglets (11.2 vs. 10.4), and by d 14 (11.1 vs. 10.2; $P = 0.04$) and at weaning (11.1 vs. 10.2; $P = 0.04$), AM females maintained more viable pigs. Given a larger litter number at weaning, AM females tended to wean a heavier litter (69.5 vs. 62.9 kg; $P = 0.08$) with no difference in average pig weight at a standard weaning age (6.18 kg; $P = 0.77$). Lactation feed intake did not differ between AM and C females between farrow and d 7 (32.4 vs. 33.7 kg; $P = 0.54$), d 8 and d 14 (42.3 vs. 41.5 kg; $P = 0.79$), and total (115.9 vs. 111.3 kg; $P = 0.43$); however, between d 15 and weaning, AM females consumed more feed than C (43.0 vs. 35.7 kg; $P = 0.03$). Colostrum and

milk analyses at weaning were not different for IgG, IgM, or IgA levels. Blood lactate (2.74 vs. 3.75 mM; $P = 0.04$) and L-lactate (2.72 vs. 3.73 mM; $P = 0.04$) fraction levels were less at weaning in AM females. Findings suggest additional replication to further validate AM effects.

Key Words: feeding, nutrition, swine

088 Evaluation of medium-chain fatty acid salts or *Enterococcus faecium* in front of a *Salmonella* Typhimurium challenge in piglets. J. J. Mallo*, *Norel SA, Madrid, Spain.*

The objective of this study was to evaluate the efficacy of sodium salts of distilled coconut fatty acids (DICOSAN; Norel S.A.) or *Enterococcus faecium* (FECINOR; Norel S.A.) against a *Salmonella* Typhimurium challenge in weanlings. A total of 72 4-wk-old piglets (8.1 ± 1.34 kg) were distributed into 24 pens and 3 experimental groups: plain diet (CTR) or the same diet supplemented with DICOSAN (DIC; 0.3%; minimum content of lauric acid 37%) or FECINOR (FEC; 0.1% equivalent to 10^6 cfu/g), all offered ad libitum. Intake and live weight were monitored along 15 d. After 1 wk adaptation, animals were orally challenged with *Salmonella* Typhimurium (10^8 cfu), and rectal temperature and fecal consistency were evaluated afterward. Fecal samples for *Salmonella* analysis were taken at d 0 and 7 before inoculation and on 1, 3, and 7 post-inoculation (PI). On d 4 and 8 PI, one animal per pen was euthanized and cecal content sampled to evaluate *Salmonella* counts. Performance, microbiological parameters and lme4 package for fecal consistency and rectal temperature were analyzed using R statistical analysis software. All of the animals showed *Salmonella* in feces 24 h PI and fever 48 h PI. No significant differences were seen on performance although ADG were numerically higher in the FEC fed animals at 4 to 8 d PI (326, 316, and 400 g/d for CTR, DIC, and FEC; $P = 0.57$). FEC treatment also improved numerically fecal consistency especially at d 2 PI when differences reached statistical trend ($P = 0.10$). Regarding microbial counts, no significant differences were seen in fecal but in cecal samples between treatments. The use of DIC resulted in a trend to diminish *Salmonella* counts at d 8 PI ($P = 0.06$) compared to CTR and FEC, effectively reducing ($P = 0.04$) the number of animals (3/8 vs. 7/8 animals) with countable bacteria ($> 10^3$ cfu/g). Results suggest a more general effect of the probiotic on the animal response to the challenge and a more specific antibacterial effect of medium-chain fatty acid salts in the intestinal lumen that could help to control the overgrowth of *Salmonella*. More studies are required to better characterize the mechanisms of action of both additives.

Key Words: *Enterococcus faecium*, medium-chain fatty acid salts, *Salmonella* Typhimurium

GARY ALLEE AMINO ACID SYMPOSIUM

089 Challenges of shifting consumer demand in the pork processing industry. C. Kaster*, *Smithfield Foods, Kansas City, MO.*

The pork processing industry continues to evolve from a commodity based, high volume, and undifferentiated business to one with greater emphasis on further processed, branded, and specialty programs. Our suppliers' pork production systems are still largely designed as commodity businesses where size, scale, and uniformity are cherished. Many of our wholesale and retail buyers are demanding exclusive products to drive customer traffic while telling a story. Meanwhile, many consumers want a greater understanding and input of where, when, and how their purchases are grown, managed, and processed. The challenge facing the pork processing industry is finding the right balance between end users and producers of pork.

Key Words: pork, processing, swine

090 Electronic sow feeding (ESF): the lemonade of pen gestation. T. D. Parsons*, *Department of Clinical Studies, School of Veterinary Medicine, University of Pennsylvania, Kenneth Square.*

Scientific evidence remains equivocal with regard to what is the best way to house gestating sows. However, 9 U.S. states have joined the precedent of the European Union and instituted legislation to phase out the use of gestational stalls. Concurrently, sixty or more large national companies in the retail and food service industry have pledged to eliminate gestation stalls from their supply chain over a 5 to 10 yr time horizon. Several packers have also committed to moving some or all of their company owned sows out of stalls and in some instances have also signaled a similar intention for those that supply them with fat hogs. Furthermore, in Canada, a new code of practice was released in July of 2014 that also places restrictions on the use of gestation stalls. Thus, if a producer plans to build new sow facilities and/or plans to stay in the business long enough to recapitalize their existing sow facilities, they will likely need to confront the decision about whether to continue to work with gestation stalls or explore what is the best option for pen gestation. While many producers are expressing concern, anxiety, and even anger today given the possibility of having to transition from gestation stalls to pen gestation, the goal of this paper is to address some of the possible upside potential available from selected pen gestation options. In particular, electronic sow feeding (ESF) provides the opportunity to capture many advantages previously unrealized in the feeding and management of gestating sows. Individual sows are uniquely and electronically identified with a radio-frequency-identification (RFID) tag. Sows enter the feed station one

at a time, their tag is read and they are fed their specified allotment for the day. ESF is the only alternative to gestation stalls that provides true individual animal nutrition. However, this paper will make the argument that ESF is actually a better way to feed an individual sow than a gestation stall. In particular, ESF provides unique opportunities for managing the gestating sow through improved approaches to feed utilization, meeting her nutritional needs, estrus control, individual animal care, and autogenous immunization. Specific examples of each of these opportunities will be discussed in detail.

Key Words: electronic sow feeding, nutrition, pen gestation

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091 Crate-free sow housing and electronic feeding systems: a value proposition for improved sow nutrition. O. F. Mendoza*, A. M. Gaines, *The Maschhoffs, LLC, Carlyle, IL.*

The subject of conventional crated housing systems for sows during the gestation period has been a point of debate driven by societal concerns over animal welfare to the extent that several countries, including some states in the U.S., have been instituting legislature to limit the use of gestation stalls or crates within the next decade. Furthermore, major national and international food companies are establishing policies that would require their pork supply chain to be crate-free, prompting modern sow production operations to look at alternative housing systems, even though, there is no clear scientific evidence that crate-free systems are better, with the different systems presenting advantages and disadvantages. Nevertheless, one of the alternatives to the gestation stall is crate-free group housing with electronic sow feeding (ESF) systems. Variations in these types of systems exist, but most of them present opportunities to improve nutritional programs as compared to gestation stalls or other group housing systems. Individual feeding management of sows is possible with ESF, in which sows visit a feeding station and are fed after they have been recognized by a computer system. A limitation of conventional feeding systems is the inability to establish differentiated feeding program for sows based on either stage of gestation and or parity. This now becomes a practical option with ESF, which allows for more precise delivery of feed to the individual sow with the potential to better match nutrient requirements as the sow progresses through the pregnancy period resulting in reduced feed wastage, cost efficiencies, and adequate body reserves to withstand successfully the upcoming lactation periods, thus increasing longevity in the herd. Another advantage of ESF systems is the ability to collect data on all sows on a "real-time" basis, which allows timely identification of sows needing special attention and provision of individual care. Moreover, ESF systems become effectively a data collection system that could allow for a continuous research setting overcoming some of the limitations of sow nutrition research. Additionally, targeted delivery of feed additives, micronutrients, hormone technologies, or autoimmunization material during specific time windows that would require manual labor in crated systems is now possible with minimal labor through the use of an ESF station. As the swine industry continues to adapt in regards to sow housing options, we need to continue to challenge practical feeding programs and evaluate the possibilities that ESF systems have opened for improved sow nutrition.

Key Words: housing, nutrition, sow

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092 Exploring connections between metabolic profiles, stress responses, and immune function. J. A. Carroll*, N. C. Burdick Sanchez, P. R. Broadway, *USDA-ARS, Livestock Issues Research Unit, Lubbock, TX.*

Livestock production faces new challenges as current and pending legislation and media propaganda seeks to alter current management practices. Therefore, researchers and producers must search for alternative management strategies to mitigate possible negative effects associated with these regulatory changes. While the effects of stress on immune function have been studied in considerable detail, there are unexplored factors that influence immune function and animal health. Implementing new health management and nutritional protocols will require a more in-depth understanding of the biological system of an animal, especially related to how nutrition influences the immune system and overall health of the animal. Nutritional immunology will most likely become a central theme as livestock producers explore opportunities to improve animal health and performance in production facilities. This will require a greater multidisciplinary scientific approach to understand how the metabolic status of an animal may influence aspects of the immune system from cellular signaling to antibody generation. There will need to be an increased effort associated with understanding the nutrient requirements associated with maintaining a healthy immune system as well as understanding the nutrient requirements of an animal undergoing or recovering from an immunological challenge. There will need to be more focus on understanding the differential programming of animals as it pertains to nutrient partitioning and energy utilization and why some animals are more resilient to immunological insults while some animals are more susceptible. Exploring and understanding prenatal and perinatal strategies for preprogramming the immune system to improve postnatal health will allow for new opportunities for improving overall animal production. Understanding how energy availability and whether endogenous (e.g., genetic selection of animals) or exogenous sources (e.g., dietary supplementation) can be an effective mediator of immune function not only to reduce the severity of animal diseases but also how it can be utilized to enhance recovery and restore homeostasis is of importance. While there will undoubtedly be multiple challenges ahead for livestock producers, there will also be exciting opportunities.

Development of "designer diets" that contain various pre and/or probiotic compounds or specific combinations of nutrients that are specific not only for different management systems and different stages of production but also for targeting specific pathogens, will undoubtedly reveal novel nutritional strategies for improving future livestock production.

Key Words: immunity, metabolic profiles, stress

093 Production specific marketing programs: what do they mean for nutritionists and how do we adapt?
M. J. Bertram*, *First Choice Livestock, Urbandale, IA.*

With increasing consumer interest in the origins and production history of meat and the emergence of the "foodie" movement, packers and retailers have begun to implement numerous marketing programs that tout perceived benefits of specific production practices, animal health programs, nutritional strategies, and ingredient exclusions that limit products that are commonly used in conventional pork production. Some of the programs that have been proposed include antibiotic free, organic, non-mammalian, and vegan feeding regimens. These programs are often nebulous in nature, lacking regulatory definitions, and can be subject to changing consumer sentiment. It is imperative for producers to seek clarification of program requirements and evaluate and weigh potential production losses and cost increases against the value generated via niche marketing. Additionally, the value of these programs are often only captured on the higher value cuts of meat while the increased cost is associated with all cuts including offal. To minimize production losses and cost increases begins with an adequate biosecurity and vaccination plan to prevent disease exposure along with the use of nontraditional ingredients to maintain intestinal integrity and positive microbial balance during the critical high stress post-weaning period. Some of these ingredients include prebiotics, probiotics, acidifiers, botanicals, yeast products, enzymes, fermented, isolated, or enzymatically treated soy products, and purified vegetable proteins. With conventional diet matrices and production practices, many of these products game inconsistent and variable responses. However, as we eliminate many of the ingredients that have allowed us to wean younger pigs, the utility of these products may become more necessary. It will also become necessary to understand the situations where these products work and also where they do not work.

Key Words: niche markets, nutrition, pork

GRADUATE STUDENT COMPETITION: MS ORAL

094 Effect of harvest method on corn residue quality and RUP supplementation on residue quality and performance of growing calves.
T. M. King*, R. G. Bondurant, J. L. Harding, J. C. MacDonald, T. J. Klopfenstein, *University of Nebraska, Lincoln.*

Technology advancements in harvesting techniques of corn residue may improve forage quality by reducing the proportion of the stem in the bale. Even with higher quality residues, metabolizable protein supplementation may be needed to achieve the desired performance of growing calves on a corn residue-based diet. The objectives of this study were to determine 1) the effect of harvest method on forage quality and steer performance in growing diets and 2) the effect of supplemental RUP on steer performance in residue-based growing diets. The experiment was designed as a 2 × 2 + 1 factorial arrangement of treatments using 60 crossbred steers (initial BW = 283; SD = 32 kg; n = 12). Factors were 3 corn residue harvest methods (low stem, high stem, and conventional) and supplemental RUP included as a 50:50 blend of Empyreal® 75 and SoyPass® at two levels (0, 3.3% diet DM). Steers fed the low stem residue diet had the greatest ADG (0.78, 0.69, 0.63 ± 0.07 for low stem, high stem, and conventional, respectively; $P < 0.05$) and consequently a greater ending BW (345, 338, 334 ± 6 kg for low stem, high stem, and conventional, respectively; $P < 0.05$) compared to the conventionally harvested corn residue. The low stem residue bales have a greater proportion of husk and leaf, which are more digestible than stems and cobs. Results from in vitro organic matter digestibility show low stem residue had the greatest digestible organic matter amount (60.3, 53.5, 54.8% for low stem, high stem, and conventional, respectively; $P < 0.05$) compared to the other two residue methods. The high stem residue diet showed no improvements over the conventional corn residue diet, which is likely due to the high stem bales containing a similar proportion of stem as the conventional bales. In situ results showed no difference in RUP content (40%) and RUP digestibility (60%) among the three residues. The addition of RUP resulted in an improvement in ADG (0.66, 0.58 ± 0.06 for supplemental RUP and no RUP, respectively; $P = 0.08$), and G:F (0.25, 0.21 ± 0.03 for supplemental RUP and no RUP, respectively; $P = 0.02$) compared to the same diets without the additional RUP. Changing the harvest method of the residue improves forage quality over conventionally harvested residue. Supplemental RUP can increase gain and improve feeding efficiency in growing steers consuming corn residue-based diets.

Key Words: growing, residue, rumen undegradable protein

095 Evaluation of a xylanase and an emulsifier in broilers fed different levels of dried yeast.

N. J. Rodriguez[1,*], J. Less[2], T. R. Radke[2], A. Hesse[2], V. G. Perez[2], *[1]UNAM, Mexico City, Mexico, [2]ADM Animal Nutrition, Decatur, IL*

The objective was to determine whether broiler performance is improved by adding xylanase alone (XY) or in combination with an emulsifier (XY+EM) in diets with different levels of dried yeast (DY). Six-day-old male Ross 708 broilers were used in a completely randomized design with 9 dietary treatments. Treatments were the inclusion of dietary DY at 0, 4, or 8% alone (None) and in combination with XY or XY+EM. Each treatment was replicated with 7 floor pens with 4 chickens/pen. Inclusion of DY (48% CP; 3280 kcal ME/kg) mainly replaced SBM. Xylanase was used without considering energy or nutrient contribution and was added at 27.5 g of net enzyme per ton of feed. The emulsifier (liquid form) was added at 1% of the diet replacing soy oil; it was given the energy value of lecithin. The feeding program consisted of phases 1 (7 d, crumble), 2 (14 d, pellet), and 3 (21 d, meal). All diets within phase were formulated to have similar ME and nutrients. Performance was measured at d 0, 7, 21, and 42. Data were analyzed using the MIXED procedure of SAS. No outliers were identified in model residuals. Pairwise comparisons were used for means separation. Linear polynomials were used to assess DY inclusion. Overall results are shown in Table 095. At 0% DY, no effects were detected. At 4% DY, XY and XY+EM improved ($P < 0.05$) ADG by 10 and 12%, respectively, but only XY+EM improved ($P < 0.05$) ADFI. At 8% DY, only XY+EM improved ($P < 0.05$) ADG and ADFI, 11% each. No effects were detected on G:F. In conclusion, XY alone was enough to improve performance at 4% DY, but XY+EM was needed to improve performance at 8% DY.

Key Words: broilers, emulsifier, xylanase

Table 095. Effect of a xylanase (XY) alone or in combination with an emulsifier (XY+EM) in broilers fed diets with different levels of dried yeast (DY) on overall (d 0 to 42) broiler performance

— Treatment —		ADG, g/d[a]	ADFI, g/d[a]
DY 0%	None	70.8	114.3
DY 0%	XY	74.4	121.1
DY 0%	XY+EM	76.0	122.3
DY 4%	None	67.5[b]	111.6[b]
DY 4%	XY	74.5[c]	120.1[b,c]
DY 4%	XY+EM	75.8[c]	122.9[c]
DY 8%	None	65.1[b]	105.8[b]
DY 8%	XY	68.7[b,c]	111.8[b,c]
DY 8%	XY+EM	72.5[c]	117.8[c]
Pooled SEM		2.22	3.48

[a] DY linear ($P < 0.05$).
[b,c] Within DY level, means with different superscript differ ($P < 0.05$).

096 Effect of sorting boar spermatozoa by sex chromosomes on oviduct cell binding.

R. A. Winters[1,*], L. M. Nettenstrom[2], D. G. Lopez[2], K. L. Willenburg[2], R. Vishwanath[2], D. J. Miller[1]. *[1]University of Illinois at Urbana-Champaign, Champaign, [2]Sexing Technologies Inc., DeForest, WI.*

The following study examined how flow cytometrically sorted sperm bind to oviduct cells and purified oviduct glycans. Previous data have shown that there are two oviduct glycan motifs, bi-sialylated lactosamine (bi-SiaLN) and Lewis X trisaccharide (Le^X) that bind noncapacitated boar spermatozoa with high affinity and specificity. The sperm-rich fraction from boars ($n = 5$) was collected and sperm were stained with Hoechst 33342 and sorted in Wisconsin. Sperm were separated into either X or Y chromosome-bearing cells and placed into the following treatments: 1) sperm sorted for the X chromosome, 2) sorted for the Y, 3) an equal mixture of sorted X and Y, and 4) a control of nonsorted sperm from the same collection. Samples were then transported to Illinois and tested for oviduct cell binding within 12 h of sorting. Additionally, we observed motility characteristics, acrosome status, and glycan binding to three soluble fluoresceinated glycans, bi-SiaLN, sulfated Le^X ($suLe^X$), and the control lactosamine disaccharide (LacNAc). Results showed that the number of sperm binding to oviduct cells was reduced by more than half in the three sorted samples compared to the control. When binding of fluoresceinated soluble glycans was investigated, the proportion of sperm that bound bi-SiaLN or $suLe^X$ averaged 81% whereas 42% of sperm bound LacNAc. The glycans bound to sperm in three patterns (pattern A: glycan binding to the apical ridge and post-acrosomal area, pattern B: post-acrosomal binding only, and pattern C: apical ridge binding only). For $suLe^X$ and bi-SiaLN glycans, pattern A was present on 38% of the sperm, pattern B on 29%, pattern C on 20%, and no fluorescence was observed on 12% of sperm from each of the four samples. The percentage of sperm that were motile in the sorted samples was reduced on average by 15% from the unsorted control. However, computer assisted semen analysis did not detect other differences in motility parameters between the sorted and control samples. All samples maintained > 97% acrosome integrity after the sorting process. In conclusion, sperm binding to the complex matrix around oviductal cell aggregates was reduced after sorting but binding to purified soluble fluoresceinated glycans was not different among sperm preparations, probably due to a requirement for higher affinity binding and motility to contact and bind intact oviduct cells. The reduction in sperm fertility observed following sorting may be due to reduced ability to bind the oviduct epithelium.

Key Words: oviduct, sex sorting, sperm

097 Effects of standardized ileal digestible valine:lysine ratio on nursery pig performance. A. B. Clark[1,*], M. D. Tokach[1], S. S. Dritz[1], K. J. Touchette[2], M. A. D. GonÁalves[1], J. M. DeRouchey[1], R. D. Goodband[1], J. C. Woodworth[1], *[1]Kansas State University, Manhattan, [2]Ajinomoto Heartland, Inc., Chicago, IL.*

A total of 280 pigs (PIC 327 × 1050; initially 6.53 kg BW) were used in a 28-d trial to evaluate the effects of increasing standardized ileal digestible (SID) Val:Lys ratio on nursery pig growth performance. Pigs were weaned at 21 d of age and 5 pigs allotted to each nursery pen according to BW and gender. A common diet was fed for 5 d when pens were assigned to 1 of 7 dietary treatments in a randomized block design with 8 pens per treatment. Experimental diets were fed from d 0 to 14 followed by a common diet from d 14 to 28. The 7 dietary treatments were 50, 57, 63, 68, 73, 78, and 85% SID Val:Lys. A prior experiment demonstrated a Lys requirement of 1.44 and 1.45% SID Lys for ADG and G:F, respectively, for pigs in this facility. Thus, diets were formulated to 1.24% SID Lys to ensure pigs were below the Lys requirement. As SID Val:Lys increased, ADG, ADFI, and G:F increased (quadratic, $P < 0.05$). Growth response variables were fitted using linear and nonlinear dose–response models with pen as the experimental unit and initial BW as a covariate with ADG and G:F fitted using heterogeneous and homogenous residual variance, respectively. Models fit were quadratic polynomial (QP), broken-line linear (BLL), and broken-line quadratic with best fit determined according to Bayesian information criterion. For ADG, the best fitting model was BLL and maximum ADG was achieved with a minimum of 62.9% SID Val:Lys (95% CI: [52.2, 73.7%]). For G:F, the best fitting model was QP [0.010294 + 0.017526*(Val:Lys)– 0.000122*(Val:Lys)^2] using a 6.53-kg initial BW. This resulted in a maximum G:F at 71.7% SID Val:Lys and 99% of maximum achieved at a 64.4% ratio. In summary, the SID Val:Lys requirement ranged from 62.9 to 71.7% depending on the response model.

Key Words: amino acids, nursery pigs, valine

098 Impact of elevated preovulatory estradiol during a fixed-time AI protocol on uterine environment and embryonic survival to Day 16. E. J. Northrop[1,*], J. J. Rich[1], R. A. Cushman[2], G. A. Perry[1], *[1]Department of Animal Science, South Dakota State University, Brookings, [2]USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE.*

The role of preovulatory estradiol in maternal recognition of pregnancy and embryonic survival has not been well established among beef cows. Our objective was to determine the effects of preovulatory estradiol on regulating the uterine environment from fertilization to maternal recognition of pregnancy. Beef cows/heifers were synchronized with the CO-Synch protocol and AIed (d 0). Blood was collected to determine estradiol (d −2 to 0) and progesterone (d 0 to 16) concentrations. Cows were classified by expression of estrus (estrus and no estrus). Uteri were flushed to collect d 16 embryos nonsurgically (Rep 1; $n = 29$) or following slaughter (Rep 2; $n = 37$). Flush media was analyzed for protein and glucose concentrations. Data were analyzed using the mixed procedure in SAS. There was an effect of estrus, time, and estrus by time ($P < 0.01$) on circulating concentrations of estradiol, with cows in estrus having greater concentrations of estradiol. There was no effect of estrus ($P = 0.41$) or estrus by time ($P = 0.16$) on subsequent circulating concentrations of progesterone. There was no difference in embryo recovery rate between estrus and no estrus animals ($P = 0.20$; 48% vs. 29%) and between replicates ($P = 0.46$; 44% vs. 33%). There were no differences between estrus and no estrus animals for uterine flush protein ($P = 0.36$; 2222 ± 513 vs. 1547 ± 525 mg/mL). However, cows that showed estrus had greater glucose concentrations in uterine flush media ($P = 0.05$; 51 ± 1.86 vs. 45 ± 1.92 mg/dL). Cows in which an embryo was recovered had greater concentrations of protein in the uterine flush ($P = 0.05$; 2643 ± 585 mg/mL) compared to cows in which an embryo was not recovered (1126 ± 463 mg/mL). There were no differences in uterine flush glucose between cows that did or did not have an embryo recovered ($P = 0.29$; 47 ± 2.12 vs. 50 ± 1.70 mg/dL). In summary, embryo recovery rates and uterine flush protein content did not differ between cows that did or did not exhibit estrus, but uterine flush glucose content was greater in cows that exhibited estrus. There was no difference in uterine flush glucose content between cows that did and did not have an embryo, but uterine flush protein content was

Table 097.

	SID Val:Lys, %								Probability, $P <$	
Item:	50	57	63	68	73	78	85	SEM	Linear	Quadratic
d 0 to 14										
ADG, g	190	221	249	249	248	251	238	11.2	0.001	0.001
ADFI, g	331	363	394	388	403	390	386	17.2	0.012	0.030
G:F	0.579	0.613	0.635	0.646	0.614	0.645	0.617	0.0189	0.101	0.039

greater in cows from which an embryo was recovered. USDA is an equal opportunity provider and employer.

Key Words: embryonic survival, estradiol, uterine environment

099 2015 National retail benchmarking study: effect of enhancement on pork quality. L. A. Bachmeier[1,*], S. J. Moeller[2], C. Carr[3], J. M. Young[1], X. Sun[1], J. H. Liu[1], S. B. Schauunaman[1], D. J. Newman[1], *[1]North Dakota State University, Fargo, [2]The Ohio State University, Columbus, [3]University of Florida, Gainesville.*

The objective of this study was to compare pork quality parameters of enhanced (EN) and non-enhanced (NON) center-cut loin chops obtained from the 2015 Pork Quality Retail Benchmarking Study. Samples were acquired from major retailers in 28 market areas across 23 states according to the 2013 Progressive Grocer Marketing Guidebook (Stagnito Media, 2013). A maximum of 10 center-cut loin packages for each brand and enhancement type (EN and NON) were selected for purchase and then evaluated by an experienced grader for subjective color and marbling scores according to the National Pork Board Color and Marbling Standards (NPB, 2011). After purchase, samples were shipped to North Dakota State University for subjective and instrumental parameters for evaluation of subjective color, subjective marbling, instrumental color (CIE L*, a*, and b* color space values), pH, cook-loss percentage, and tenderness as determined by the Warner-Bratzler shear force method. Data was analyzed using the mixed procedure in SAS (SAS Institute, Cary, NY). For in-store subjective color, there was significant difference between EN and NON chops (2.92 vs. 2.75; $P = 0.002$). For in-store subjective marbling, EN had a lower score than NON (2.00 vs. 2.32; $P < 0.001$). Laboratory evaluation of subjective color showed a tendency for EN chops to be darker in color than NON chops (2.74 vs. 2.65; $P = 0.09$). Laboratory evaluation of subjective marbling showed a significant difference between EN and NON chops (2.15 vs. 2.32; $P = 0.009$). For L*, EN chops were darker (lower L* value) than NON (54.69 vs. 55.97; $P < 0.0001$). For a*, EN chops were significantly more red (greater a* value) compared to NON (16.36 vs. 16.01; $P = 0.01$). EN chops had a lower b* value than NON chops (9.54 vs. 10.36; $P < 0.0001$). EN chops had lower cook loss percentage than NON (11.69 vs. 14.55%; $P < 0.001$). EN chops also had higher pH values than NON (5.98 vs. 5.75; $P < 0.0001$). EN chops had lower Warner-Bratzler shear force values than NON (19.78 vs. 26.01 N; $P < 0.0001$). Data from these results confirm that enhancing fresh pork can significantly improve water holding capacity and tenderness, resulting in an improved eating experience.

Key Words: enhancement, pork, quality

100 Post-mortem proteolysis and meat tenderness in crossbred steers identified as lowly or highly feed efficient. C. P. Blank*, J. R. Russell, S. M. Lonergan, S. L. Hansen, *Iowa State University, Ames.*

The objective of this study was to assess effects of beef cattle feed efficiency (FE) on post-mortem meat tenderness. Crossbred steers were grown at the University of Missouri (76 d) on a whole-shell corn (MUCorn, $n = 89$) or roughage-based diet (MURough, $n = 90$), phenotypically classified for FE based on residual feed intake (RFI) calculations, and finished at Iowa State University (ISU). Within each growing phase (GP) diet, the 12 most (HFE; average RFI −3.33 ± .77, SE) and 12 least (LFE; average RFI 2.90 ± .94) efficient steers (48 steers total) were assigned to GrowSafe pens and transitioned to corn (ISUCorn) or byproduct-based diet (ISUByp; 87 d) for the finishing phase (FP). Optaflexx was fed for 28 d before harvest. Rib sections were collected from the 48 steers, and aged for 2 or 14 d for further analysis of calpastatin (d 2), troponin-T (d 2, d 14), and WBSF (d 14). Data were analyzed using PROC MIXED of SAS with fixed effects of MU diet, ISU diet, FE classification, and the interactions; significance was determined at $P \leq 0.05$. Dressing percent and ribeye area were greater in LFE steers than HFE steers ($P \leq 0.04$), and ribeye area was increased in ISUCorn vs. ISUByp steers ($P = 0.01$). There was a tendency for an ISU diet × FE effect on steak lipid content ($P = 0.08$) and marbling score ($P = 0.03$) driven by greater lipid content in steaks from LFE steers vs. HFE steers within ISUByp, but no differences were detected due to FE classification within ISUCorn. Moisture and protein content of the steaks were not affected by diet or FE ($P \geq 0.12$). Minolta objective color scores and percent cook loss measured on steaks aged 14 d revealed no differences due to diet or FE ($P \geq 0.21$). No interaction between diets and FE classification ($P \geq 0.19$) were observed for Warner-Bratzler shear force (WBSF), calpastatin activity, or d 2 or d 14 troponin-T degradation. However, MURough steers had greater WBSF than MUCorn steers *($P = 0.05$)*. Day 2 calpastatin activity tended ($P = 0.10$) to be greater in HFE steers than LFE steers. No differences were observed in d 2 troponin-T degradation *($P \geq 0.12$)*; however, d 14 troponin-T was greater in ISUCorn vs. ISUByp steers ($P = 0.005$). These data suggest that diet type and feed efficiency classification may independently affect meat tenderness.

Key Words: cattle, feed efficiency, meat tenderness

101 In vitro investigations on the use of non-nutritive sorbent additives to sequester boar taint compounds. P. Park[1,*], I. B. Mandell[1], C. F. M. de Lange[2], J. Squires[1], *[1]Department of Animal and Poultry Science, University of Guelph, Guelph, ON, Canada, [2]University of Guelph, Guelph, ON, Canada.*

The objective of this study was to explore the effectiveness of four (4) low-cost feed additives with adsorbing capacities against androstenone and assess for their feasibility as dietary interventions to control boar taint. Boar taint is an unsavory odor and taste detected from pork of some intact male pigs when cooked, caused by high accumulation of the sex steroid androstenone and the indole skatole. Available research exploring dietary approaches to control androstenone is scarce. Candidate additives (bentonite, BNT; diatomaceous earth, DE; spent filter aid, SFA; and sodium-calcium aluminosilicate, JUMP) have all been found to be effective treatments against aflatoxin B1 and zearalenone in the gut of pigs and chickens as dietary supplementation. Each was used to bind radiolabeled androstenone (AND), estrone (E1), and estrone sulfate (E1S) from buffer solutions in a pH 7.4 in vitro system developed in our laboratory (n = 4). Michaelis-Menten enzyme kinetics was used to analyze binding effectiveness, expressed as Bmax (maximum binding) and Km (amount of additive required to reach 50% of Bmax). Tukey's range test was performed for statistical significance with SAS (SAS Institute, Cary, NC). All tested additives demonstrated high Bmax against AND, with BNT being the most effective binder of both AND and E1 (Table 101). Most additives also appear to exhibit selective binding between steroids, with the highest difference seen between binding of AND versus E1S (P < 0.05). We conclude that all four additives tested in this experiment effectively bound androstenone under in vitro conditions and that further research involving animal models is warranted to explore their effectiveness and selectivity in the gastrointestinal tract of pigs to control boar taint.

Key Words: boar taint

Table 101. Michaelis-Menten parameters (value ± SEM) of four adsorbents against steroids AND, E1, and E1S. Letters represent statistical significance between treatments within bound steroid (P < 0.05); values with numbers indicate no difference across bound steroids within each treatment (P > 0.05).

		Bmax (%)	Km (μg/mL)
AND	BNT	87.1 ± 0.08[a]	17.1 ± 2.1[a,1]
	DE	80.6 ± 0.5[b]	14.5 ± 1.9[ab]
	SFA	74.5 ± 0.2[c]	9.1 ± 2.1[b,3]
	JUMP	82.2 ± 0.2[d]	22.1 ± 0.2[a]
E1	BNT	66.9 ± 0.1[a]	14.1 ± 0.03[a,1]
	DE	59.0 ± 0.1[b]	0 ± 0[b,2]
	SFA	72.6 ± 0.5[c]	15.1 ± 1.8[a,3]
	JUMP	59.0 ± 0.4[b]	0.5 ± 0.1[b,4]
E1S	BNT	49.4 ± 0.6	0.03 ± 0.03
	DE	48.8 ± 0.6	0.01 ± 0.01[2]
	SFA	49.7 ± 0.5	0.2 ± 0.1
	JUMP	49.7 ± 0.1	0.8 ± 0.1[4]

102 Changes in late gestation beef cow circulating metabolite and metabolic hormone concentrations due to feeding stockpiled tall fescue versus tall fescue hay. J. M. Larson[1,*], K. N. Niederecker[1], A. M. Meyer[2], *[1]Division of Animal Sciences, University of Missouri, Columbia, [2]University of Missouri, Columbia.*

The objective was to investigate effects of grazing stockpiled tall fescue (STF) versus feeding summer-baled hay during late gestation on nutrient availability for fetal development. Multiparous, spring-calving crossbred beef cows (yr 1: n = 48; yr 2: n = 56) either strip-grazed STF (n = 4 pastures; 12.3% CP, 63.9% NDF; DM basis) or received ad libitum tall fescue hay (6.9% CP, 66.6% NDF; DM basis) fed in uncovered drylots (n = 4) until calving. Jugular blood samples were obtained from cows on d 0 (baseline; d 188 of gestation), 20, 35, 56, 77, and 99 (remaining prepartum cows). Effects of forage system, sampling day, year, and all interactions were included in the model. Sampling day was considered a repeated effect. Calf date of birth was included in the model when P < 0.25; pasture or drylot was the experimental unit. Correlations were determined between calf birth weight and the last prepartum maternal metabolite or hormone concentration. The forage system × day × year interaction affected (P < 0.001) NEFA and tended to affect thyroxine (P = 0.06). In year 1, NEFA was greater (P < 0.001) on d 56 in cows grazing STF than cows consuming hay. In year 2, NEFA tended to be greater (P = 0.09) on d 35 and was greater (P < 0.001) on d 77 and 99 in cows grazing STF. Cows grazing STF tended to have greater (P = 0.06) thyroxine on d 77 in year 1, but there were no differences ($P \geq$ 0.18) in year 2. There was a forage system × day interaction (P < 0.01) for BUN, cortisol, and triiodothyronine. After d 0, BUN was greater (P < 0.001) in cows consuming STF on all days measured. Cortisol was greater (P = 0.003) on d 35 and tended to be greater (P = 0.10) on d 99 in cows grazing STF. Triiodothyronine was less (P = 0.03) on d 0 but greater (P = 0.004) on d 99 in cows grazing STF. Cows grazing STF tended to have greater (P = 0.08) glucose than cows consuming hay. Calf birth weight was positively correlated with prepartum maternal BUN (r = 0.31, P = 0.002) and NEFA (r = 0.12, P = 0.005) but not glucose, cortisol, triiodothyronine, or thyroxine ($P \geq$ 0.15). Results indicate cows grazing STF had altered metabolic status, which may impact fetal development and subsequent calf performance.

Key Words: developmental programming, forage systems, pregnancy

103 Effects of treating sorghum wet distillers grains plus solubles with calcium hydroxide in steam-flaked corn-based finishing diets on dry matter intake and ruminal fermentation characteristics.
W. W. Gentry[1,*], C. P. Weiss[1], C. M. Meredith[1], C. L. Brauer[1], F. T. McCollum[1], N. A. Cole[2], J. S. Jennings[1], *[1]Texas A & M AgriLife Research and Extension Center, Amarillo, [2]USDA-ARS, Bushland, TX.*

This experiment was conducted to determine the effects of treating sorghum wet distillers grains plus solubles (WDGS) with calcium hydroxide in steam-flaked corn (SFC) diets on dry matter intake and ruminal fermentation characteristics in growing beef steers. Six ruminally and duodenally cannulated beef steers (380 ± 5.4 kg of BW) were used in a 3 × 3 replicated Latin square design. Dietary treatments consisted of corn WDGS, sorghum WDGS, or calcium hydroxide treated (2.67% DM basis) sorghum WDGS in SFC-based finishing diets. All WDGS were included at 30% on a DM basis. Treated sorghum WDGS were allowed to sit for 7 d in sealed plastic containers before feeding. Animals were fed once daily at 0700 h. Periods consisted of 17 d of diet adaptation and 4 d of subsequent collection. Fecal and duodenal samples were wet composited by animal within period. Data were analyzed using PROC MIXED of SAS with animal as the experimental unit. Means were separated using LSMEANS with the PDIFF option. Dietary treatment did not affect body weight gain ($P = 0.15$), DMI ($P = 0.80$), or OMI ($P = 0.79$). Cattle receiving the corn WDGS treatment had a lower ruminal pH ($P < 0.01$) throughout the trial. No difference ($P = 0.22$) in average ruminal pH was observed between the sorghum WDGS and treated sorghum WDGS. Overall, sorghum WDGS had better rumen buffering capacity compared to corn WDGS; however, differences in pH did not affect DMI or OMI.

Key Words: calcium hydroxide, fermentation, sorghum wet distillers grains plus solubles

104 Gross return to corn acres through cattle feeding as influenced by choice of harvest endpoint.
T. A. Johnson*, A. Hohertz, A. DiCostanzo, *University of Minnesota, St. Paul.*

Forty-nine Charolais × Red Angus steers (initial average BW = 526 kg) were fed individually in a Calan-Broadbent feeding system to evaluate performance and interactions resulting from performance and crop yield when corn is harvested as either silage (SIL), earlage (EAR), high-moisture corn (HMC), or corn (DRC). Steers were randomly allocated to 1 of 4 dietary treatments where SIL, EAR, HMC, or DRC constituted 75% of diet DM. Remaining SIL, EAR, HMC, and DRC diet contained 11% haylage (0% for SIL), 10% modified wet corn distillers grains (MDGS), 4% liquid supplement with Rumensin (SUPP), and 11% DRC (SIL). Gross return (gross $/hd) was determined as dollars remaining after subtracting non-corn crop expenses (cattle purchase, veterinary medicine, yardage, bedding, and other feed ingredient) from gross cattle sale. Worth of each corn crop endpoint was determined from corn grain worth ($/25.4 kg) and its relationship to corn grain content in SIL, EAR, and HMC crops. This value was compared to SIL, EAR, and HMC worth determined by ANOVA (gross $/hd divided by 1000 kg). The worth of each corn crop endpoint was also determined by dividing gross return (gross $/hd) by acres used to raise crop. The former method is used to determine corn crop endpoint worth for a feeder that purchases crops (owns no land), and the latter is used to determine corn crop endpoint worth for a feeder who owns corn land. Cattle fed HMC had the lowest ($P \leq 0.05$) DMI. Cattle fed DRC gained at faster ($P < 0.05$) ADG than cattle fed the other corn crops. Cattle fed HMC had greater ADG ($P < 0.05$) than those fed SIL or EAR. No difference between cattle fed DRC or HMC was observed for G:F, but feeding either led to greater ($P < 0.05$) feed conversion than SIL or EAR. Final BW and HCW were greatest for DRC ($P < 0.05$), intermediate ($P < 0.05$) for HMC, and lowest ($P < 0.05$) for EAR and SIL. There was a tendency ($P = 0.08$) for treatment effect on fat thickness wherein cattle fed DRC or HMC tended to have greater fat thickness than those fed SIL. No treatment differences were found for REA or marbling. Worth (gross $ return/1,000 kg) of SIL, EAR, or HMC was greater than that of DRC. Harvesting corn as SIL, EAR, HMC, or DRC had no impact ($P > 0.05$) on crop worth (gross $ return/acre).

Key Words: feedlot performance, corn, crops

GRADUATE STUDENT COMPETITION: PhD ORAL

105 Effect of feeding a corn hybrid containing α amylase on finishing cattle performance and carcass characteristics.
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Two finishing trials were conducted to compare feeding a corn hybrid containing an α amylase enzyme (Syngenta Enhanced Feed Corn; SYT-EFC) or a commercially available corn grain (CON) on steer performance and carcass characteristics. Experiment 1 utilized 300 calf-fed steers (298 ± 16 kg) with 10 steers per pen and 6 replications per treatment. Five treatments were evaluated in a 2 × 2 + 1 factorial arrangement as a randomized block design. Factors included corn trait (SYT-EFC or CON), corn by-product type [sweet bran (SB) or wet distillers grains plus solubles (WDGS)], and a 50:50 blend of SYT-EFC and CON with WDGS. Experiment 2 utilized

240 calf-fed steers (287 ± 15 kg) with 10 steers per pen and 6 replications per treatment. Dietary treatments included SYT-EFC, CON, a 50:50 BLEND of SYT-EFC and CON, and CON with an added enzyme supplement (NZ) in WDGS-based diets. In Exp. 1, a corn trait X byproduct interaction was observed for ADG and G:F ($P = 0.05$ and 0.02, respectively). Steers fed SYT-EFC with SB had greater ADG and G:F than steers fed CON with SB, which had the lowest ADG and G:F. Based on corn grain concentration, there was a 14.9% improvement in G:F when SYT-EFC was fed compared to CON in SB diets. For diets containing WDGS, there were no differences ($P \geq 0.35$) in final BW, DMI, ADG, or G:F; however, a 3.0% numerical improvement in G:F was observed for steers fed SYT-EFC compared to CON. No interactions were observed for any carcass characteristics ($P \geq 0.07$); however, marbling score, fat depth, and calculated yield grade were greater ($P < 0.01$, $P = 0.01$, and $P = 0.03$, respectively) for steers fed SYT-EFC compared to CON. Fat depth and calculated yield grade were greater ($P = 0.03$ and $P = 0.02$, respectively) for steers fed SYT-EFC and BLEND compared with CON. In Exp. 2, final BW, ADG, and G:F were greater ($P \leq 0.03$) for steers fed SYT-EFC, BLEND, and NZ compared to CON. On a corn grain basis, an 8.4% improvement in G:F was observed due to SYT-EFC versus CON. Hot carcass weights were greater ($P < 0.01$) for SYT-EFC, BLEND, and NZ compared to CON. These data suggest that feeding SYT-EFC improves G:F of feedlot cattle, and the corn is 3.0 to 14.9% better than control corn hybrids.

Key Words: α amylase, corn hybrid, feedlot cattle

106 Effects of supplemental soy peptide on growth performance and gut health of nursery pigs.
L. Zheng*, I. Park, S. W. Kim, *North Carolina State University, Raleigh.*

The objective of this experiment was to evaluate the effect of soy peptide (Yunong, China) on growth performance, intestinal morphology, and oxidative stress in nursery pigs. A total of 40 pigs (20 barrows and 20 gilts at 5.33 ± 0.10 kg BW) were randomly allotted to 4 treatments in a randomized complete block design. Sex and initial BW were used as blocks. Pigs were fed a basal diet supplemented with soy peptide at the level of 0, 5, 10, or 15 g/kg based on 3 phases (7, 10, and 10 d, respectively). Soy peptide, which was produced by soybean meal fermentation, contained a greater amount ($P < 0.05$) of small-sized peptides (< 37 kDa, 100.0%) compared with those of conventional soybean meal (44.7%). Body weight and feed consumption were recorded on d 7, 17, and 27. Increasing supplementation of soy peptide improved gain:feed (0.560 to 0.663, quadratic, $P < 0.05$) in phase 1 and tended to increase ADG (380 to 453 g/d, quadratic, $P = 0.056$) and ADFI (522 to 571 g/d, quadratic, $P = 0.084$) in phase 2. Increasing levels of soy peptide tended to increase villus height in the duodenum (517.6 to 572.5 μm, quadratic, $P = 0.083$) and the jejunum (442.6 to 504.9 μm, quadratic, $P < 0.05$). Proliferation activity measured by Ki-67 staining in the duodenum showed a higher percentage of positive reactions in the pigs fed soy peptide than those fed a basal diet (10.6 to 18.2%, $P < 0.05$). Increasing dietary soy peptide decreased tumor necrosis factor-α (TNF-α) in serum (72.8 to 52.4 pg/mL, linear, $P < 0.05$). Supplementation of soy peptide reduced TNF-α in the jejunum (1.24 to 0.46 pg/mg, $P < 0.05$). Pigs fed soy peptide had lower malondialdehyde in the jejunum compared to those fed a basal diet (0.52 to 0.23, μmol/g protein, $P < 0.05$). In conclusion, soy peptide supplemented at 5 to 10 g/kg to nursery diets improved growth performance and gut health of pigs in association with enhanced villus development, reduced inflammatory cytokine levels, and reduced oxidative stress products.

Key Words: growth performance, gut health, soy peptide

107 Evaluating the inclusion level of medium chain fatty acids to reduce the risk of PEDV in feed and spray-dried animal plasma.
R. A. Cochrane[1,*], M. Saensukjaroenphon[1], S. S. Dritz[1], J. C. Woodworth[1], A. R. Huss[1], C. R. Stark[1], J. M. DeRouchey[1], M. D. Tokach[1], R. D. Goodband[1], J. F. Bai[1], Q. Chen[2], J. Zhang[2], P. C. Gauger[2], R. Main[2], C. K. Jones[1], *[1]Kansas State University, Manhattan, [2]Iowa State University, Ames.*

Research has confirmed that chemical treatments, such as medium chain fatty acids (MCFA) and commercial formaldehyde, can be effective to reduce the risk of porcine epidemic diarrhea virus (PEDV) cross-contamination in feed. However, the efficacy of MCFA levels below 2% inclusion is unknown. The objective of this experiment was to evaluate if a 1% inclusion of MCFA is as effective at PEDV mitigation as a 2% inclusion or formaldehyde in swine feed and spray-dried animal plasma (SDAP). Treatments were arranged in a 4 × 2 × 6 plus 2 factorial with 5 chemical treatments: 1) PEDV positive with no chemical treatment, 2) 0.325% commercial formaldehyde, 3) 1% MCFA, and 4) 2% MCFA; 2 matrices: 1) complete swine diet and 2) SDAP; 6 analysis days: 0, 1, 3, 7, 14, and 21 post inoculation; and 1treatment each of PEDV negative untreated feed and plasma. Matrices were first chemically treated, then inoculated with PEDV, and stored at room temperature until being analyzed by RT-qPCR. Data were analyzed by the GLIMMIX procedure of SAS. The analyzed values represent threshold cycle (CT), at which a higher CT value represents less detectable RNA. All main effects and in-

Table 107.

	Chemical treatment					
Matrix	Negative	Positive	MCFA 1%	MCFA 2%	Formalde-hyde	Pooled SEM
Feed	undetectable	34.2	41.4	42.8	37.2	0.98
SDAP	undetectable	32.2	32.4	31.6	37.6	

teractions except for day × form were significant ($P < 0.02$). Feed treated with MCFA, regardless of inclusion level, had fewer ($P < 0.05$) viral particles than feed treated with formaldehyde. However, the SDAP-treated with either 1% or 2% MCFA had similar ($P > 0.05$) concentrations of detectable PEDV RNA as the untreated SDAP, while the SDAP treated with formaldehyde had fewer viral particles ($P < 0.05$). The complete feed had a lower ($P < 0.05$) quantity of PEDV RNA than SDAP (34.2 vs. 32.2 for feed vs. SDAP, respectively) ($P < 0.05$). Analysis day also decreased ($P < 0.05$) the quantity of detectable viral particles from d 0 to d 21, (33.2 vs. 39.0, respectively). In summary, time, formaldehyde, and MCFA all appear to enhance RNA degradation of PEDV in swine feed and ingredients, but their effectiveness varies within matrix. The 1% inclusion level of MCFA was as effective as 2% in complete feed, but neither was effective at reducing the magnitude of PEDV RNA in SDAP.

Key Words: feed matrix, medium chain fatty acids, PEDV

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108 Liquid feeding fermented DDGS to weanling pigs: improvement of growth performance with added enzymes and microbial inoculants.

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Controlled fermentation of coproducts can improve energy availability and gut function through synergistic soluble fiber hydrolysis. This study assessed effects of extended DDGS fermentation on performance and digestive function of newly weaned piglets fed corn and soybean meal based liquid diets. Enzymes (67.2 IU β-glucanase and 51.4 IU xylanase/g DDGS; AB Vista) and silage inoculant (360,000 CFU *Pediocoocus pentosaceus* 12,455 and *Propionibacterium jensenii* 30,081/g DDGS; Lallemand Inc.) were added to dry DDGS at the time of liquid feed preparation and delivery (UNFER) or allowed to ferment with DDGS (1 to 7 d at 40°C; 16% DM; FER). Diets were composed of a common base supplement for each of three phases (P; d 0 to 7, 7 to 20, 20 to 42), mixed with DDGS (7.5 (P1), 16.25 (P2), and 25 (P3) % of DM) and water (25% DM). Pigs were separated into two rooms according to initial body weight (BWi; heavy (HBW, 7.6 ± 0.8 kg) or light (LBW, 5.8 ± 0.6 kg)). The study was a randomized block design with results presented as lsmeans ± SEM (FER vs. UNFER, respectively). Owing to a BWi by diet interaction ($P < 0.05$), data were analyzed separately for the two BWi groups (4 pens/BWi and dietary treatment, 14 pigs/pen). To obtain uniform final BW, LBW pigs were fed P3 diets until d 48. On d 42, pH and organic acid concentration were determined in ileal digesta pooled from 2 pigs/pen. Complete liquid FER diet ($n = 9$) had higher content of lactic acid (42.6 ± 17.4 vs. 17.6 ± 1.4 mM) and acetic acid (55.3 ± 37.1 vs. 3.9 ± 0.7 mM) than the UNFER diet ($n = 3$). Overall, there were no differences ($P > 0.10$) in ADG (424 vs. 424 ± 14 g/d for HBW and 404 ± 15 vs. 386 ± 12 g/d for LBW) and DMI (605 vs. 581 ± 16 g/d for HBW and 540 ± 19 vs. 509 ± 16 g/d for LBW). For d 42 to 48, LBW pigs fed FER had greater ADG (941 ± 60 vs. 773 ± 52 g/d, $P < 0.05$), resulting in higher end BW (25.8 ± 0.5 vs. 24.5 ± 0.4 kg, $P < 0.05$). In digesta, total organic acid concentration and pH did not differ between treatments ($P > 0.10$). Digesta fermentation patterns (% of total organic acids), however, differed with FER increasing n-butyric acid (15.0 vs. 1.0 ± 3.8%, $P = 0.04$) and tending to lower lactic acid (30.0 vs. 47.1 ± 6.9%, $P = 0.06$) within HBW, while within LBW, FER tended to increase acetic acid (53.7 ± 7.4 vs. 31.1 ± 6.4%, $P = 0.07$). FER benefited LBW pigs late in the nursery period, altering the gut metabolome, possibly due to soluble fiber hydrolysis and improved gut development in pigs potentially compromised by low weaning BW.

Key Words: DDGS, liquid feeding, nursery pigs

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109 Impact of sex on composition and quality of fresh loins, bellies, and fresh and processed hams.

E. K. Arkfeld[1,*], D. A. Mohrhauser[2], D. A. King[3], T. L. Wheeler[3], A. C. Dilger[1], S. D. Shackelford[3], D. D. Boler[1], *[1]University of Illinois, Urbana, [2]Smithfield Foods, Denison, IA, [3]USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE.*

The objective was to characterize the effect of sex across production focus on primal quality of pigs slaughtered in marketing groups designed to reduce variability. Pigs ($N = 7672$) from a lean growth [$n = 1468$ barrows (LB); $n = 2151$ gilts (LG)] or superior meat quality [$n = 1895$ barrows (QB); $n = 2158$ gilts (QG)] production focus were slaughtered over two seasons. Data were analyzed as a 2 × 2 factorial design. Unequal magnitudes of differences of sexes within production focus drove interactions. Random effects included barn ($N = 8$), marketing group ($N = 3$), and season ($N = 2$). Variability between sexes was measured using a Levene's test. Carcass composition, subjective loin quality, and gluteus medius color were collected on all carcasses. In-plant loin quality and belly quality analyses were conducted on 52.0% and 47.5% of carcasses, respectively. Loins and hams from select carcasses ($N = 862$) were collected for slice shear force (SSF) analysis and processed ham characteristics. Barrows (95.01 ± 2.41 kg) had a heavier HCW than gilts (94.17 ± 2.40 kg; $P < 0.0001$) but did not differ ($P = 0.09$) in variability. Fat depth was greater ($P < 0.0001$) and more variable ($P < 0.01$) in barrows (16.83 ± 0.76 mm) than gilts (14.65 ± 0.76 mm). However, LB had a 13.86% greater fat depth than LG ($P < 0.01$), and QB had a 15.65% greater fat depth than QG ($P < 0.01$). Gilts (68.46 ± 2.49 mm) had a greater loin depth than barrows ($P < 0.01$; 67.22 ± 2.49 mm) with no differences ($P = 0.60$) in variability between sexes. Gilts (58.16 ± 0.58%) had a greater percent lean ($P < 0.01$) with less variability ($P < 0.01$) than barrows (56.66 ± 0.58%). Lean percentage was increased 1.28 units in LG com-

pared with LB but was increased 1.71 units in QG compared with QB ($P < 0.01$). Barrows had heavier (7.60 ± 0.26 vs. 7.32 ± 0.26 kg) and firmer (2.26 ± 0.12 vs. 1.88 ± 0.12) bellies than gilts ($P < 0.01$). Loin marbling was not different between sexes ($P = 0.89$). Gilts (15.11 ± 2.02 kg) had a greater SSF than barrows (14.07 ± 2.02 kg; $P < 0.01$). Pre-trim ham weights were not different between sexes ($P \geq 0.39$); post trim ham weights were heavier in gilts (9.86 ± 0.19 kg) than barrows (9.70 ± 0.19 kg; $P = 0.01$). Gilts (5.14 ± 0.10 kg) had a greater cooked ham weight than barrows (4.97 ± 0.10 kg). Although marketing groups aim to eliminate variability, sex contributes variation to a population. Sex significantly altered primal weight and quality differences across and within production focuses. Supported by National Pork Board Grant 14–221.

Key Words: pork, sex, variability

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110 Immune system stimulation (ISS) induced by *E. coli* lipopolysaccharide (LPS) alters amino acid metabolism in growing pigs. W. D. Stuart[1,*], T. E. Burkey[2], N. K. Gabler[3], K. J. Schwartz[3], D. Klein[1], J. A. Dawson[1], A. R. Pendleton[4], C. F. M. de Lange[5], A. Rakhshandeh[1], *[1]Texas Tech University, Lubbock, [2]University of Nebraska, Lincoln, [3]Iowa State University, Ames, [4]Amarillo College, Amarillo, TX, [5]University of Guelph, Guelph, ON, Canada.*

We previously observed that PRRSV infection increased plasma Met and Thr flux but decreased Lys flux in growing pigs. These changes reflect modification of AA utilization during ISS. This study evaluated the effects of ISS induced by LPS on whole body protein deposition (PD) and plasma free amino acid (AA) flux and pool size. Ten gilts (BW 9.4 ± 1.1 kg) were surgically fitted with venous catheters, individually housed in metabolism crates, and feed restricted (550 g/d) on a corn-SBM based diet (ME 14.3 MJ/kg, SID Lys 11.5 g/kg). ISS was induced by two intramuscular injections of increasing amounts of LPS (30 and 36 µg/kg BW) given 48 h apart. Blood samples were collected at 0 and 72 h after initiation of ISS and assayed for hematology and blood chemistry. Body temperature (BT) was monitored on a daily basis. N-balances were determined during a 3-d pre-ISS and a 3-d ISS period. At the end of each N-balance period, a single dose of [U-^{13}C, U-^{15}N] AA mixture (Lys, Met, Thr, Trp, Ile, Leu, Val, Phe, Gln) was infused intravenously, and serial blood samples were taken at 0, 2.5, 5, 7.5, 10, 15, 20, 30, and 45 min after tracer administration to determine isotopic enrichment. A double exponential model was fitted to the plasma enrichment for each pig and AA, and equation parameters were used to estimate plasma AA flux and pool size. Blood chemistry, hematology, and BT results indicated that LPS induced effective ISS in pigs ($P < 0.05$). ISS had no effect on PD (59.4 vs. 55.7 g/d; $P = 0.31$), but it decreased plasma flux (µmol/kg BW/h) for Ile (112 vs. 76; $P < 0.05$) and Phe (126 vs. 79; $P < 0.05$). In agreement with PRRSV challenged pigs, LPS tended to reduce the plasma Lys flux (from 394 to 325, $P = 0.08$). Plasma flux of other AA was not affected by ISS. ISS increased and tended to increase the pool size (µmol/kg BW) for free Leu (22 vs. 34, $P < 0.05$) and Gln (16 vs. 25, $P = 0.11$), respectively, but reduced the pool size for free Ile (13 vs. 9.0, $P < 0.05$). Collectively, these results suggest that ISS induced by LPS alters AA flux and pool size in growing pigs. The decrease in Lys, Phe, and Ile flux in LPS induced ISS pigs may be attributed to a reduction in whole body protein synthesis or decreased catabolism of these AA. NPB project 13–082.

Key Words: growing pig, immune system stimulation, plasma amino acid flux

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111 Effects of heat stress and zinc supplementation on the lipidome of growing pigs. L. Wang[1,*], P. E. Urriola[2], Z. Luo[2], Z. J. Rambo[3], M. E. Wilson[3], J. L. Torrison[3], G. C. Shurson[2], C. Chen[1], *[1]Department of Food Science and Nutrition, University of Minnesota, St. Paul, [2]Department of Animal Science, University of Minnesota, St. Paul, [3]Zinpro Corporation, Eden Prairie, MN.*

Heat stress (HS) compromises growth performance and health status and is a major detrimental event in pig production. Zinc (Zn) has been explored as a supplement for protecting against the adverse effects of HS. In this study, metabolic effects of HS and Zn supplementation were evaluated by examining the lipidome of growing pigs fed with ZnNeg (no Zn supplementation), ZnIO (120 ppm $ZnSO_4$), or ZnAA (60 ppm $ZnSO_4$ + 60 ppm zinc amino acid complex) diets under diurnal HS (12 h at 37°C and 12 h at 25°C per day) or thermal-neutral (TN) condition (21°C). Diets were based on corn-soybean meal and formulated to meet NRC (2012) requirements. Following a 3 × 2 factorial design, crossbred gilts (71 ± 9 kg BW, $n = 8$/trt) were acclimated to experimental diets for 2 wk and then challenged with a diurnal HS treatment or maintained in a TN environment for 7 d. Liquid chromatography-mass spectrometry (LC-MS) based lipidomic analysis of serum, liver, cecal fluid, and fecal samples indicated that HS led to comprehensive changes in the lipidome while Zn supplementation selectively affected specific lipid species under HS. Compared to TN, HS decreased the levels of the phosphatidylcholines (PCs) containing odd chain fatty acids (pentadecanoic acid and heptadecanoic acid) ($P < 0.05$) while it increased PCs containing very long chain fatty acid (carbon number ≥ 22) or stearic acid in serum and the liver ($P < 0.05$). The HS group also had lower ($P < 0.05$) levels of oleic acid, linoleic acid, and their lysophosphatidylcholine and amide derivatives but higher ($P < 0.05$) levels of medium-chain dicarboxylic acids (suberic acid and sebacic acid) in cecal fluid and fecal samples than TN group. Moreover, under HS, ZnIO diet selectively increased acetic acid, propionic acid, and butyric acid in cecal fluid ($P < 0.05$). Considering microbial metabolism is responsible for

generating many of these lipid markers, HS and Zn supplementation might affect the lipidome partly through changing the metabolic activities of gut microflora.

Key Words: heat stress, lipidomics, zinc supplementation

112 Genetic parameters and genomic regions associated with piglet response to vaccination for porcine reproductive and respiratory syndrome (PRRS) virus and co-infection with PRRS virus and porcine circovirus type 2b (PCV2b). J. R. Dunkelberger[1,*], N. V. L. Seräo[1,2], M. A. Kerrigan[3], J. K. Lunney[4], R. R. R. Rowland[3], J. C. M. Dekkers[1], *[1]Iowa State University, Ames, [2]North Carolina State University, Raleigh, [3]Kansas State University, Manhattan, [4]USDA, ARS, BARC, APDL, Beltsville, MD.*

Objectives of this research were to estimate genetic parameters and to identify genomic regions associated with PRRS viral load (VL), PCV2b VL, and average daily gain (ADG) in nursery pigs vaccinated or non-vaccinated for PRRS virus (PRRSV), followed by co-infection with PRRSV and PCV2b. Data used included 396 commercial crossbred pigs from two PRRS Host Genetics Consortium trials, all from the same genetic supplier. Pigs were sent to Kansas State University after weaning and randomly sorted into two rooms. All pigs in one room were vaccinated for PRRS, and 28 d later, pigs in both rooms were co-infected with PRRSV and PCV2b, followed for 42 d, and genotyped using the 80K BeadChip. PRRS VL after vaccination and post co-infection and PCV2b VL were calculated as area under the curve of serum viremia from −28 to 0, 0 to 21, and 0 to 42 d post co-infection, respectively. Genetic parameters were estimated by fitting multivariate animal models in ASReml4 with litter and pen (trial) as additional random effects. Trait-specific fixed effects of trial and weight and age at vaccination were also fitted. Genome-wide association (GWA) studies were performed by fitting SNPs as fixed effects one at a time in bivariate animal models for the non-vaccinated (Non-Vx) and vaccinated (Vx) groups for each trait. Heritability estimates following vaccination were 0.31, 0.07, and 0.10 for ADG Non-Vx, ADG Vx, and PRRS Vx, respectively. During the co-infection period, heritability estimates were slightly higher at 0.53, 0.57, 0.56, 0.20, 0.18, and 0.15 for ADG Non-Vx, ADG Vx, PRRS Non-Vx, PRRS Vx, PCV2b Non-Vx, and PCV2b Vx, respectively. Standard errors ranged from 0.14 to 0.22. A strong, positive genetic correlation (0.95 ± 1.01) was observed for PRRS VL post-vaccination with PRRS VL Non-Vx. Unique genomic regions were identified between Vx and Non-Vx pigs for each trait, the most significant of which was identified for PCV2b VL and located near the major histocompatibility complex, an important region for response to infection. The chromosome 4 region, which has been associated with VL following PRRS-V-only infection, was associated with PRRS VL Non-Vx but not PRRS Vx or PRRS VL post-vaccination. Together, these results suggest that selection for improved performance under co-infection of PRRS and PCV2b is possible. Additionally, identification of unique genomic regions between Vx and Non-Vx pigs may enable selection of pigs with better response to vaccination. This research was supported by USDA-NIFA grants 2012–38420–19286 and 2013–68004–20362.

Key Words: disease, GWAS, swine

113 Optimizing cost and environmental impact of pig diets. J. Burek[1,*], G. Thoma[1], C. V. Maxwell[2], J. Popp[1], R. Ulrich[1], *[1]University of Arkansas, Fayetteville, [2]Department of Animal Science, Division of Agriculture, University of Arkansas, Fayetteville.*

Livestock production is one of the major causes of the world's environmental problems, such as climate change impact. Researchers are looking for sustainable pig diet formulations within the Climate Change Mitigation and Adaptation in Agriculture (CCMAA) program. The single-objective diets including least cost, least climate change impact, least water, and least land use were modeled using Windows-based User Friendly Feed Formulation (WUFFDA) linear models. Baseline U.S. pig diets for 1 nursery, 2 sow, and 5 grow phases formulated by the University of Arkansas' pig nutritionist included corn, soybean and fish meal, fat, lactose, dry whey, amino acids, minerals, vitamins, and additives. We added the U.S. pig industry top 80 most used feed ingredients to the WUFFDA models. Nutrient characteristics, inclusion limits, cradle-to-farm gate life-cycle assessment (LCA) environmental impacts, and cost data for feed ingredients were obtained from the U.S. Animal Feed Database available in the Pig Production Environmental Calculator (PPEC). Preliminary results show potential to lower cost and environmental footprint in pig producers' feeding systems (Table 113). The linear models input data are changeable including feed costs and availability, pig production practices, environmental footprints, and maximum inclusion rates. Thus, so far we can only conclude that the solution to increase sustainability of pig production for different criteria in the United States is to diversify feed ingredients, in particular for the least water and least land use diets. The formulated diets are currently being validated by

Table 113. Pig diet weight, cost, and environmental impact results for optimized diets per kg market pig, live weight

Cradle-to-farm-gate LCA	Average U.S. pig diet	Least cost	Least climate change impact	Least water depletion	Least land use
Diet weight (kg)	3.09	3.12	2.99	3.14	3.14
Total pig diet cost ($)	0.91	0.87	1.13	2.04	1.46
Climate change impact (kg CO_2e)	3.08	2.80	1.99	3.14	2.60
Water depletion (m^3)	0.24	0.24	0.14	0.07	0.11
Land use (m^2a)	4.25	7.75	6.04	11.05	1.49

swine nutritionists to check models and diets and propose recommendations to improve their economic and environmental feasibility. Nutritionists have an important role because they create connection between the scientific research, validation, and pig producers. Also, we will perform the multi-objective analysis and evaluate the potential to simultaneously reduce cost and environmental impacts. The proposed diets will be available in the PPEC for pig producers, which will allow pig producers to make informed decisions that can help reduce costs and environmental impacts throughout pig life-cycle.

Key Words: life cycle assessment, linear optimization, pig diets, pig production

GRADUATE STUDENT COMPETITION: MS POSTER

114 Alterations of the rumen bacterial and archaeal communities in growing and finishing beef cattle and its effects on methane emissions.

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The rumen harbors a complex microbial community that is greatly influenced by diet composition. This microbial community is critical to the survival of the animal and provides up to 80% of the animals' energy needs. However, as a by-product, the rumen microbial community also produces methane. The sub-group of methane producing organisms in the rumen are called methanogens. The interactions between methanogens and the rumen microbial population is dictated by diet. As a result, the methane being released from cattle will be influenced by the diet being fed to the cattle. Therefore, evaluating the microbial community composition under different dietary conditions and relating these interactions to methane emissions is critical to methane mitigation. To evaluate the effects of diet on microbial community composition and methane emission, 120 animals were fed 10 different growing and 6 finishing diets. Growing diets included high and low quality forage, with and without monensin supplementation, and different inclusions of modified distillers grains plus solubles (MDGS), and finishing diets contained different fat sources (corn oil, tallow, and distillers) with and without monensin supplementation, and direct fed microbial (DFM). Microbial community composition and methane emission was monitored. Methane and CO_2 concentrations of respired air were taken during feeding in an individual feeding facility utilizing 120 individual bunks equipped with the Calan® gate system and an automated gas collection system. Rumen contents were collected via esophageal tubing for microbial community analysis. The V3 region of the 16S rRNA gene was sequenced using the Ion Torrent personal genome machine (PGM). When compared to the respective control diets, the microbial community composition differed in growing and finishing diets. To further evaluate the microbial community involved in methane emission and performance, correlation analysis was performed using microbial community composition and performance parameters. This analysis identified many OTUs correlated with methane emission, performance, and intake. This study demonstrates that certain members of the rumen microbial community have a profound effect on animal performance and methane emission.

Key Words: Interactions, methane, microbial community

115 Effects of stocking density on finishing pig growth performance.

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A total of 405 pigs (PIC 327 × 1050) from 2 consecutive finishing groups (group 1 initially 66 ± 1.8 kg BW, group 2 initially 61 ± 2.5 kg BW) were used to examine the effects of stocking density on finishing pig growth performance. Pens of pigs were balanced by initial BW and randomly allotted to 1 of 3 treatments with either 7 or 8 replications per treatment (group 1 and 2, respectively). Pens were stocked with 9 pigs, and adjustable gates provided treatments that allowed for 0.84, 0.74, or 0.65 m^2 per pig. All pigs were fed the same diets fed in 3 phases. Pigs were provided with 7.91 cm of feeder space per pig. In both studies, as stocking density decreased, ADG and ADFI increased (linear, $P < 0.019$), but there was no difference in G:F. As a result, final weight was 3.9 and 5.3 kg greater (linear, $P \leq 0.005$) in groups 1 and 2, respectively, when comparing the lowest to the highest stocking density treatments. When comparing growth performance to a suggested required *k*-value of 0.0336, performance should have been affected above 122, 102, and 83 kg at 0.84, 0.74, and 0.65 m^2 per pig. In group 1, performance should not have been affected until after 109.0 kg, 94.0 kg, and 80.3 kg for the 0.84, 0.74, and 0.65 m^2 per pig treatments, respectively. However, in group 1 even after d 14 (less than 74.5 kg), negative effects of increased stocking density were observed on ADFI (linear, $P < 0.08$). In group 2, performance should not

Table 115.

Group 2	Space allocation per pig, m^2				Probability, $P <$	
Item	0.84	0.74	0.65	SEM	Linear	Quadratic
Pens, no.	8	8	8	–	–	–
d 0 to 77						
ADG, kg	0.995	0.964	0.931	0.0134	0.005	0.949
ADFI, kg	2.917	2.804	2.702	0.0323	< 0.001	0.899
G:F	0.341	0.344	0.345	0.0032	0.416	0.814
Final BW, kg						
d 77	138.24	135.76	132.93	1.1626	0.004	0.902

have been affected until after 118 kg, 87 kg, and 74 kg for the 0.84, 0.74, and 0.65 m^2 per pig treatments. Similar to group 1, feed consumption and consequently ADG decreased linearly ($P \leq 0.033$) as stocking density increased, before pigs reached the *k*-value that should have influenced performance. Overall, this study indicates that increasing stocking density resulted in poorer ADG driven by a reduction in ADFI and the accepted *k*-value of 0.0336 might underestimate the impact of increased stocking density.

Key Words: finishing pig, space allowance, stocking density

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116 Improving the feeding value of corn stover to enhance cattle performance in a backgrounding phase. K. Nenn[1,*], P. H. V. Carvalho[2], E. Mousel[3], G. A. Bridges[3], S. L. Bird[3], T. L. Felix[2], A. DiCostanzo[1], *[1]University of Minnesota, Saint Paul, [2]University of Illinois at Urbana-Champaign, Urbana, [3]University of Minnesota, Grand Rapids.*

The objective of this study was to investigate the effects of alkali-treatment ($CaOH_2$) or water addition to corn stover on in situ DM and NDF digestibility (DMD and NDFD) and growth performance of cattle during a backgrounding phase. Fifty-one lightweight Angus steers (average BW 197 kg), fed individually in a Calan-Broadbent feeding system, were randomly allotted to 1 of 3 corn stover (30% of diet DM) feeding treatments: 1) dry, untreated corn stover (85% DM), 2) corn stover treated with $CaOH_2$ at 6% inclusion (as-fed basis) and water hydrated to 50% DM, or 3) corn stover water hydrated to 50% DM. Legume-grass silage (15%), dry rolled corn (25%), dry distillers grains and solubles (25%), and a vitamin and mineral supplement (5%) constituted the balance of the diet DM. Steers were fed once daily at 0600 h, and orts were weighed and sampled during this time. Body weight was measured on d 1and 49 after withdrawing feed and water for 16 h. In situ DMD and NDFD were measured at 12, 24, 36, and 48 h in 2 ruminally cannulated steers. Averaged over time, DMD and NDFD differed ($P < 0.05$). Digestibility of DM and NDF of calcium hydroxide-treated corn stover were greater (38.1% and 45.7%), that of untreated corn stover was intermediate (28.1% and 32.8%), and that of water-treated corn stover was lowest (16.9% and 15.5%). Similar results were observed using an in vitro gas production batch culture. Cattle fed water-treated corn stover consumed more ($P < 0.05$) feed DM and had faster rates of gain ($P < 0.05$) than those fed untreated corn stover. Cattle fed calcium hydroxide-treated corn stover had intermediate rates of gain that were similar ($P > 0.05$) to those of cattle fed water-treated or untreated corn stover. Feed conversion was not affected ($P > 0.05$) by corn stover treatment. An alternative to alkali-treatments, albeit when forage supply is not limiting, may be simple water addition as cattle fed water-treated corn stover gained weight more rapidly while consuming more DM.

Key Words: alkali-treatment, corn stover, gains

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117 Effect of milk yield genotype on lipidomic profiles of multiparous Holstein cows during the first 9 wk of lactation. F. Ding[1,*], G. T. Cousillas[2], W. J. Weber[2], B. A. Crooker[2], C. Chen[1], *[1]Department of Food Science and Nutrition, University of Minnesota, St. Paul, [2]Department of Animal Science, University of Minnesota, St. Paul.*

The concentrations of individual fatty acids (FAs) are commonly measured to define the chemical composition and nutritional value of cow milk. However, the distribution of FAs in different milk triacylglycerols (TAGs) and the distribution of these TAGs in different cow milks are rarely examined due to the challenges of analyzing numerous TAGs in milk. In this study, cows (n = 12/genotype) from unselected (stable milk yield since 1964, UH) and contemporary (CH) Holsteins that differed by more than 4500 kg milk/305 d (UH < CH) were fed the same diet ad libitum and housed together beginning 5 wk prepartum. Milk samples were collected weekly from each Tuesday pm milking through 9 wk of lactation. No differences in milk protein and lactose content (PRO%: 3.13% vs. 2.98%, $P = 0.49$; LAC%: 4.69 vs. 4.75, $P = 0.39$) were observed between UH and CH samples. However, compared to UH, CH milk had a higher fat content (FAT%: 3.55% vs. 4.33%, $P < 0.01$). Milk TAGs were further examined by high-resolution liquid chromatography and mass spectrometry and multivariate data analysis (MDA). The distribution patterns of weekly UH and CH samples in the MDA model indicated that TAGs profiles of UH and CH differed greatly in early weeks of lactation but became much more comparable by week 9. The structures of TAGs markers that differed between UH and CH were elucidated by MSMS fragmentation. Hierarchical clustering analysis of these TAGs markers revealed that oleic acid-containing TAGs were enriched in CH milk while the TAGs containing palmitic acid, short-chain, and medium-chain FAs existed in much higher abundance in UH milk. Overall, these observations indicated that, in early lactation, CH had greater incorporation of mobilized fatty acids than UH, which led to different milk TAG profiles between two genotypes.

Key Words: lipidomics, milk, triacylglycerol

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118 Mob grazing effects on cattle performance in southeast Arkansas. H. L. Bartimus[1,2,*], T. G. Montgomery[3], D. Philipp[1], J. Cater[3], K. P. Coffey[1], B. C. Shanks[2], *[1]University of Arkansas, Division of Agriculture, Fayetteville, [2]Lincoln University, Jefferson City, MO, [3]University of Arkansas-Monticello, Monticello.*

Ultra-high-density stocking or mob grazing management has become increasingly popular with producers. Mob grazing

systems are typically characterized by extremely high stocking densities for approximately 1 d or less with the goal of improving soil organic matter and diversification of forage species composition in the long-term. The objective of this study was to evaluate animal performance and health measurements of calves from a mob grazing management option compared with a moderate rotational stocking program. Beefmaster calves (n = 58; 221 ± 8.7 kg initial BW) were stratified by sex and body weight and then allocated randomly to 1 of 4 pastures that were assigned randomly to treatments consisting of 1) a moderate rotational stocking program (MS) or 2) an ultra-high-density rotational stocking program (UH). Pastures consisted primarily of bermudagrass (*Cynodon dactylon*) but also contained significant amounts of broadleaf signalgrass (*Brachiaria platyphylla*), crabgrass (*Digitaria sanguinalis*), and dallisgrass (*Paspalum dilatatum*). Calves began grazing on July 16, 2015 and continued for 75 d until September 29, 2015. The MS calves were managed on 6 paddocks with rotations at 5- to 7-d intervals; the UH calves were managed using 60 paddocks with rotations daily, Monday through Friday. This created a stocking density of approximately 5000 kg of BW/ha and 50,000 kg of BW/ha for MS and UH, respectively. This stocking density is at the low end of UH programs but was chosen to reduce the negative impacts of extremely high grazing pressures on animal gains. Blood samples were collected on September 29 and analyzed for complete blood counts. Data were analyzed using PROC MIXED of SAS. Calf BW and BW change did not differ ($P \geq 0.18$) between MS and UH calves but were greater ($P < 0.05$) for steers than heifers. Total and differential white blood cell counts and red blood cell concentrations were not affected ($P > 0.21$) by treatment, sex of calf, or the treatment by sex of calf interaction. Therefore, after the first year of a long-term study, mob grazed calves performed similarly to calves managed using a moderate rotational stocking program, indicating that such systems can be implemented without having negative impacts on animal growth and health.

Key Words: cattle, mob grazing, performance

119 Cortisol agonist improves growth performance and subsides systemic inflammation in newly weaned pigs. H. Wooten[1,*], J. J. McGlone[1], M. Wachtel[2], A. Rakhshandeh[1], *[1]Texas Tech University, Lubbock, [2]Texas Tech University Health Sciences Center, Lubbock.*

Segregated early weaning (SEW) is one of the most stressful periods that results in intestinal inflammation and reduced productivity of pigs. Anti-inflammatory effects of glucocorticoids have been well documented. Dexamethasone (DEX), a cortisol agonist (CA), is a pharmaceutical compound prescribed in veterinary medicine as an anti-inflammatory agent and has the potential to subside the negative effect of systemic inflammation. Our objective was to evaluate the effect of CA on growth performance, intestinal histomorphology, and measures of immune function in weaning pigs. Eighteen gilts of commercially relevant genetics (BW 5.6 ± 0.85 kg) were assigned to three treatments: (i) unweaned (UWS), (ii) SEW plus CA (WCA; 0.2 mg DEX/kg BW), and (iii) SEW plus saline (WS). Pigs were weaned at 23 ± 2 d of age and received their treatments via intramuscular injections at day −1 and 3 post-weaning. Serial blood samples were taken via jugular puncture on Day 0, 1, 4, and 5 post-weaning and assayed for interleukin-1β (IL-1β), antioxidant levels, and haptoglobin. Pigs in WCA and WS had free access to a conventional corn-soy based diet (14.2 MJ/kg ME and 9 g/kg SID Lysine) after weaning. Pigs were euthanized by intravenous injection of sodium pentobarbital 5 d after weaning and a segment of the jejunum was removed for histomorphology examination. Body weight of the animals was monitored on a daily basis. Treatment with CA did not affect villus architecture and feed intake ($P > 0.10$). Weaning reduced the villus height by 30% (709 SE 62.6 μm in UWS; $P < 0.03$) but had no effect on crypt depth. Relative to WS and UWS, WCA pigs had higher plasma antioxidant levels (1.14, 1.04, and 1.05 SE 0.032 mM, for WCA, UWS, and WS, respectively; $P < 0.02$). Treatment with CA reduced plasma levels of haptoglobin (from 0.74 to 0.39 SE 0.164 g/ml) and IL-1β (from 17.0 to 2.6 SE 5.84 pg/ml) in weaned pigs ($P < 0.04$). Body weight (kg) was higher in WCA (6.4 SE 0.05) than SW (6.2 SE 0.05) but lower than UWS pigs (6.8 SE 0.08; $P < 0.04$). Relative to WS, gain-to-feed ratio was higher among WCA pigs (0.56 vs. 0.90 SE 0.070; $P < 0.01$). Collectively, these results suggest that treatment with CA can partially mitigate the negative effect of weaning stress on growth performance of piglets by subsiding systemic inflammation.

Key Words: cortisol agonist, dexamethasone, weaning pig

GRADUATE STUDENT COMPETITION: PhD POSTER

120 Characterization of nutrient content, yield, and gross return to cattle feeding at three corn crop endpoints. H. E. Larson[1,*], A. A. Hohertz[1], M. Lostetter[2], A. DiCostanzo[1], *[1]University of Minnesota, St. Paul, [2]University of Minnesota Rosemount Research and Outreach Center, Rosemount.*

Data collected at 3 reproductive stages and at harvest from 11 corn fields (8.5 ha/field; 4 as corn grain and 7 as corn grain/corn silage traits) were utilized to measure yields, nutrient concentrations, and simulated gross return from feeding cattle on 40 ha of corn harvested as corn silage (CS), corn earlage (E), or whole corn (WC). Field sample (3.72 m^2 plot) collection began at silking (R1) 73 d after planting and ensued for corn reproductive stages R5 (CS), R6 (E), and harvest (WC). Stages

R5, R6, and harvest occurred 49, 56, and 86 d following the onset of R1. Plant DM at R1, R5, or R6 was evaluated using Pearson's correlation coefficients as possible predictors of DM content of alternative endpoint crops. Correlations of corn grain yield at harvest with WC residue yield, E, and E residue yield were also tested as predictors of various endpoint yields given WC yield. Gross return of crop harvest for sale to simulated enterprises: grain market or cattle feeding using WC, as CS, or E was determined. Each enterprise valued corn grain at market price ($0.14/kg). Credit for crop residue (market price for corn stover) removed for feed or bedding was given but adjusted to debit caused by residue removal based on fertilizer value (market prices for urea, diammonium phosphate, and potash). Fertilizer value of manure (pricing same as for residue) was credited when cattle feeding was simulated. Corn trait effect on DM, CP, NDF, and ADF at CS, E, and WC was not significant ($P > 0.05$). Total plant DM at R1 was a poor predictor of crop DM as CS, E, or WC ($P > 0.05$). Additionally, total plant DM as CS was not highly correlated with crop DM as E or WC ($P > 0.05$). Yield of E, E residue, or CS were not correlated ($P > 0.05$) to WC yield. However, WC yield was correlated (0.878; $P = 0.003$) to WC harvest residue. Simulated gross returns from cattle feeding were greater ($P > 0.05$) than marketing corn grain. Simulated gross returns were greatest ($P < 0.05$) when feeding cattle WC, intermediate ($P < 0.05$) when feeding cattle E, and lowest ($P < 0.05$) when feeding cattle CS.

Key Words: corn, crops, feedlot

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121 Carcass gain, efficiency, quality, and profitability in steers at extended days on feed. R. G. Bondurant[1,*], J. C. MacDonald[1], G. E. Erickson[1], K. Brooks[1], K. W. Bruns[2], R. N. Funston[3], *[1]University of Nebraska, Lincoln, [2]University of Nebraska-Linclon, West Central Research & Extension Center, North Platte, [3]University of Nebraska, North Platte.*

Crossbred steers (n = 114, initial BW = 334; SD = 30 kg) were utilized to evaluate the change in carcass composition throughout the feeding period and the economic profit/loss realized by feeding cattle 0, 22, and 44 d longer than the industry average. Steers were assigned randomly to 1 of 3 pens and stepped up on a common finishing ration 24 d before the start of the study. On d 1, cattle were weighed and assigned randomly to 3 serial harvest groups within pen, allowing for 38 steers per harvest (1/3 of each pen). Steers were fed a common finishing ration using the GrowSafe system, allowing for calculation of daily individual feed intake and individual steer to serve as the experimental unit. Carcass ultrasound measurements of LM area, intra-muscular fat percentage, and 12th rib fat thickness were collected on 76 steers (2 pens) at 1, 78, and 134 d on feed (DOF). Steers were considered industry average when the group assigned to the first slaughter averaged 1.3 cm for 12th rib fat thickness (142 DOF). The second and third slaughter groups were harvested at 163 and 185 DOF, respectively. Economic assumptions were applied to steers to determine profit/loss per steer when feeding longer DOF. Steer DMI was not different among DOF while live ADG and live G:F decreased linearly ($P \leq 0.04$) as steers were fed to longer DOF. However, HCW increased linearly ($P < 0.01$) from 374 to 410 kg, as steers were fed from 142 to 185 DOF. Steer LM area quadratically increased ($P = 0.04$) from 89.0 to 93.5 cm^2 (142 and 163 DOF, respectively) and remained constant for 185 DOF at 92.3 cm^2. Marbling score numerically increased from 475 to 506 (142 and 185 DOF, respectively) but was not significantly different. Calculated YG and 12th rib fat thickness increased linearly ($P < 0.01$) as DOF increased for steers. Total feedlot costs linearly increased ($P < 0.01$) from $431.33 to $551.14 (142 vs. 185 DOF, respectively) while profit per steer tended to increase linearly ($P = 0.14$) from 142 to 185 DOF ($18.78 vs. $79.30, respectively). The increase in profit despite the added total feedlot costs can be attributed to more HCW sold and a potential increase in QG premiums. When comparing economics at current market conditions, steers can be fed for 44 d longer and increase profit even though HCW and YG discounts increase.

Key Words: carcass traits, feeding duration, profit

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122 Weaned pig responses to *Escherichia coli* lipopolysaccharide challenge when receiving dietary yeast-based nucleotides. S. M. Waititu[1,*], M. C. Nyachoti[1], F. Yin[1], R. Patterson[2], J. C. Rodriguez-Lecompte[3], *[1]University of Manitoba, Winnipeg, MB, Canada, [2]Canadian Biosystems, Calgary, AB, Canada, [3]University of Prince Edward Island, Charlottetown, PE, Canada.*

This study investigated the response of piglets receiving a nucleotide-rich yeast extract (NRYE) without or with feed enzymes (ENZ) and antimicrobial growth promoters (AGP) on performance, blood cell profile, serum and ileum cytokines, and gut structure after an *Escherichia coli* lipopolysaccharide (LPS) challenge. Thirty-six pigs were allotted to 6 diets including: a non-challenged control (CON), LPS-challenged control (LPS), LPS + AGP, LPS + NRYE, LPS + ENZ, and LPS + ENZ + NRYE. On Day 7, pigs were bled and thereafter injected with LPS or sterile saline. Blood samples were collected at 6, 48, and 96 h post-challenge (hpc). After 96 hpc, pigs were euthanized to obtain duodenum, jejunum, and ileum tissues. Overall (d 1 to 11), NRYE supplementation tended to attenuate LPS-induced reduction in gain/feed ratio ($P = 0.096$), but LPS + AGP pigs had higher body weight ($P = 0.04$) and average daily gain ($P = 0.03$) than LPS + NYRE pigs. At 6 hpc, LPS + NRYE and LPS + ENZ + NRYE pigs had lower ($P < 0.05$) plasma urea N (PUN) and higher ($P < 0.05$) platelet count than LPS pigs. At 96 hpc, LPS-induced villus atrophy in the jejunum and duodenum was attenuated ($P < 0.05$) in LPS + ENZ + NRYE pigs. At 6 hpc, serum TNF-α and IL-10 concentrations were reduced ($P < 0.05$) and

increased ($P < 0.05$), respectively, in pigs receiving AGP, NRYE, and ENZ + NRYE. At 96 hpc, compared with LPS pigs, ileal TNF-α expression was lowered in LPS + NRYE ($P = 0.01$) and LPS + ENZ + NRYE ($P = 0.01$) pigs, whereas ileal IL-1β and IL-10 expression was lower in all treatments ($P < 0.05$). In conclusion, LPS-challenged piglets fed diets supplemented with NRYE without or with enzymes expressed similar beneficial responses as those fed diets with AGP in terms of lowering PUN concentration, reducing duodenal and ileal villi atrophy, and downregulating serum and ileal proinflammatory cytokines. This suggests that supplementation of NRYE can promote the health of piglets during early weaning in antibiotic-free feeding regimens.

Key Words: lipopolysaccharide, nucleotide-rich yeast extract, piglet

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123 Dietary lysine affected the expression of genes related to ubiquitin-proteasome protein degradation pathway in skeletal muscle of finishing pigs. T. Wang*, N. Regmi, J. M. Feugang, M. A. Crenshaw, J. R. Blanton, S. F. Liao, *Mississippi State University, Mississippi State.*

It has been known that some amino acids, such as leucine, can function as signaling molecules to regulate the skeletal muscle growth of pigs. However, which signaling pathway(s) that may be regulated by dietary lysine is unclear. This study was conducted to identify the genes that may be regulated by dietary lysine and that are responsible for the muscle growth of pigs. Nine crossbred barrows (94.4 ± 6.7 kg BW) were randomly allotted to 3 dietary treatments (3 pigs/treatment). Three corn and soybean-meal based diets were formulated to meet the NRC (2012) requirements for nutrients except for lysine, whose concentrations were 0.43, 0.71, and 0.98% (as-fed basis) for the lysine-deficient, lysine-adequate, and lysine-excess diets, respectively. The feeding trial lasted 5 wk, during which time the pigs were allowed ad libitum access to diets and water. After the trial, all pigs were harvested and muscle samples were collected from longissimus dorsi (between the 10th and 12th ribs). Total RNA was extracted from 50 mg of each sample using the TRIzol reagent. The Porcine Gene 1.0 ST Array (Affymetrix, Inc.) was used to quantify the expression levels of 19,211 genes. Raw microarray data were normalized with the gcRMA algorithm and analyzed with ANOVA using Partek Genomics Suite (Partek, Inc.). A total of 674 transcripts were differentially expressed ($p < 0.05$); 60 out of 131 transcripts (at $p < 0.01$) belong to 58 genes and 71 were unannotated. Canonical pathway analysis of these 58 genes using the IPA software (Qiagen.com) revealed that the protein ubiquitination pathway was significantly affected ($P < 0.01$) by dietary lysine level, which involved at least 6 genes. Specifically, when compared to the lysine-adequate group, the expression of DNAJA1, HSP90AB1, and UBE2B was up-regulated in the lysine-deficient group, while the expression of DNAJA1, HSP90AA1, HSPH1, and UBE2D3 was downregulated in the lysine-excess group. The protein ubiquitination pathway plays a major role in the degradation of short-lived or regulatory proteins by the 26S proteasome complex, affecting a variety of cellular processes including cell cycle, cell proliferation, apoptosis, and transcription regulation. Taken together, decreasing dietary lysine level may activate, while increasing dietary lysine level may inhibit, the ubiquitin-proteasome pathway and regulate protein accretion in skeletal muscle of late-stage finishing pigs. Further studies are needed to elucidate how the proteins coded from these genes influence pig skeletal muscle degradation. This project is supported by USDA Hatch/Multistate Project 233803.

Key Words: lysine, muscle, pig, protein ubiquitination pathway

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124 Impacts of early weaning and winter feeding strategy on cow-calf performance. J. J. Kincheloe[1,*], K. C. Olson[1], P. S. Johnson[1], R. N. Gates[1], D. Landblom[2], H. A. Richter[3], A. V. Grove[4], *[1]South Dakota State University, Rapid City, [2]North Dakota State University, Dickinson, [3]Natural Resources Conservation Service, Pierre, SD, [4]AG Research, LLC, White Sulfur Springs, MT.*

Low-input winter feeding programs and early weaning of calves can reduce annual feed costs and maintain cow performance; however, few reports in the literature examine long-term response or the interaction of these management strategies on the cow herd. The objective of this study was to evaluate the effects of early versus normal weaning (WEAN) in conjunction with two winter feeding strategies (WINTER) on cow BW, body condition score (BCS), reproductive performance, and calf performance. Mixed-age Angus × Simmental cows ($n = 239$) were used in a 6-yr study conducted at the SDSU Antelope Livestock and Range Research Station. Cows were randomly assigned to one of two weaning treatments (early wean [EW] in August or normal wean [NW] in November). Following normal weaning and through calving, cows were randomly assigned to one of two feeding treatments: wintered on native range with access to a distillers-grains-based supplement (low-input winter feeding [LOW]) or fed mixed alfalfa-grass hay with the option of grazing native range (high-input winter feeding [HIGH]). After initial treatment assignment, cows remained in original treatments throughout the project. Cow BW and BCS were recorded before calving, at initiation of breeding, at early weaning, and at normal weaning. Reproductive response, calf performance, and culling rates were recorded. Cow BW and BCS were greater ($P < 0.05$) for EW vs. NW cows at normal weaning every year. Cows on the EW treatment lost more BW from calving to breeding compared to the NW treatment (mean loss 28.5 vs. 7.0 ± 3.9 kg; $P = 0.0001$). There was a WEAN × WINTER interaction ($P = 0.05$) for pregnancy

rate (98% for NW HIGH vs. 94% NW LOW cows, with EW treatment intermediate). Mean calving date was 3 d later ($P < 0.05$) by cows on EW HIGH than EW LOW or NW HIGH. Calving and weaning rates did not differ ($P > 0.70$) among WEAN or WINTER treatments. Calf ADG from birth to EW tended ($P = 0.06$) to be greater for EW vs. NW calves (1.09 vs. 1.06 ± 0.015 kg/d, respectively). Cows on LOW had greater ($P < 0.05$) cull rates and were on study a shorter amount of time compared to cows on HIGH. Early vs. normal weaning maintained cow BW and BCS at greater levels throughout the study. WEAN and WINTER treatments rarely interacted in their influence on performance.

Key Words: DDGS, early weaning, hay, winter feeding

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125 Influence of growing phase feed efficiency classification on finishing phase growth performance and carcass characteristics of beef steers fed different diet types.

J. R. Russell[1,*], E. L. Lundy[1], N. O. Minton[2], W. J. Sexten[2], M. Kerley[2], S. L. Hansen[1], *[1]Iowa State University, Ames, [2]University of Missouri, Columbia.*

A multi-year study utilized 985 crossbred steers (464 ± 32 kg, SD) fed in six separate groups to determine the influence of growing phase (GP) feed efficiency (FE) classification and diet type on finishing phase (FP) FE. At University of Missouri, steers were fed GP corn (G-Corn; 528 steers) or roughage-based (G-Rough; 457 steers) diets using GrowSafe feed bunks to measure DMI for 69 to 89 d. At the end of the GP, steers were ranked by residual feed intake (RFI), shipped to Iowa State University, and blocked into FP pens (5 to 6 steers/pen) by GP diet and RFI rank (lower, middle, or upper one-third). Steers were transitioned to either FP corn or byproduct-based diets. After completion of the sixth group, average GP gain:feed within GP diet was calculated for each FP pen (168 total pens) using GP initial BW as a covariate. Pens were classified as highly (HFE; > 0.5 SD from the G:F mean; 58 pens), mid (MFE; ± 0.5 SD from the G:F mean; 60 pens), or lowly (LFE; < 0.5 SD from the G:F mean; 50 pens) feed efficient. Data were analyzed using PROC MIXED of SAS. Experimental unit was FP pen, and the model included the fixed effects of GP diet, FE classification, FP diet, and the interactions. Group (1 to 6) was included as a fixed effect. There were no three-way interactions ($P \geq 0.2$) for any traits. Finishing phase G:F was not affected by any interactions ($P \geq 0.5$) but was greater ($P \leq 0.03$) for HFE versus MFE and LFE and greater ($P = 0.02$) for MFE versus LFE. Growing phase diet × FE classification effects were detected ($P \leq 0.01$) for FP final BW (FBW), ADG, and DMI. Among G-Corn steers, LFE had greater ($P = 0.03$) FBW than HFE while ADG was unaffected ($P \geq 0.2$) by FE classification, but among G-Rough steers, HFE and MFE had greater ($P \leq 0.04$) FBW and ADG than LFE. Among G-Corn steers, LFE had greater ($P \leq 0.003$) DMI than MFE and HFE, but DMI was unaffected ($P \geq 0.3$) by FE classification among G-Rough steers. Overall, differences in finishing phase G:F between FE classifications were driven by different factors depending on diet; DMI differed among corn-grown steers and ADG differed among rough-age-grown steers. In this study, FE was repeatable from the growing to the finishing phase.

Key Words: cattle, feed efficiency, repeatability

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126 Effects of grinding corn through a 2-, 3-, or 4-high roller mill on milling characteristics, and finishing pig growth performance and carcass characteristics.

J. T. Gebhardt[1,*], M. D. Tokach[1], J. C. Woodworth[1], J. M. DeRouchey[1], R. D. Goodband[1], K. F. Coble[2], C. R. Stark[1], C. K. Jones[1], S. S. Dritz[1], *[1]Kansas State University, Manhattan, [2]New Fashion Pork, Jackson, MN.*

Finishing pigs ($n = 922$, initial BW = 40.1 kg) were used in a 97-d experiment to determine the effects of grinding corn through various roller mill configurations on milling characteristics and growth performance and carcass characteristics of finishing pigs in a commercial setting. Pens were randomly allotted to 1 of 4 experimental treatments by initial BW with 11 pens/treatment and 21 pigs/pen. All diets were fed in 5 phases with the same corn-soybean meal-based diets containing 20% dried distiller's grains with solubles. Experimental treatments included corn ground to 685 µm using 2 sets of rolls (2-high), corn ground to 577 µm using 3 sets of rolls (3-high), corn ground to 360 µm using 4 sets of rolls in a fine grind configuration (4-high fine), and corn ground to 466 µm using 4 sets of rolls in a coarse grind configuration (4-high coarse). The same roller mill was used for all configurations with the appropriate lower rolls completely open when using 2 or 3 sets of rolls. Grinding rate (tonnes/hour) was greatest ($P < 0.05$) for the 2-high and 4-high coarse configurations followed by the 3-high configuration and lowest for the 4-high fine configuration. Electricity cost was lowest ($P < 0.05$) per tonne of ground corn for the 2-high configuration and was greatest for the 4-high fine configuration. Pigs fed diets containing corn ground with the 2-high configuration had the greatest ($P < 0.05$) ADFI and ADG with pigs fed diets with corn ground using the 4-high fine configuration having the poorest ADFI and ADG (2.81, 2.73, 2.65, 2.73 kg for ADFI and 0.987, 0.967, 0.940, 0.971 kg for ADG for 2-high, 3-high, 4-high fine, 4-high coarse, respectively). There were no differences in G:F, caloric efficiency, or carcass characteristics among pigs fed diets ground with the different roller mill configurations. Feed cost/kg gain was lowest ($P < 0.05$) for the 4-high coarse configuration and revenue/pig was greatest ($P < 0.05$) for the 2-high and 4-high coarse configurations. Income over feed cost (IOFC) was lowest ($P < 0.05$) for pigs fed diets with corn ground using the 4-high fine configuration; however, there were no differences in IOFC among the other milling configurations. In our study, roller mill configuration had a significant impact on grinding

electricity cost, grinding rate, as well as ADFI and ADG; however, roller mill configuration had no impact on G:F.

Key Words: finishing pigs, grinding cost, roller mill

GROWTH, DEVELOPMENT, MUSCLE BIOLOGY AND MEAT SCIENCE

127 Pork quality: 2015 national retail benchmarking study. L. A. Bachmeier[1,*], S. J. Moeller[2], C. Carr[3], J. M. Young[1], X. Sun[1], J. H. Liu[1], S. B. Schauunaman[1], D. J. Newman[1], *[1]North Dakota State University, Fargo, [2]The Ohio State University, Columbus, [3]University of Florida, Gainesville.*

The purpose of this benchmarking study is to quantify pork quality variation in the retail self-serve meat case and provide information that can be used to implement changes necessary to meet the National Pork Board SMART objective of reducing pork having a subjective color score of 1 or 2 by 10% by the year 2020. The objective of this study was to benchmark pork quality from the top 3 major retailers and supermarkets in each market area across the United States according to the 2013 Progressive Grocer Marketing Guidebook (Stagnito Media, 2013). A total of 133 retail supermarkets, representing 28 market areas from 23 states were selected for the study. Samples were collected between January 2015 and April 2015 to eliminate seasonal variation. An experienced grader analyzed subjective color and marbling scores according to the National Pork Board Color and Marbling Standards (NPB, 2011) and various quality defects (bruising, blood splash, bone dust) in the meat retail case. Ten center-cut loin chop packages for each brand and enhancement type (enhanced and non-enhanced) were purchased. After purchase, samples were shipped to North Dakota State University for subjective and instrumental parameters for evaluation of subjective color, subjective marbling, instrumental color (CIE L*, a*, and b* color space values), pH, cook-loss percentage, and tenderness as determined by the Warner-Bratzler shear force method. Data were analyzed using the means and mixed procedures in SAS (SAS Institute, Cary, NY). Mean subjective color score values were 2.85 ± 0.79 for in store evaluation and 2.74 ± 0.79 for in laboratory evaluation. Mean subjective marbling score values were 2.30 ± 1.07 for in store evaluation and 2.27 ± 1.02 for in laboratory evaluation of subjective marbling. Mean instrumental color values were 55.56 ± 3.63 for L*, 16.60 ± 2.30 for a*, and 10.33 ± 1.53 for b*. Mean pH value was 5.83 ± 0.32. Mean cook-loss percentage was 14.22 ± 6.34%, and the Warner-Bratzler shear force value was 24.25 ± 7.23 N. Results indicate that a great deal of pork quality variation exists in the retail meat case nationwide.

Key Words: benchmarking, pork, quality

128 *Moringa oleifera* as an alternative protein source to soybean meal in pig production. A. Ruckli[1], G. Bee[2,*], *[1]Institute for Livestock Sciences, Posieux, Switzerland, [2]Agroscope Institute for Livestock Sciences, Posieux, Switzerland.*

Due to the rather ideal amino acid composition, soybean meal (SBM) is commonly used as the sole protein source in pig diets. In countries where this protein source is not easily available, alternative protein sources such as *Moringa oleifera* (MO) leaves have been proposed for pig diets. The aim of the present study was to establish the impact of replacing SBM by MO in a finisher diet on growth performance and carcass and meat quality. For the study, 24 Swiss Large White pigs from 6 litters were selected at 66.7 kg BW and assigned within litter to 2 treatments: finisher diet containing SBM (7.18%) and MO (15.56%) as the major protein source. All pigs were reared in one pen equipped with 4 automatic feeders equipped with individual pig recognition systems. They had ad libitum access to the assigned isonitrogenous (162 g/kg DM) and isoenergetic (14.4 MJ/kg DM) diets. The pigs were weighed weekly, and individual feed intake was monitored daily. After 55 d of feeding, pigs were slaughtered and organ weights and carcass and meat quality traits were assessed. Body weight at slaughter was 8.59 kg lighter (109.87 vs. 118.46 kg; $P < 0.01$) in MO than SBM pigs. The lower (771 vs. 954 g/d; $P < 0.01$) growth rate was a result of the lower average daily feed intake (2.71 vs. 3.41 kg/d; $P < 0.01$) whereas gain:feed was not affected (284 vs. 280 g/kg; $P = 0.49$). Hot carcass weight and carcass yield was lower (87.30 vs. 97.45 kg; 79.42 vs. 82.27%; $P < 0.01$ for each) in the MO group. Due to heavier ($P \leq 0.06$) ham (17.46 vs. 16.76%) and shoulder (12.09 vs. 11.23%) and lower (14.78 vs. 16.31%; $P < 0.01$) subcutaneous fat weight, lean meat percentage was greater in MO than SBM pigs (55.17 vs. 53.36%; $P = 0.05$). Expressed as percentage hot carcass weight, relative liver weight was greater (8.08 vs. 7.09%; $P < 0.01$) and relative kidney (1.48 vs. 1.63%) and lung weight (2.61 vs. 2.74%) were lower ($P < 0.01$ for each) in MO pigs. The loin of MO pigs was less ($P < 0.01$) red (a*: 5.0 vs. 5.8) and yellow (2.1 vs. 2.6), and ultimate pH was 0.1 units greater (5.6 vs. 5.5; $P = 0.02$). Similar effects were observed on backfat color. Water holding capacity but not shear force was impaired in the loin of MO pigs as drip loss (1.35 vs. 0.88%), thaw (8.47 vs. 6.91%), and cooking loss (23.14 vs. 21.90%) were greater ($P \leq 0.06$). Despite similar nutrient content of the finisher diets, replacing SBM by MO not only impaired growth but also negatively affected important meat quality traits.

Key Words: *Moringa oleifera*, pig, protein source

129 Effect of marketing group on the variability of fresh loin, belly, and fresh and processed ham quality from pigs sourced from a commercial processing facility. E. K. Arkfeld[1,*], K. B. Wilson[1], M. F. Overholt[1], B. N. Harsh[1], J. E. Lowell[1], E. K. Hogan[1], B. J. Klehm[1], B. M. Bohrer[1], B. C. Peterson[1], K. A. Kroscher[1], C. R. Stites[1], D. A. Mohrhauser[2], D. A. King[3], T. L. Wheeler[3], A. C. Dilger[1], S. D. Shackelford[3], D. D. Boler[1], *[1]University of Illinois, Urbana, [2]Smithfield Foods, Denison, IA, [3]USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE.*

The objective was to quantify the effect of marketing group (MG) on variability of pork primal quality. Pigs (N = 7684) were slaughtered in 3 MGs from 8 barns. Pigs were from production programs focused on lean growth (MG 1: n = 1131; MG 2: n = 1466; MG 3: n = 1030) or superior meat quality (MG 1: n = 929; MG 2: n = 1559; MG 3: n = 1569). Data were analyzed as a split-plot design to test production program and MG. The Levene's test was used to determine differences in MG variability. Carcass composition, VISNIR predicted slice shear force (SSF), subjective loin quality measures, and iodine values were collected on all carcasses. In-plant loin and belly quality analyses were randomly conducted on 52.0% and 47.5% of the carcasses, respectively. Loins and hams from selected carcasses (N = 864; 10% of population target) were collected for SSF analysis and processed ham characteristics. Quality pigs from MG3 had a lighter HCW and belly weight than quality pigs from MGs 1 and 2 ($P \leq 0.03$). Pigs from MG 1 were fatter ($P = 0.04$) than pigs from MG 3, but MG 2 was not different ($P \geq 0.27$) from other MGs. Loin depth and percent lean were not different among MGs ($P \geq 0.23$). Variability ($P \leq 0.01$) differed among MGs for HCW, fat depth, and percent lean. Loin depth variability was similar across all MGs ($P = 0.20$). Iodine value means ($P = 0.10$) and variability ($P = 0.07$) were not affected by MG. No belly quality measures were affected by MG ($P \geq 0.10$). Selected ham weights before and after skin removal were lighter in lean MG 1 than lean MGs 2 and 3 and were lighter in quality MG 3 than quality MGs 1 and 2 ($P < 0.01$). Loin marbling, VISNIR predicted SSF, and measured SSF were not different due to MG ($P \geq 0.39$). Lean pigs from MG 3 had a heavier inside ham weight than lean MG 1 and quality MGs 2 and 3 ($P \leq 0.05$). Lean MG 3 had a heavier outside ham weight than lean MG 1 and quality MG 3 ($P < 0.01$). Within MG 3, green weight and netted boneless weight were heavier in hams from lean pigs than quality-focused pigs ($P \leq 0.05$). Cured color was darker in MG 3 than MGs 1 and 2 ($P < 0.01$). Use of MGs did not control variability in carcass composition. Although MG had no effect on loin or belly quality, it did alter cured ham color. Differing genetic selection focus impacted the weight of primals within MGs. Supported by National Pork Board Grant 14–221.

Key Words: composition, marketing group, quality

130 Carcass length is a poor predictor of the number of boneless chops from a pork loin. K. B. Wilson[*,1], M. F. Overholt[1], E. K. Hogan[1], C. M. Shull[2], A. C. Dilger[1], D. D. Boler[1], *[1]University of Illinois, Urbana, [2]The Maschhoffs, LLC, Carlyle, IL.*

The objective was to determine the predictive ability of pork carcass length on the number of boneless loin chops from a loin. Barrows and gilts (N = 1238) were raised under commercial conditions and marketed when the average pig weight in a pen reached 138 kg. Pigs were slaughtered over 7 wk in a commercial processing facility. Carcass length was measured on the left side of each carcass from the anterior of the aitch bone to the anterior of the first rib at 1 d postmortem. Carcasses were fabricated, and boneless Canadian back loins (IMPS 414) were vacuum-packaged and transported to the University of Illinois Meat Science Laboratory. Loins were stored at 4°C for 14 d. At the end of the aging period, loins were weighed, measured for stretched length (stretched to maximum length without distortion), compressed length (compressed to minimum length without distortion), and sliced into 2.54-cm chops using a Treif Puma slicer. Complete boneless chops were counted, and ends and incomplete chops were weighed. Carcass length varied from a minimum of 78.2 cm to a maximum of 96.5 cm. Chops yielded from boneless loins varied from a minimum of 13 chops to a maximum of 20 chops. Data were analyzed using the regression procedure of SAS. The dependent variable was the number of boneless chops. Coefficient of determination was determined for carcass length, boneless loin weight, stretched loin length, and compressed loin length. Carcass length explained 15% ($P < 0.0001$) of the variation in the number of boneless loin chops. Loin weight explained 33% ($P < 0.0001$) of the variation in the number of boneless loin chops. Stretched loin length explained 9% ($P < 0.0001$) of the variation in the number of boneless loin chops. Compressed loin length explained 28% ($P < 0.0001$) of the variation in the number of boneless loin chops. Multiple linear regression was used to determine a predictive equation for the number of boneless loin chops using stepwise selection option of all independent variables. The combination of loin weight and compressed loin length was able to explain 39.3% ($P < 0.0001$; C(p) = 12.399) of the variation in the number of boneless loin chops using a required F statistic at the SLENTRY and SLSTAY level = 0.15. Overall, carcass length is a poor predictor of the number of boneless chops generated from a pork loin.

Key Words: carcass length, chop yield, loin

131 Intramuscular variation in fresh ham muscle color. D. A. King*, S. D. Shackelford, T. L. Wheeler, *USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE.*

This experiment was conducted to characterize a defect involving pale muscle tissue in the superficial, distal portion of ham muscles, causing two-toned appearance of cured ham products. Biceps femoris muscles (n = 200), representing 3 production systems, were obtained from the ham-boning line of a large processor. Instrumental color attributes (L*, a*, and b*) were determined on the medial and lateral surfaces of the muscle using a Hunter MiniScan colorimeter (25 mm port) before they were sliced (2.54 cm thick) perpendicular to the long axis of the muscle. Slices were numbered from the proximal end of the muscle so that slice numbers represented anatomical location. Severity of the defect was greatest on the distal end of the muscle corresponding to slices 6 and 7 (of 9 slice locations). The superficial (affected, lateral) portion of these slices was separated from the deep (unaffected, medial) portion. Myoglobin concentration and muscle pH were determined on both portions. The medial surface of the muscle had much lower ($P < 0.05$) L* (53.1 versus 63.4) and greater ($P < 0.05$) a* (23.2 versus 15.3) and b* (18.5 versus 15.4) values than the lateral surface. Compared to the superficial portion, the deep portion of the muscle had greater ($P < 0.05$) muscle pH (5.68 versus 5.51) and myoglobin content (1.98 versus 0.86 mg/g). Muscle pH and myoglobin content explained 20 and 7% of the variation in L* values of the deep portion of the muscle, respectively. Conversely, myoglobin content and muscle pH explained 28 and 8% of the variation in L* values in the superficial portion of the muscle, respectively. Similar relationships were seen with regard to a* values. Five minimally affected and 5 severely affected muscles were sampled in the superficial (lateral) and deep (medial) portions for muscle fiber type determination. Fiber type distribution did not differ ($P > 0.05$) between the deep and superficial portions of minimally affected muscles. However, in severely affected muscles, the deep portion had increased ($P < 0.05$) proportion of red fibers and concomitant decrease ($P < 0.05$) in white fibers relative to the superficial portion. Muscle fiber areas were smaller ($P < 0.05$) in severely affected muscles, regardless of location. These data indicate that the superficial (lateral) portion of the muscle is much lighter and less red in color, resulting from a lack of myoglobin content in this portion of the muscle associated with a shift in muscle fiber type.

Key Words: color, fiber-type, myoglobin

132 A mitochondrial protein increases glycolytic flux in muscle postmortem. S. K. Matarneh[1,*], E. M. England[2], T. L. Scheffler[3], C. N. Yen[1], D. E. Gerrard[1], *[1]Virginia Polytechnic Institute and State University, Blacksburg, [2]The Ohio State University, Columbus, [3]University of Florida, Gainesville.*

Development of meat quality attributes is prominently influenced by the rate and extent of postmortem pH decline. Abnormally low ultimate pH (pH < 5.4) adversely impacts meat color, texture, water holding capacity, and protein content. Postmortem muscle acidification is usually explained by the degradation of muscle glycogen via glycogenolysis and glycolysis to yield lactate and hydrogen ions, which accumulate in the muscle and cause a drop in pH. The role of mitochondria in this process is not well-established; therefore, the purpose of this study was to determine the role of mitochondria in postmortem metabolism. Muscle samples were excised from the longissimus lumborum muscle of six market weight pigs within 5 min of exsanguination. Samples were either immediately frozen in liquid nitrogen or designated for mitochondria isolation. Frozen muscle samples were homogenized into a reaction buffer that mimics postmortem glycolysis. Either 0 or 0.5 mg/ml isolated mitochondria was incorporated into the buffer with or without mitochondrial inhibitors for complexes I, IV, and V. Aliquots were removed at 0, 30, 120, 240, and 1440 min for pH and metabolite analysis. Data were analyzed with a mixed model in SAS-JMP, and changes over time were determined by repeated measures. Mitochondria lowered ($P < 0.05$) pH values at 240 and 1440 min regardless of inhibitors. The reduction in pH was coupled with enhanced ($P < 0.05$) glycogen degradation, glucose 6-phosphate formation, and lactate accumulation. These data indicate that the effect of mitochondria was through increasing the rate of glycolytic flux and not through mitochondrial electron transport chain as indicated by the lack of inhibitors effect; however, the mechanism by which mitochondria enhanced glycolytic flux is still unknown. To study this phenomenon further, mitochondrial samples were homogenized with a polytron and then centrifuged, and the resulting supernatants were transferred to another tube while pellets were resuspended again. Mitochondrial supernatants or pellets were added to the in vitro model to test which compartment was responsible for the effect. Mitochondrial supernatants produced the same effect as preparations including total mitochondria. No effect was observed with the mitochondrial pellet. To further narrow our target of investigation, mitochondrial supernatant proteins were precipitated with perchloric acid (PCA). Supernatants were centrifuged and neutralized before retesting in the in vitro system. The effect of mitochondrial supernatant was lost after PCA treatment. These data indicate that a mitochondrial-based protein is capable of increasing glycolytic flux in postmortem muscle.

Additional research is needed to identify the causative agent.

Key Words: glycolytic flux, mitochondria, postmortem metabolism

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133 Low fat ground beef patties have increased oxidation compared with high fat ground beef patties. D. R. Reynolds[1,*], J. V. Cooper[1], B. R. Wiegand[1], Z. D. Callahan[2], A. B. Koc[3], L. Schumacher[1], L. Fernando[1], C. L. Lorenzen[1], *[1]University of Missouri, Columbia, [2]Division of Animal Sciences, University of Missouri, Columbia, [3]Clemson University, Clemson, SC.*

Meat oxidation is caused by several factors including light source, oxygen incorporation during grinding, and degree of fat saturation. The objective of this study was to determine the impact of fat percentage on color and lipid oxidation in ground beef. Subcutaneous fat was removed from top rounds ($n = 20$), which were ground to produce patties (113.4 g) with either 5 or 25% fat. No additional fat was added to patties containing 5% fat. Subcutaneous fat from each top round was added back to achieve 25% fat content. Patties were packaged in Styrofoam trays with oxygen-permeable overwrap and then assigned into deli cases (5°C) with one of three lighting conditions: low UV fluorescent, light emitting diode (LED), or no light (negative control). Patties were removed from storage on d 1, 3, 5, and 7 for evaluation of objective color measurements L*, a*, and b* and lipid oxidation determination by thiobarbituric acid reactive substances (TBAR). Myoglobin states were calculated using selected wavelengths. Means were separated using GLIMMIX on SAS. Patties with 5% fat had greater a* values ($P < 0.05$) than 25% for storage d 1, 3, and 7; the exception was Day 5 where there was no difference ($P > 0.05$). Metmyoglobin (MMb) percentage increased by storage day for both 5 and 25% fat with a difference ($P < 0.05$) on Day 7 of storage where patties with 25% fat had a greater percentage (45.28) MMb than patties with 5% fat (44.14). Conversely, oxymyoglobin (MbO_2) percentage decreased by storage day for both 5 and 25% fat with a difference ($P < 0.05$) on Day 7 of storage where 5% fat patties had a greater MbO_2 percentage (53.71) than patties with 25% fat (52.43). TBAR values increased by day for each fat percentage ($P < 0.0001$). After storage Day 1 ($P > 0.05$), means were consistently lower ($P < 0.05$) on storage Day 3, 5, and 7 for patties with 25% fat. Data from this study confirmed that the phospholipid membrane layer plays a larger role in lipid oxidation than additional added subcutaneous fat in ground beef.

Key Words: fat percentage, ground beef, myoglobin, oxidation

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134 Comparison of new and modern lighting technologies on ground beef color. J. V. Cooper[*1], D. R. Reynolds[1], B. R. Wiegand[1], Z. D. Callahan[2], A. B. Koc[3], L. Schumacher[1], C. L. Lorenzen[1], *[1]University of Missouri, Columbia, [2]Division of Animal Sciences, University of Missouri, Columbia, [3]Clemson University, Clemson, SC.*

Meat color is the most important factor that drives consumer purchasing decisions. The objective of this study was to determine the impact of 2 different light sources on oxidation that causes color change in ground beef from the conversion of oxymyoglobin (MbO_2) to metmyoglobin (MMb) in a controlled environment. Top rounds ($n = 20$) were ground at 2 different fat levels (5 and 25%) and made into patties (113.4 g). Patties were assigned to 1 of 3 lighting treatments (low UV fluorescent, Light Emitting Diode [LED], and no light [negative control]) within temperature controlled deli cases at 5°C. Patties were removed on storage d 1, 3, 5, and 7 of storage. Utilizing a Hunter MiniScan 4500L, objective color measurements L*, a*, and b* were utilized to determine relative myoglobin variant concentrations as a measure of myoglobin oxidation. Means were separated using the GLIMMIX function of SAS with differences determined at $P < 0.05$. Objective color measurement for redness, a*, decreased for all light treatments by storage day ($P < 0.0001$) where storage Day 1 > 3 > 5 > 7, respectively. Oxymyoglobin values for all light treatments decreased daily ($P < 0.0001$) but showed no differences among treatments until d 5 where no light > LED > FLO with means of 57.52, 56.75, and 55.94%, respectively. Inversely, MMb values increased daily ($P < 0.0001$) but showed no differences among treatments until d 5 where FLO > LED > no light with means of 41.70, 40.10, and 38.96%, respectively. In this study, no light was the superior display lighting; however, on storage d 5 LED had more desirable MbO_2 and less MMb than LED. Indicating that LED a* and MbO_2 values were more similar to patties treated with no light than FLO treated patties.

Key Words: color, ground beef, lighting, myoglobin

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135 Grass fed or dark, firm, and dry? A. Apaoblaza[1], S. K. Matarneh[*1], E. M. England[2], T. L. Scheffler[3], S. K. Duckett[4], D. E. Gerrard[1], *[1]Virginia Polytechnic Institute and State University, Blacksburg, [2]The Ohio State University, Columbus, [3]University of Florida, Gainesville, [4]Clemson University, Clemson, SC.*

Fresh beef quality development is dictated by the extent of postmortem pH decline. During the conversion of muscle to meat, pH drops from 7.2 to an ultimate pH near 5.6. However, some animals exhibit insufficient postmortem muscle acidification (pH > 6.0) which lead to dark, firm, and dry (DFD) or dark cutting meat. Cattle fed a grass-based diet often produce meat with a greater ultimate pH, which can be undesirable to consumers due to its darker color. Recently, our group showed

that the ultimate pH of meat in pigs is controlled by muscle metabolic profile. We hypothesized that grass-fed cattle have a more oxidative metabolic profile than grain-fed cattle. To test this notion, longissimus dorsi samples from 10 grain-fed and 10 grass-fed beef cattle were collected 24 h postmortem. Muscle samples were analyzed for ultimate pH and glycolytic potential. The abundance of lactate dehydrogenase (LDH), glyceraldehyde 3-phosphate dehydrogenase (GAPDH), and succinate dehydrogenase complex subunit A (SDH-A) was determined by immune-blotting. Greater ultimate pH ($P < 0.05$) was observed in the muscle of grass-fed cattle compared with grain-fed cattle, while no differences in glycolytic potential were detected. As predicted, the grass-fed beef exhibited a more oxidative metabolic profile as indicated by the greater ($P < 0.05$) abundance of SDH-A and the lower ($P < 0.05$) abundance of LDH and GAPDH. To confirm these findings and to minimize sources of variability, muscle samples from both feeding strategies each were pulverized in liquid nitrogen, then incorporated at 1:10 (wt/vol) into a reaction buffer that contained all metabolites needed for glycolysis. Using this in vitro model, we used muscle tissue as the source of glycolytic enzymes and compared anaerobic glycolysis under the same environment. Aliquots were removed at 0, 30, 120 240, and 1440 min for pH and lactate analysis. Greater ($P < 0.05$) pH values were observed at 240 and 1440 min when grass-fed beef muscle tissue was used. The elevated pH values 240 and 1440 min were coupled with lower ($P < 0.05$) lactate accumulation. The longissimus dorsi of grass-fed cattle exhibits a greater ultimate pH and a more oxidative metabolic profile than grain-fed cattle. The greater ultimate pH may contribute to the darker color of grass-fed beef.

Key Words: Dark cutting, grass fed, metabolic profile

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136 Autophagy induction in the pig follicular stage ovary during heat stress. B. J. Hale*, C. L. Hager, A. A. Al-Shaibi, J. T. Seibert, L. H. Baumgard, A. F. Keating, J. W. Ross, *Iowa State University, Ames.*

Heat stress (HS) occurs when heat dissipation mechanisms are overwhelmed by heat accumulation processes. HS in pigs is associated with seasonal infertility, a major source of production losses in the swine industry. We have previously shown that HS interferes with molecular pathways contributing to follicle recruitment and development in pigs. Autophagy is the process by which somatic cells degrade and recycle cellular components and is activated by a variety of stressors. During autophagy the cytoplasm is sequestered into a double-membraned cytosolic vesicle, the autophagosome, which fuses with a lysosome to form an autolysosome enabling degradation by lysosomal hydrolases. The Bcl-2 family member protein, Bcl-xL, regulates autophagy through its interaction with Beclin 1 (BECN1), and BECN1 increases membrane isolation after initial induction. During autophagosome membrane extension microtubule-associated protein 1 light chain 3 β (LC3B) is cleaved to form LC-3B-II, which associates with the autophagosomal membrane. An increase in LC3B-II is considered to directly correlate with the abundance of autophagosomes. The objective of this study was to characterize autophagy-related proteins following cyclical HS experienced during the follicular phase preceding ovulation. To accomplish this, 12 gilts were synchronized using Matrix® administered orally for 14 d and subjected to cyclical HS ($n = 6$) or thermal neutral (TN; $n = 6$) conditions for 5 d immediately following Matrix® withdrawal. The ambient temperature in the TN room was 20.3°C ± 0.1°C, and the TN room humidity was 33 ± 13%. The cyclical HS room temperature was 26–32°C and the HS room humidity was 24 ± 6%. During the maximal HS load for each day, the HS pigs had increased ($P = 0.001$) average rectal temperatures (39.8°C ± 0.2°) compared to the TN pigs (38.8°C ± 0.2°). Ovarian protein abundance of BECN1, LC3B-II, and Bcl-xL were elevated as a result of HS ($P < 0.05$). LC3B was localized to the granulosa and theca cells of growing follicles, though HS had no effect on LC3B cell specificity. Bcl-xL was more abundant in the oocytes of growing follicles ($P = 0.008$) due to HS and was qualitatively increased in primary follicles due to HS. These results suggest that autophagy is induced in the ovary due to HS, though future investigations are required to determine if autophagy is a mechanism which enables the ovary to mitigate the deleterious effects of HS on the follicle and maturing oocyte. This project was supported by the Iowa Pork Producers Association.

Key Words: aut ophagy, heat stress, ovary

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137 Use of visible and near infrared spectroscopy to predict beef and pork quality. S. D. Shackelford*, D. A. King, T. L. Wheeler, *USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE.*

A method was developed for evaluation of meat quality with visible and near-infrared spectroscopy. An optimal method was developed for evaluation of the LM cross-section of ribbed beef carcasses with a high-intensity reflectance probe and that method was used to evaluate U.S. Select carcasses online during beef grading in 2 experiments ($n = 292$; $n = 467$). It was determined that carcasses could be sorted into groups that differed in mean LM slice shear force (SSF)at 2 and 14 d postmortem and the percentage of samples with LM SSF > 40 (2 d postmortem) or 25 kg (14 d postmortem). Although the system used in the previous experiments allowed for online tenderness prediction, it was not optimized for beef carcass evaluation. Additionally, a limitation to the commercial adoption of that system was that the predicted SSF value was affected by the length of time that the LM was exposed to air (bloomed) before evaluation. A commercial vendor optimized the technology hardware for carcass measurement. Because optimization included changes to the system, a new model had to be developed ($n = 1155$) and it was proven to predict SSF without bias due to bloom time. That model was field tested ($n = 4204$) and shown to work for both U.S. Choice and

U.S. Select carcasses. Application to the ribeye during grading resulted in classes that differed in SSF for LM, gluteus medius, semimembranosus, biceps femoris, and adductor ($P < 0.0001$). This technology was applied to the ventral side of boneless pork loins ($n = 901$) and a model was developed that resulted in classes that differed in SSF at 14 d postmortem. Upon field testing ($n = 1208$ from 4 plants) it was determined that reflectance at 822 nm was indicative of variation in tenderness both among and within plants. Predicted tenderness classes, based on reflectance at 822 nm, differed in mean LM SSF values at 15 d postmortem ($P < 10^{-26}$) and in the percentage of loins with SSF > 25 kg ($P < 10^{-16}$). This technology also effectively sorted pork loins with regard to intramuscular fat level and lean color stability.

Key Words: Near-Infrared, Prediction, Tenderness

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138 The quandaries of measuring meat quality.

J. K. Apple*[1], J. W. S. Yancey[2], [1]*Department of Animal Science, University of Arkansas Division of Agriculture, Fayetteville,* [2]*Department of Animal Science, University of Arkansas, Fayetteville.*

Meat quality is an ambiguous term, and its definition may include some component of eating quality (fresh meat appearance and palatability), shelf-life (color stability and palatability retention), wholesomeness (microbiological safety), nutritional composition (lean-to-fat ratio, calories, nutrient content and availability, etc.), and convenience (method and ease of preparation). It seems, however, that measuring meat quality varies as widely as its definition, and there remains considerable inter-institution variation among meat quality sampling and measurement. There are standardized sensory panel training protocols and shear force procedures when measuring cooked meat palatability, but academia, meat industries, and consumers use a variety of cookery methods based on cost, familiarity, facilities, tradition, and science. Water-holding capacity (WHC), an economically relevant meat quality attribute, can be measured using drip-tubes, any variant of the suspension method, Carver-press, or centrifugation. Visual color of fresh meats impacts consumer purchasing decisions, but how many researchers screened potential visual color panelists for their ability to discriminate color differences using the Farnsworth-Munsell 100-Hue test? Furthermore, instrumental meat color is typically measured using 1 of 2 colorimeters, but choice of illuminant/light source, aperture size, and number of readings/sample can impact color data collection and the relationship between visual and instrumental color measurements. Additionally, iodine value has become a valued measure of pork fat quality; yet, the choice of sampling site on a carcass varies among pork companies and research groups, and the available information indicates that the fatty acid compositions of the various fat depots, as well as fat layers within a specific depot, are not always closely correlated. In conclusion, the choice of any meat quality measurement should be based on: 1) sound science; 2) high repeatability; and 3) the production of industry- and/or consumer-relevant results.

Key Words: Color, Fat quality, Palatability, Water-holding capacity

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139 Differentiating lamb flavor.

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Since we are expecting consumers to pay more for lamb, the outstanding flavor of lamb must be consistent and/or improved allowing for lamb consumers to be continually satisfied. The importance of lamb flavor in the marketplace is underscored by the fact that consumers' flavor preferences are reflected in their lamb purchase decisions. The most recent National Lamb Quality Audit (NLQA) data identified eating satisfaction at the most prominent factor defining lamb quality, and eating satisfaction was most commonly defined as lamb flavor and/or taste. Additionally, 71.7% of the purchasers of U.S. lamb surveyed in the NLQA indicated that they were willing to pay a premium for guaranteed eating satisfaction, and they also indicated, on average, that they were willing to pay an 18.6% premium for this guarantee. This information serves as an indication that differentiating lamb on the basis of flavor may result in considerable premiums and allow for the American lamb industry to capitalize on opportunities with lamb flavor to increase demand. It has been well established that production practices and animal age influence lamb flavor by altering fat and lean composition. Specifically, as lambs mature, and even if lambs are grain-fed for extended/excessive periods of time, there is an increase in the concentration of branched-chain fatty acids resulting in undesirable, "mutton-like" off-flavors. Also, grass-finishing results in a higher proportion of long-chain, unsaturated fatty acids which are less stable and an increase in skatole potentially result in undesirable flavors. The NLQA data indicated that respondents closest to the consumer identified characterized American lamb as having "good flavor", "milder flavor", flavorful, and "different than grass flavor". Responses regarding the image of imported lamb resulted in lamb described as "less flavorful", "gamey flavor", "different flavor", "stronger flavor", and "consistent flavor".The NLQA data suggest that consumers desire for lamb flavor to be characterized for individual products allowing the purchaser to make a purchase on the basis of their flavor preference (e.g., bold, medium, or mild). Fat and lean compositional differences can be measured using volatile flavor compound analysis and olfactometry (electronic nose), and researchers focusing on the flavor or meat have been able to associate meat flavor attributes with these methods. The purpose of this research is to develop a proof of concept for using these technologies to differentiate lamb flavor and identify the opportunity to utilize these technologies at production speeds to segregate lambs into unique flavor groups.

Key Words: Flavor, Lamb

140 Effects of *M. hyopneumoniae* vaccination program and water-delivered antibiotic programs on growth performance and morbidity and mortality in wean-to-finish pigs. N. M. Stas*[1], M. Ellis[1], J. E. Estrada[2], B. A. Peterson[3], C. M. Shull[3], E. Parr[3], C. Johnson[3], [1]*University of Illinois, Champaign-Urbana,* [2]*University of Illinois, Urbana-Champaign,* [3]*The Maschhoffs, LLC, Carlyle, IL.*

The objective of this study was to determine the effectiveness of 2 *M. hyopneumoniae* vaccination programs and 5 water-delivered antibiotic programs at improving growth performance, and reducing morbidity and mortality of pigs under commercial conditions during the wean-to-finish period (6.5 ± 0.55 kg to 133.9 ± 1.55 kg BW). A total of 4760 pigs housed in mixed-sex pens (barrows and gilts) of 34 pigs/pen were used. The pigs used came from a population that had a history of *M. hyopneumoniae* infection. Pigs were kept at commercial floor spaces (0.62 m^2/pig) and had ad libitum access to feed and water throughout the study. The study was conducted as a RCBD with a 2 × 5 factorial arrangement of treatments: 1) Mycoplasma Vaccine: Program 1 (2cc RespiSure-ONE® at 3 to 4 d of age and 1cc Fostera™ PCV MH at 28 d postweaning) vs. Program 2 (Program 1 + 2cc RespiSure-ONE® at wk 10 postweaning; and 2) Water Antibiotic: Plan 1 (100 g/gal Neomycin at weaning for 7 d + 350 g/gal OTC and 0.25L/gal Denagard® at d 7 for 7 d) vs. Plan 2 [Plan 1 + 350 g/gal OTC and 0.25L/gal Denagard® (d 28 for 7 d)], vs. Plan 3 [Plan 1 + 40 g/gal Aivlosin® (d 28 for 7 d)], vs. Plan 4 [Plan 1 + 350 g/gal OTC and 0.25L/gal Denagard® (d 28 for 7 d) + 80 g/gal Lincomycin Soluble (wk13 postwean for 7 d)], vs. Plan 5 [Plan 1 + 40 g/gal Aivlosin® (d 28 for 7 d) + 80 g/gal Lincomycin Soluble (wk 13 postwean for 7 d)]. There was a Mycoplasma Vaccine by Water Antibiotic treatment interaction ($P < 0.05$) for overall ADG; however, the differences between treatment subclass means were small and inconsistent. There was no effect ($P > 0.05$) of Mycoplasma Vaccine or Water Antibiotic treatments on ADFI, G:F, or morbidity and mortality. Fluid testing for *M. hyopneumoniae* was performed periodically throughout the study period; positive test results were only observed near the end of the study in pigs subjected to Program 1. These results suggest no differences in performance for the *M. hyopneumoniae*vaccine programs or the water-delivered antibiotic programs.

Key Words: antibiotic, pigs, vaccine

141 Effects of reduced-fat modified distillers grains with solubles in finishing diets of feedlot steers on carcass characteristics, fresh and processed beef quality. M. A. Nelson*, C. Fehrman, A. A. Hohertz, A. DiCostanzo, R. B. Cox, *University of Minnesota, Saint Paul.*

Feeding various concentrations of reduced-fat modified distillers grains with solubles (RFMDGS) in finishing feedlot diets was evaluated using fifty crossbred (Angus × Gelbvieh × Holstein × Jersey) steers (initial bodyweight: 379 ± 32 kg). Steers were randomly assigned to 1 of 4 dietary treatments consisting of 14.93% RFMDGS of dietary dry matter (DMD) with 0.74% corn oil DMD (FF15; 4.58% ether extract (EE)); 15.60% RFMDGS DMD (RF15; 3.92% EE); 30.84% RFMDGS DMD (RF30; 4.79% EE); and 46.27% RFMDGS DMD (RF45; 5.52% EE). Steers were fed 181d using a Calan gate system and were harvested at a commercial abattoir. Hot carcass weight; 12th rib backfat; ribeye area; percent kidney, pelvic, and heart fat; and marbling score were collected 24 h postmortem. Strip loins were collected for vacuum purge loss evaluation and fabricated into steaks for drip loss, cook loss, Warner–Bratzler shear force (WBSF), and sensory evaluation. Untrained panelists evaluated cooked steaks on overall liking, flavor liking, texture liking, toughness, juiciness, and off-flavor. Liking ratings were conducted on a 120 point line scale with 120 being strongest like imaginable. Intensity ratings were conducted on a 20 point like scale with 20 being extremely tough, juicy, or intense. Shoulder clods were processed into ground beef and bologna. Untrained sensory panelists evaluated bologna on overall liking, flavor liking, texture liking, toughness, and off-flavor utilizing the same scales as steak sensory. Data were analyzed using the MIXED procedure in SAS with an α level of 5%. Treatment did not affect carcass characteristics ($P = 0.27$) or moisture loss ($P = 0.09$). Values for WBSF of FF15 steaks were greater compared to all other treatments ($P = < 0.01$). Treatment did not affect liking ratings ($P = 0.07$) of steaks. Subjective steak toughness from FF15 were greater than RF15 (10.78 and 8.77, respectively; $P = 0.01$). Subjective juiciness of FF15 steaks was greater than RF45 (8.50 and 6.94; $P = 0.03$). Bologna from RF45 had a greater subjective overall liking and texture liking compared to FF15 (78.14 and 71.63, respectively; $P = 0.03$; 78.25 and 67.51, respectively; $P = < 0.01$. Subjective toughness of FF15 bologna was greater than all other treatments ($P = < 0.01$). Treatment did not affect subjective flavor liking or off-flavor ($P = 0.22$ and $P = 0.51$, respectively) in bologna. Results indicate feeding 45% RFMDG had no effect on carcass traits, decreased subjective toughness in steaks, and increased overall consumer appeal in bologna.

Key Words: beef, quality, reduced-fat modified distillers grains with solubles

142 Diets with organic trace minerals Bioplex®) and yeast Protein (NuPro®) improved the water-holding capacity of pork loin meat. R. M. Delles*[1], A. Naylor[2], A. Kocher[2], K. A. Dawson[1], R. S. Samuel[1], [1]*Center for Animal Nutrigenomics and Applied Animal Nutrition, Alltech Inc., Nicholasville, KY,* [2]*Alltech Australia, Roseworthy, Australia.*

The objective of this study was to investigate the impact of diets with organic trace minerals and yeast protein on pork meat quality during retail display. At 3 wk of age, 324 pigs were weaned, stratified by weight and sex, and placed into 1 of 6 pens, which were randomly allocated to 1 of 2 treatments: (1) barley and wheat diets with inorganic trace minerals (CON) or (2) barley and wheat diets with organic trace minerals and yeast protein (OMN: Alltech, Inc.) Pigs received phase diets over 17 wk. Sixteen pigs (100 ± 5 kg live weight) from each group, 8 replicates per treatment, were slaughtered for meat quality and tissue enzyme activity measurements. Tissue for enzyme and proteomic analysis was obtained from the 10th rib, 2 h post-mortem, frozen in liquid nitrogen and stored at −80°C. After carcasses were chilled at 4°C for 24 h, boneless loin samples (IMPS 414) were removed, vacuum packaged, and frozen at −30°C, for up to 1 mo. Loins were thawed at 4°C in the dark for 36 h, cut into 2.54 cm chops, overwrapped with an air-permeable polyvinylchloride film, and placed in a retail display cooler at 2 to 4°C for up to 7d. Lipid oxidation (TBARS: mg MDA/kg meat) was higher in CON samples, but only significantly ($P < 0.05$) on d4 of retail storage. On d 0, protein carbonyl content was 21.5% lower ($P < 0.05$) in OMN samples compared to CON samples. Water-holding capacity, as measured by purge and cooking losses, was improved in OMN samples on d 4 ($P < 0.05$) and 7 ($P < 0.10$). However, the shear force of OMN pork meat was only lower ($P < 0.05$) than CON samples on d 0 (4.1 vs. 4.4 kgf). Catalase and glutathione peroxidase activities tended to be ($P < 0.10$) and were higher ($P < 0.05$) in OMN samples, respectively. Proteomic analysis revealed that triosephosphate isomerase, creatine kinase, and annexin A1 were overabundant in OMN samples compared to CON. Diets supplemented with organic trace minerals and yeast protein resulted in similar or improved meat quality attributes versus CON, possibly due to the greater enzyme activity and protein expression. OMN pork exhibited improved protein oxidative stability, and subsequently greater water-holding capacity of boneless pork loin chops throughout retail display.

Key Words: Organic trace minerals, Proteomics, Yeast protein

143 Predicting pork color scores using machine vision and support vector machine technologies. X. Sun*, J. M. Young, J. H. Liu, L. A. Bachmeier, R. Somers, S. B. Schauunaman, D. J. Newman, *North Dakota State University, Fargo.*

The objective was to investigate the ability of image color features to predict subjective pork color scores (NPB, 2011). Enhanced retail pork center-cut loin chops in overwrapped packages were purchased and transported to North Dakota State University for analysis. Chops were assessed on the cross-sectional surface for subjective color score by one trained observer (score 2, $n = 75$; score 3, $n = 284$; score 4, $n = 240$; score 5, $n = 86$) and instrumental color (CIE L*, a*, and b*) using a Minolta Colorimeter (CR-410, 50 mm diameter orifice, 2° observer, C light source; Minolta Company, Ramsey, NJ). Images of pork loin samples were then acquired using a machine vision system which include a charge-coupled device (CCD) camera (MV-VS141FM/C, Micro-vision Ltd., China) with a 5mm C-mount lens (aperture of f/1.4 to 16C, H0514-MP2 1/2" fixed Lens, computer CBC Americas Corp, USA). After background and muscle segmentation from images, 18 image color features (mean and standard deviation of R, G, B, H, S, I, L*, a*, b*) were extracted from 3 different color spaces: RGB (Red, Green, Blue), HSI (Hue, Saturation, Intensity), and L*a*b*. Color features were submitted to partial least squares (PLS) regression and support vector machine (SVM) regression analyses to establish prediction models for different color scores. A subsample (80%) of data were used to train the PLS and SVM models, which were then validated on the remaining 20% of the data. For color score 2, the accuracy of the PLS model was 86.7% classified correctly and the SVM model was 93.3% classified correctly. For color score 3, the PLS model predicted 81.5% correctly and the SVM model predicted 79.6% correctly. For color score 4, PLS model predicted 89.6% correctly and the SVM model predicted 91.7% correctly. For color score 5, the SVM model predicted the highest accuracy of 72.7% while the PLS model's prediction accuracy was 90.9%. Image color features isolated through the development of PLS and SVM models show potential as a means to predict pork color scores.

Key Words: color score, machine vision, pork

144 Using machine vision technology to determine pork intramuscular fat percentage. J. H. Liu*, X. Sun, J. M. Young, L. A. Bachmeier, R. Somers, S. B. Schauunaman, D. J. Newman, *North Dakota State University, Fargo.*

The objective of this study was to test the usefulness of using machine vision technology as a tool to determine intramuscular fat (IMF) percentage in pork loin samples. Loin samples (2.54-cm chop) collected from 2 processing plants were utilized in this experiment for IMF determination. Fresh LM

chops were collected and shipped to North Dakota State University for analysis. After arrival, LM chops were trimmed of subcutaneous fat and any connective tissue. Color images of both sides of the LM sample were acquired using machine vision technology which included a camera, lighting system, and computer. Program code was developed at North Dakota State University to segment the background, lean muscle tissue, and IMF. After segmentation, pixels assigned as lean muscle tissue and IMF were counted to calculate an image IMF percentage. Subjective marbling scores (NPB, 2011) were called by an experienced grader from each image. Crude fat percentage was calculated using the ether extract method (AOAC, 1990). Image IMF percentage was compared to ether extract values and subjective marbling score. Results show that subjective marbling score had a correlation of 0.79 with ether extract while image IMF had a correlation of 0.56 with ether extract. The correlation between image IMF and subjective marbling score was 0.56. These results indicate that subjective marbling is currently the most accurate method to determine IMF percentage. However, improvement in machine vision technology shows potential of being a tool for IMF determination in the future.

Key Words: intramuscular fat, machine vision system, marbling

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145 Cutability, nutrient content, and comparison of harvested big game species at progressive stages of processing. D. D. Reed*, E. P. Berg, M. J. Marchello, W. D. Slanger, P. T. Berg, *North Dakota State University, Fargo.*

The potential use of game meat as a nutrient dense food has been largely ignored regarding feeding a growing world population. Data assessing the yield of edible portion lean for many species of wild game is difficult to obtain. The objective of this study was to generate a database for the calculation of edible lean meat from harvest of big game species (antelope, whitetail, mule deer, elk, and moose). The North Dakota Game and Fish Department assisted with recruitment of hunters who were instructed to retain both the entrails and carcass after field dressing. Twenty-two antelope (*Antilocapra americanus*), 20 whitetail deer (*Odocoileua virginianus*), 24 mule deer (*Odocoileus hemionus*), 24 moose (Alces alces), and 12 Elk (*Cervus canadensis*) were obtained to determine cutability. Weights of field dressed carcasses and entrails were recorded at the NDSU meat lab. Carcasses were skinned and lean tissue was removed to be weighed. The cutout weights obtained were field dressed weight, skinned and dressed weight, boneless lean meat and shot loss weight (tissue discarded due to bullet damage). One 454-g sample was taken from the same location of the longissimus muscle of each specie carcass for nutrient analysis. Means and standard deviations were determined and any tests of hypothesis that 2 means are equal were done with independent sample *t* test. Nutritional values for antelope (121.5 mg/100g) and whitetail deer (117.1 mg/100g) had higher cholesterol compared to Standard (USDA marbling score Traces 00–100) beef (60.4 mg/100g) and other game meats. The average yield of lean red meat was 42.6% of live weight, 55.3% of field dressed weight and 68.4% of the skinned/dressed carcass of antelope; 48.7% of live weight, 58.5% of field dressed weight and 68.0% of the skinned/dressed carcass of whitetail deer; 42.8% of live weight, 54.2% of field dressed weight and 65.0% of the skinned/dressed carcass of mule deer; 36.5% of live weight, 50.3% of field dressed weight and 67.0% of the skinned/dressed carcass of moose; and 40.0% of live weight, 54.2% of field dressed weight and 64.8% of the skinned/dressed carcass of elk. These nutrition and yield data may be a valuable tool for estimating the potential dietary contribution of antelope, whitetail, mule deer, moose, and elk annually harvested in by North Dakota hunters.

Key Words: meat source, nutrient composition, wild game

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146 Use of plasma orosomucoid in newborn piglets to predict preweaning growth performance and its potential mechanism of action. T. G. Ramsay*[1], L. A. Blomberg[1], J. L. Vallet[2], T. J. Caperna[1], *[1]USDA, ARS, BARC, Beltsville, MD, [2]USDA, ARS, US MARC, Clay Center, NE.*

Orosomucoid (ORM) is the most prevalent serum protein in the newborn pig. The present study was designed to determine if plasma ORM at birth can be used to predict the relative performance of piglets within a litter between birth and weaning using a highly sensitive ELISA specific for pig ORM. Second, this study looked at the potential mechanism of action of ORM on growth by examining the effects of ORM on protein synthesis in vitro. Plasma was obtained from 19 litters (202 piglets) at the US Meat Animal Research Center. Parity ranged from 1 to 4 (2.4 ± 0.6) with an average litter size of 10.6 ± 0.4 pigs. Samples were analyzed using a pig ORM ELISA developed by USDA-ARS Beltsville. Plasma ORM in newborn piglets was negatively correlated with growth rate between birth and weaning at 21 d of age (linear regression correlation coefficient [CC] = –0.225, $P < 0.003$). This correlation was improved by expressing plasma ORM relative to total plasma protein (CC = −0.370, $P < 0.0001$). When ORM was calculated on a per kg birth weight basis, the CC further improved (−0.462, $P < 0.0001$). How elevated concentrations of plasma ORM at birth are related to poor postnatal growth has not been identified. Therefore, in vitro experiments were performed to determine if ORM can interfere with protein synthesis using the skeletal muscle C_2C_{12} cell line. C_2C_{12} myotubes were treated with serum free Dulbecco's modified Eagle's medium, 0.5% BSA, and 0, 0.1, 1.0 or 10.0 µg/mL mouse ORM in the initial experiment. Treatments were added to cultures for 1 h, then supplemented with 0.5 µCi ^{3}H-tyrosine/mL medium for an additional 2 h for a total exposure time to ORM for 3

h, followed by washes and protein extraction. ORM had no effect on protein synthesis as measured by ^{3}H-tyrosine incorporation ($P > 0.05$; $n = 4$ trials). Treatment with 20 ng IGF1/mL medium increased ^{3}H-tyrosine incorporation by 53% ($P < 0.01$, $n = 3$ trials); whereas the addition of ORM reduced IGF1 induced ^{3}H-tyrosine incorporation by 40% ($P < 0.01$, $n = 3$ trials). These data indicate that ORM can indirectly reduce ^{3}H-tyrosine incorporation into C_2C_{12} myotube proteins by altering IGF1 efficacy, suggesting ORM interferes with the growth promoting effects of IGF1 and may contribute to the observed negative correlation between plasma ORM at birth and preweaning growth rates in swine.

Key Words: α 1-acid glycoprotein, biomarker, growth, neonate, orosomucoid

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147 Effects of feeding calcium hydroxide treated corn stover during backgrounding on carcass characteristics and beef quality. C. Fehrman*[1], E. Mousel[2], A. DiCostanzo[1], R. B. Cox[1], *[1]University of Minnesota, Saint Paul, [2]University of Minnesota, Grand Rapids.*

Sixty-seven purebred Angus steers (initial BW ±197 kg.) were used to evaluate the effects of calcium hydroxide treated corn stover in backgrounding diets after a common finishing phase. Steers were randomly assigned to 1 of 4 treatments 1) backgrounding a turnip cover crop (CC) for 29 d before adapted to ad libitum alfalfa haylage diet for remaining 20 d of study; 2) untreated corn stover as the control treatment (CON), 3) corn stover treated with 50% DM water (H_2O); 4) 50% DM water and calcium hydroxide ($CaOH_2$). Steers were fed individually using a Calan system. All diets were formulated on a dry matter (DM) basis to contain 30% corn stover, 15% alfalfa haylage, 25% dried distillers grains with solubles, 25% dry rolled corn, and 5% supplement containing monensin. Steers were slaughtered when average backfat of the group reached 0.4 inches. Carcass characteristics were collected 48 h postmortem and both boneless strip loins and shoulder clods (IMPS #180 and #114) from the right side of the carcass were collected. Strip loin steaks were used to evaluate purge, cook loss, and Warner-Bratzler shear force (WBSF). Shoulder clods were processed to ground beef for evaluation of retail shelf life. Dietary treatment had no effect on carcass characteristics including HCW ($P = 0.6943$), ribeye area ($P = 0.2590$), backfat ($P = 0.7795$), USDA Yield Grade ($P = 0.8904$), USDA Quality Grade ($P = 0.8771$), and marbling score ($P = 0.8496$). Although purge loss ($P = 0.8839$) and cook loss ($P = 0.1492$) were not affected by treatment, WBSF was lower for CC than CON (1.6 vs. 2.23kg respectively; $P = 0.001$). Objective b* values of fresh steaks on Day 0 were higher for CON than $CaOH_2$ (18.7 vs. 15.76; $P = 0.0019$), and on Day 5, CON was higher than CC (17.42 vs. 14.71; $P = 0.0064$) and $CaOH_2$ (17.42 vs. 14.87; $P = 0.0231$). Ground beef subjective lean color was more bright cherry red and discoloration affected less of the samples on Day 3 for CON than CC and $CaOH_2$ (5.45 vs. 4.73 and 4.85; 8.95 vs. 7.40 and 7.48; $P < 0.001$). The consumer panel found that CON was more desirable than CC on Day 2 (6.42 vs. 5.69; $P = 0.0007$), than H_2O (5.45 vs. 4.95; $P = 0.0413$) and CC (4.55; $P < 0.001$) on Day 3, and than CC (3.55 vs. 3.01; $P = 0.0146$) on Day 4. The use of calcium hydroxide treated corn stover in backgrounding diets of beef calves does not affect carcass characteristics, moisture loss, or WBSF, but does have minimal impact on ground beef shelf life.

Key Words: alkali-treatment, beef, corn stover

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148 Effects of late gestational cow tall fescue forage system on steer offspring carcass characteristics. Z. D. Callahan*[1], K. N. Niederecker[1], J. M. Larson[1], B. R. Wiegand[2], A. M. Meyer[2], *[1]Division of Animal Sciences, University of Missouri, Columbia, [2]University of Missouri, Columbia.*

We hypothesized that cows grazing stockpiled tall fescue (STF) during late gestation would have greater nutrient intake than cows fed summer-baled hay, which would result in increased prenatal nutrient supply and ultimately improved fetal development and subsequent carcass characteristics. Forty-eight multiparous, spring-calving crossbred beef cows (683 + 16 kg BW) were allocated to either strip-graze STF (59.7% NDF, 12.3% CP; DM basis; $n = 4$ pastures) or consume ad libitum tall fescue hay in uncovered drylots (64.9% NDF, 6.2% CP; DM basis; $n = 4$ pens) beginning on d 188 ± 2 of gestation. Treatments were terminated within a week post-calving (average calving date: February 18, 2014), and all cow-calf pairs were managed as a single group until weaning. Postweaning, steer offspring ($n = 17$) were placed under common management and fed growing and finishing diets. Steers were slaughtered in 4 groups based on degree of finish, and samples were collected from the longissimus dorsi, semimembranosus, and supraspinatus. Data were analyzed with maternal forage system as a fixed effect, and dam pasture or pen was considered the experimental unit. It has been previously reported that birth weight was reduced in calves born to cows fed hay during late gestation, suggesting impaired fetal growth due to low forage nutrient availability. Despite this, there was no effect ($P > 0.23$) of maternal forage system on carcass weight, yield grade, marbling score, backfat thickness, ribeye area, KPH, or dressing percent. Additionally, Warner Bratzler shear force, cook loss, percent moisture, and percent fat of the 3 muscles sampled were not impacted by maternal forage system ($P > 0.16$). Longissimus dorsi b* value was greater ($P = 0.03$) for steers born to cows grazing STF compared with steers from hay-fed cows, but there were no other differences ($P > 0.16$) in L*, a*, or b* for the 3 muscles samples. Supraspinatus from steers born to cows grazing STF also tended to have greater ($P = 0.12$) deoxymyoglobin and less ($P = 0.12$) oxymyoglobin. No other differences (P

> 0.25) were observed for metmyoglobin, oxymyoglobin, or metmyoglobin concentrations due to maternal forage system. In conclusion, maternal forage system did not impact steer offspring carcass yield or quality in the current study but may impact product color.

Key Words: carcass, developmental programming, meat color

149 Evaluation of glycated albumin as a metabolic marker for marbling in commercial feeder cattle.
M. Alkhuriji*, S. Vetter, K. C. Swanson, E. P. Berg, *North Dakota State University, Fargo.*

The objective of this study was to determine if glycated albumin can serve as a metabolic marker for marbling in beef cattle. This project utilized 113 crossbred steers consigned to the NDSU Beef Cattle Research Complex. Steers (391 ± 2.80 kg) were randomly assigned to a 2 × 2 × 2 factorial arrangement (n = 14 or 15 per treatment) to determine the effects of conventional (CONV) or natural (NAT) feeding strategies and grain adaptation length (14 vs. 28 d). Diets consisted of corn, dried corn distillers grains with solubles, and 10% forage (hay and corn silage). Blood samples were collected on d 28, 56, 84, 112, and 140 to determine serum glucose (T-GLU) and insulin (T-INSU). On Day 140 before slaughter, blood samples were collected to evaluate total serum protein (T-SP), total serum albumin (T-SA), total serum glycated albumin (T-GA), and percent of T-GA (P-GA). After 140 d on feed, all steers were delivered as one group to a commercial packing facility. Hot carcass weight and carcass measurements (subcutaneous fat thickness adjacent at the 12th rib [FD12], 12th rib ribeye area [REA], marbling score, and kidney, pelvic, and heart fat percentage [KPH]) were measured following a 24 h chill. Total serum protein and T-SA were not influenced by treatment relative to marbling score and feeding strategy and did not correlate with marbling score. CONV possessed a greater concentration of T-GA and P-GA (115.02 vs. 74.43 μmol/L, P = 0.001; 38.88 vs. 16.3%, P = 0.001, CONV vs. NAT respectively). Neither T-GA nor P-GA correlated with marbling score, however, both had a negative correlation with KPH and FD12. Carcasses from NAT fed steers had greater T-GLU concentrations than CONV (115.86 vs. 107.21 mg/dL, respectively; P = 0.02). Steers possessing a slight degree of marbling had the highest T-GLU vs. other marbling categories (P = < 0.0001). The average of T-INSU for modest and moderate marbling scores were greater than small (33.18 and 36.59 vs. 26.84 μU/mL, respectively; P = 0.01), however, all were similar to slight and slightly abundant. Glycated albumin was found to be negatively correlated with the fat depots KPH and FD12 but not associated with marbling score.

Key Words: feeder cattle, glycolated hemoglobin, marbling score

HARLAN RITCHIE SYMPOSIUM

150 Alternative cow-calf production systems: Opportunities and challenges.
R. J. Rasby*[1], J. M. Warner[2], K. H. Jenkins[3], T. J. Klopfenstein[2], *[1]Department of Animal Science, University of Nebraska, Lincoln, [2]University of Nebraska, Lincoln, [3]University of Nebraska, Scottsbluff.*

The University of Nebraska is currently engaged in investigating alternative options to traditional cow/calf production systems. The premise is to research cow/calf enterprises that center around the large number of corn acres that are available in many midwestern and northern plains states. In our experiments, composite June/July calving cows are managed in a dry lot for 365 d. Cows are limit-fed a diet of distillers grains and crop residue (either ground corn stalks or wheat straw). Limit-fed rations meet the cow's nutrient requirements and rations are about 19% Crude Protein and 80% TDN on a dry matter basis, but level of dry matter intake varies depending on stage of production. Initially we designed an experiment to investigate whether it is more efficient, from a feeding perspective, to early wean calves when dry lotting cow-calf pairs. Early weaned (EW) calves were 90 da of age at weaning and were fed the same diet as fed their dams and non-weaned cow-calf pairs. EW calves had a daily DMI of 4.0 kg/h/da from October through January when calves (NM) were weaned from their dams at about 205 da of age. This amount was adjusted weekly and added to 6.9 kg/hd/da DM fed EW cows to derive the total amount fed to the NW pairs. EW cows and calves consumed 11.0 kg total DM/da. NW pairs consumed 10.8 kg total DM/d. Approximately 8.6 kg TDN DM/da was supplied to both EW and NW treatments. As both DMI and cow-calf performance were relatively similar between EW and NW pairs, feed utilization was comparable and BCS was acceptable (≥ 5.0) before the beginning of the breeding season and in January and pregnancy rates have been acceptable. Our data suggest that early weaning does not reduce the feed energy requirements necessary to support the cow-calf pair. Therefore, decisions on early-weaning should be made on a management and forage availability basis as opposed to feed efficiency. We have also compared our confinement cow-calf system to extensive forage cow-calf systems when cows in the extensive forage system calve in either March or June. Total cow confinement systems are more expensive than extensive forage grazing systems. Our current objective is to test a winter management system incorporating winter cornstalk grazing on cow and calf performance for a summer calving cow herd.

Key Words: Beef Cow, Systems, Dry lot

NONRUMINANT NUTRITION

151 Evaluation of copper source addition in the grow-finish phase. L. Greiner[1], A. Graham[*1], B. Knopf[1], R. J. Harrell[2], J. Connor[3], *[1]Carthage Innovative Swine Solutions, LLC, Carthage, IL, [2]Professional Swine Management, Carthage, IL, [3]Carthage Veterinary Service, Ltd, Carthage, IL.*

A total of 1167 pigs (66.36 ± 4.10 kg) were used to evaluate differences in 3 copper sources added in the late grow-finish phase. Treatment diets included a control (CON) with no added copper, and the CON diet plus 150 ppm of $CuCl_2$, CON plus 150 ppm of $CuSO_4$, or CON plus 80 ppm of organic copper (Cu Mintrex®, Novus International, Inc., St. Charles, MO). Diet phase changes occurred at d 21 and 32 d post-allotment. Pigs were penned in blocks of either 24 or 25 pigs/pen with a computerized feed system delivering feed to single-sided feeders. There were a total of 12 replications per treatment group. Data were analyzed as a randomized complete block design using the PROC MIXED procedure of SAS with pen as the experimental unit and treatment as a fixed effect. From d 0 to 21 of the study, there were no significant differences ($P > 0.24$) in performance for the overall effect of CON-fed pigs compared to those fed supplemental copper, regardless of source. During the second phase, there was a tendency for increased ADG (0.84, 0.88, 0.89, and 0.89 kg/d; $P = 0.06$, respectively) among pigs that were fed supplemental copper, regardless of source or inclusion rate. The inclusion of supplemental copper significantly improved (0.31, 0.34, 0.35, 0.33; $P < 0.01$, respectively) the G:F, regardless of source or dose. At d 32, all pigs were weighed and first markets occurred. At this point, all pigs were fed a common diet that included ractopamine and all pens remained on study until completely marketed (approximately 35 d after the first market date). There were no differences (0.98, 0.98, 0.98, 0.97; $P > 0.27$) in the growth performance of pigs during the ractopamine phase. For the overall period (d 0 to market), copper supplementation improved G:F (0.33, 0.34, 0.35, 0.34; $P = 0.01$, respectively). When organic copper was fed, the response was not significantly different from the CON, but did tend ($P = 0.10$) to have improved G:F. There also tended to be a decrease in overall ADFI compared to the CON when either $CuSO_4$ or $CuCl_2$ was fed (2.67, 2.46, 2.56 kg/d; $P = 0.13$, respectively). In conclusion, the addition of supplemental copper, regardless of source, resulted in improved G:F in late finishing swine diets.

Key Words: copper, grow-finish, pigs

152 Effects of *Lactobacillus acidophilus* fermentation product supplementation in different nutrient density diets on growth performance, nutrient digestibility, fecal microbiota and fecal noxious gas emissions in weanling pigs. R. X. Lan[*1], J. M. Koo[2], S. I. Lee[1], I. H. Kim[1], *[1]Department of Animal Resource & Science, Dankook University, Cheonan, South Korea, [2]Shinhan BioChem Co.,, Hwaseong, South Korea.*

Energy density may influence the efficacy of probiotics in pigs. This study aims to determine the effects of LAFP (*Lactobacillus acidophilus* fermentation product; SynGenX®, Diamond V, Cedar Rapids, IA) in different energy diets on growth performance, nutrient digestibility, fecal microbiota and noxious gas emission in weaning pigs. A total of 140 weaning pigs (28d) were used in a 6-wk trial, which allotted into 4 dietary treatments with 2 levels of LAFP supplementation (0 or 1 g/kg) and 2 levels of energy (Phase 1: d 1 to 14, 3750 or 3900 kcal/kg; Phase 2: d 15 to 42, 3550 or 3700 kcal/kg). All pigs were fed diets mixed with 2 g/kg of chromium oxide to calculate apparent total tract digestibility (ATTD). Fecal sample (1 g) from each pen was diluted with 9 mL of 10 g/L peptone broth to evaluate fecal microbiota. All data were subjected to the mixed procedure of SAS for a randomized complete block design with a 2 × 2 factorial arrangement. Interactive effects ($P < 0.05$) of energy and LAFP on H_2S and acetic acid emission were observed at d 42. During d 0 to 14 and d 0 to 42, pigs fed the high-energy diets had greater ADG than pigs fed low-energy diets ($P < 0.05$). During d 15 to 42, pigs fed the diets supplemented with LAFP had greater ($P < 0.05$) ADFI and G:F than pigs fed the diets without LAFP. During d 0 to 42, pigs fed the diets supplemented with LAFP had greater ($P < 0.05$) ADG and G:F than pigs fed the diets without LAFP. Pigs fed the high-energy diets had greater ($P < 0.05$) ATTD of GE than those fed the low-energy diets at d 14. Pigs fed the diets supplemented with LAFP had greater ($P < 0.01$) ATTD of DM than pigs fed the diets without LAFP. Dietary supplementation of LAFP increased ($P < 0.01$) *Lactobacillus* counts and decreased ($P < 0.01$) *E. coli* counts compared with pig fed the diets without LAFP at d 14 and 42. At d 42, H_2S and acetic acid emission were increased ($P < 0.05$) in feces from pigs fed high-energy diets. At d 14 and 42, total mercaptans, H_2S and acetic acid, and at d 42, NH_3 emission were decreased ($P < 0.05$) in feces from pigs fed LAFP diets. The results of this study indicates that the beneficial effects of LAFP supplementation on fecal noxious gas emission are more dramatic with high-energy diets.

Key Words: energy density, *Lactobacillus acidophilus* fermentation product, weanling pigs

Table 154.

Item	CON	NAR	VIR	SE	NAR vs. CON, $P <$	VIR vs. CON, $P <$	NAR vs. VIR, $P <$
ADG, d 0 to 108	0.955	0.968	0.965	0.007	NS	NS	NS
ADFI, d 0 to 108	2.340	2.345	2.374	0.02	NS	NS	NS
G:F, d 0 to 108	0.398	0.408	0.400	0.003	0.05	NS	0.10

153 Inclusion of a hydrolyzed yeast product in grow/finish pig diets reduced mortality. C. L. Levesque*[1], S. Jalukar[2], N. Gutierrez[3], J. F. Patience[3], [1]*South Dakota State University, Brookings,* [2]*Arm and Hammer Animal Nutrition, Mason City, IA,* [3]*Iowa State University, Ames.*

CELMANAX SCP is an enzymatically hydrolyzed yeast product containing yeast culture and other complex carbohydrates. A performance study (142 d) was conducted to assess dietary inclusion level of CELMANAX SCP in grow/finish pig diets based on growth performance, loadout variability (i.e., BW variation at first cut) and carcass characteristics at slaughter (loin and backfat depth, lean percent). A total of 1344 grower pigs (30.3 ± 0.6 kg BW) were randomly divided among 64 pens (n = 16 pens/treatment) in a commercial wean-to-finish facility. Pens were assigned to one of 4 dietary levels of CELMANAX SCP (0.0, 0.01, 0.02, and 0.04%) in a 5-phase feeding program with phase changes occurring on d 28, 57, 84, and 114. Tylan was included at 40 g/ton in Phase 1– 4 and the first 28.4 kg feed/pig in Phase 5. For the remainder of Phase 5, Tylan inclusion was 100 g/ton. Pigs were weighed on a pen basis at the start of each phase as well as individually on d 0 and d 114, which corresponded with first cut. Pens were observed daily and any deaths or removals were recorded. Data were analyzed with the Proc MIXED procedure in SAS with pen as the experimental unit. Differences among treatments was based on Tukey's adjusted means test. There were no differences in pig performance within each phase, across the overall experiment, or for carcass characteristics of all pigs marketed. Body weight at first pull was 123.2 ± 1.3 kg and overall performance (gain, feed disappearance, and gain:feed) was 0.85 ± 0.01 kg/d, 2.40 ± 0.05 kg/d, and 0.34 ± 0.01, respectively. During the trial, there were 2 disease outbreaks (PRRS positive test in Phase 2 and ileitis incident in Phase 4) where an increase in mortality occurred. However, during both periods, pigs fed 0.02% CELMANAX SCP recorded the lowest mortality resulting in a lower (P = 0.02; Chi squared test) overall mortality at 2.8% compared to 7.5, 6.7, and 4.3% in pigs fed 0.0, 0.01, and 0.04% CELMANAX SCP, respectively. This resulted in a net return over feed cost ($/pig started) of $55.82, 56.01, 59.64, 57.20 in pigs fed 0.0, 0.01, 0.02, and 0.04% CELMANAX SCP, respectively; a $3.82 gain in net return over feed cost in pigs fed 0.02% CELMANAX SCP. Dietary inclusion of CELMANAX SCP had no impact on growth performance or loadout variability but reduced overall mortality resulting in improvement in net return.

Key Words: growth performance, grow/finish pigs, hydrolyzed yeast, mortality

154 The effects of feeding narasin or virginiamycin on growth and harvest performance of pigs during the grow-finish period. R. A. Arentson*[1], J. J. Chewning[2], [1]*Elanco, Greenfield, IN,* [2]*Swine Research Services, Inc., Springdale, AR.*

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 pigs during the grow-finish period. On d −7, seventy-two pens each containing 8 pigs with a BW of 23.4 kg were blocked by weight within gender and then treatments: 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 5 pelleted diets containing corn, soybean meal, and DDGS with the appropriate amount of antimicrobial premix added to identical diets within each of the 5 phases. Pigs were weighed on d 0, 28, 56, 76, 97, and 108 to determine initial weight, phase weights, and ADG. Feed issuance and weigh backs were recorded to determine ADFI and G:F. When pigs reached a BW of 127.4 kg, they were transported to a food company for harvest. HCW, fat depth, and loin depth were measured on each carcass. During d 0 to 28, ADG and ADFI of pigs fed diets containing NAR or VIR was greater ($P <$ 0.05) than CON. During d 28 to 56, pigs fed VIR had a greater ADG and ADFI than those fed CON ($P < 0.05$), and tended to have a greater ADFI ($P < 0.1$) than those fed NAR. Pigs fed NAR had a greater ($P < 0.05$) G:F from d 0 to 28 than pigs fed CON or VIR. From d 0 to 108, pigs fed NAR had a greater (P < 0.05) G:F than those fed CON, and tended to be greater ($P <$ 0.10) than those fed VIR. Pigs fed NAR and VIR had a greater ($P < 0.05$) carcass yield than those fed CON. In conclusion, pigs fed NAR or VIR for the entire grow-finish period have greater carcass yield than those fed control, and pigs fed NAR have a greater G:F than those fed CON.

Key Words: Narasin, pig, Virginiamycin

155 Growth performance and serum IgA concentrations in weanling pigs fed dietary prebiotics. Y. S. Li*[1], M. D. Trenhaile[1], M. M. Lima[2], K. C. Moore[1], D. M. van Sambeek[1], T. E. Burkey[1], P. S. Miller[1], *[1]University of Nebraska, Lincoln, [2]Department of Animal Science, São Paulo State University, Jaboticabal/SP, Brazil.*

To determine the effects of dietary prebiotics on growth performance and immune status of weanling pigs, 64 crossbred pigs (initial BW = 6.6 kg; d 20 to 22 post-farrowing) were selected and randomly allotted to 16 experimental pens with 4 dietary treatments (2 barrows and 2 gilts per pen, 4 pens per treatment). The treatments were maintained during Phase I (d 0 to 14 postweaning) and Phase II (d 14 to 28 postweaning). The control diet was a conventional nursery diet formulated with corn, soybean meal, dried whey, fish meal, bovine plasma, and supplements to meet or exceed the 2012 NRC requirements. The additional 3 diets were formulated to contain 0.1% chicory, 0.1% mannan oligosaccharides (MOS), and 0.02% chitosan, respectively. Pigs were given ad libitum access to feed and water in an environmentally-controlled room. From d 0 to 28 postweaning, feed disappearance and individual BW were measured weekly for determination of ADG, ADFI, and G:F. Blood samples were collected weekly for measurements of serum IgA concentrations. Data were analyzed as a completely randomized design using the MIXED procedure of SAS. Overall, dietary prebiotics did not affect ($P > 0.10$) BW (average 16.7 kg; d 28), ADG (361 g), or ADFI (513 g). However, from d 7 to 14, pigs fed MOS had lower (671 g/kg; $P < 0.05$) G:F compared to pigs fed control (830 g/kg), chicory (851 g/kg), and chitosan (871 g/kg) diets. For Phase I, G:F of pigs fed MOS tended to be lower (656 g/kg; $P < 0.10$) than pigs fed control (791 g/kg) and chitosan (783 g/kg), but was not different from chicory (755 g/kg; $P > 0.10$). For Phase II, G:F of pigs fed control (673 g/kg), chicory (686 g/kg), MOS (695 g/kg), and chitosan (695 g/kg) were not different ($P > 0.10$). There were no time × treatment interactions ($P > 0.10$) affecting circulating IgA concentrations. Serum IgA increased ($P < 0.05$) over time from 0.148 to 0.438 mg/mL (d 0 to 28 postweaning), but was not affected by dietary prebiotic. In conclusion, with the exception of subtle decreases in feed efficiency, prebiotic supplementation had no effect on growth performance or serum IgA concentrations in weanling pigs.

Key Words: growth performance; prebiotics; weanling pigs

156 Effects of modified yeast cell wall extract on growth performance and health status of pigs fed diets with low level mycotoxins. I. Park*, J. Guo, S. W. Kim, *North Carolina State University, Raleigh.*

This study was performed to determine the effect of modified yeast cell wall extract (YCWE) (Mycosorb A+, Alltech, Lexington, KY) on growth and health of pigs fed diets naturally contaminated with aflatoxin B1 and fumonisin under the FDA regulatory level. One hundred twenty pigs (60 barrows and 60 gilts at 55.69 ± 6.29 kg BW) were randomly allotted to 4 treatments (2 × 2 factorial arrangement) with 10 pens (3 pigs per pen) per treatment, and fed the experimental diets for 5 wk period. Factors were mycotoxin (0 or 150 ug/kg aflatoxin and 19 mg/kg fumonisin) and YCWE (0 or 2 g/kg diet). All diets were formulated to meet or exceed the NRC nutrient requirements. Feed intake and body weight were measured weekly. At the end of 5 wk, 32 pigs representing a median BW of 8 pens per treatment were selected to take blood samples and euthanized to obtain intestinal tissues. Blood samples were obtained to measure the numbers of blood cells, and to separate serum for liver function test, tumor necrosis factor-α (TNF-α), immunoglobulin G (lgG), malondialdehyde (MDA), and 8-hydroxy-2'-deoxyguanosine (8-OHdG). Mucosa from duodenum and jejunum were obtained to evaluate morphology and to measure TNF-α, MDA, and IgG. Data were analyzed using the Mixed procedure in SAS with pen as the experimental unit using treatments and sex as fixed effects and initial BW as a random effect. Mycotoxin decreased ($P < 0.05$) ADG (1.210 to 0.992 kg/d) at 1 wk, and tended to decreased ($P = 0.099$) BW (68.4 to 67.5 kg) at 2 wk, without affecting overall growth performance after 5 wk feeding. Mycotoxin decreased ($P < 0.05$) neutrophil counts (7.28 to 5.83 cell/mL) and serum cholesterol (86.7 to 77.1 mg/dL). The YCWE decreased ($P < 0.05$) serum 8-OHdG (1.48 to 0.60 ng/mL), and tended to decrease ($P = 0.051$) crypt depth (285 to 261 μm) in duodenum. TNF-α, MDA, and IgG in serum and intestinal mucosa were not affected by 2 treatment factors. There was no interaction between 2 treatment factors. Collectively, dietary mycotoxin under the FDA regulatory level had minor effects on growth performance and hematology, and supplemental YCWE reduced oxidative stress in pigs indicated by reduced serum 8-OHdG.

Key Words: 8-OHdG, growing pig, growth performance, mycotoxin, modified yeast cell wall extract

157 Effects of dietary Cu, Zn, and ractopamine-HCl on finishing pig growth performance, carcass characteristics, and antimicrobial susceptibility of enteric bacteria. J. A. Feldpausch*[1], R. Amachawadi[1], M. D. Tokach[1], H. M. Scott[2], S. S. Dritz[1], T. G. Nagaraja[1], R. D. Goodband[1], J. C. Woodworth[1], J. M. DeRouchey[1], *[1]Kansas State University, Manhattan, [2]Texas A&M University, College Station.*

A total of 480 pigs (PIC 327 × 1050; initially 48.7 kg) were used to determine the interactive effects of supplemental Cu, Zn, and ractopamine HCl on finishing pig growth, carcass characteristics, and antimicrobial susceptibility of enteric bacteria. Treatments were arranged in a 2 × 2 × 2 factorial with main effects of added copper ($CuSO_4$; 0 vs. 125 ppm Cu), added

zinc (ZnO; 0 vs. 150 ppm Zn) and ractopamine HCl (0 vs. 10 ppm during the last 28 d before marketing; Paylean®; Elanco Animal Health, Greenfield, IN). All diets contained 11 ppm Cu and 73 ppm Zn from the trace mineral premix. Pens of pigs were balanced and blocked on initial BW then randomly allotted to 1 of the 4 mineral treatment diets. Twenty-eight d before marketing, pens within each block and mineral treatment were randomly assigned to receive either 0 or 10 ppm ractopamine in addition to the mineral treatment. Adding either Cu or Zn alone did not improve ADG or ADFI yet resulted in numerical improvements in overall G:F and caloric efficiencies but improvements were not additive (Cu × Zn, $P = 0.057$, 0.068 and 0.064 for G:F and caloric efficiency on a ME and NE basis, respectively). Ractopamine improved ($P < 0.001$) overall ADG, G:F, and caloric efficiency thereby increasing final BW by 3% with no change in ADFI. Ractopamine increased ($P < 0.001$) HCW, percent carcass yield, HCW G:F, loin depth, and percent fat-free lean and decreased ($P = 0.014$) backfat. An interaction existed whereby adding Zn or Cu alone to diets containing ractopamine numerically improved percent carcass yield and HCW G:F, but no improvement was observed when the Cu or Zn was added to the control diet or when Cu and Zn were fed in combination in the ractopamine diets (Cu × Zn × ractopamine, $P = 0.011$ and 0.018 for yield and HCW G:F, respectively). Fecal samples were collected on d 0 and at the conclusion of the finishing period (d 90) for bacterial isolation and antimicrobial susceptibility determinations according to minimal inhibitory concentration breakpoints. *Escherichia coli* and *Enterococcus* spp. isolates displayed varying levels of resistance to certain antibiotics before initiation of treatments on d 0. Resistance to most antibiotics decreased ($P < 0.05$) over time or was stable for those that had a low base-line percentage of resistance. Ractopamine and Zn did not adversely affect antimicrobial resistance but extended feeding of 125 ppm Cu throughout the finishing period appeared to antagonize any time-associated decrease in enterococcal resistance to tetracycline, tylosin, and quinupristin/dalfopristin.

Key Words: finishing pig, mineral, antimicrobial resistance

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158 *Lactobacillus acidophilus* fermentation product modulates inflammatory activity by regulating the TLR4 and NFkB expression in porcine peripheral blood mononuclear cells after lipopolysaccharide challenge.

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A total of forty weaned pigs [(Landrace × Yorkshire) × Duroc] were used to evaluate the effects of *Lactobacillus acidophilus* fermentation product (LAFP; SynGenX®, Diamond V, Cedar Rapids, IA) on inflammatory activity after lipopolysaccharide (LPS) challenge. Experimental treatments were T1) control diet + saline challenge; T2) control diet with 0.1% LAFP + saline challenge; T3) control diet + LPS challenge; T4) control diet with 0.1% LAPF + LPS challenge. The BW of individual pig was recorded at the beginning and d-14 and feed consumption was recorded on an individual pig basis during the experiment to calculate ADG, ADFI and G/F. On d 14 of the trial, piglets were challenged with saline (T1 and T2) or LPS (T3 and T4). Blood samples were obtained at 0, 2, 4, 6, and 12h after challenged and analyzed cytokine production and gene expression pattern. Serum insulin-like growth factor 1 (IGF-1), cortisol, tumor necrosis factor α (TNF-α), and IL-6 were determined by ELISA. For peripheral blood mononuclear cells (PBMCs) isolation, the collected blood (with an equal volume of balanced salt solution) was mixed with a half volume of Histopaque solution, and was then centrifuged at 400 × *g* for 35 min at room temperature. The PBMCs were carefully aspirated from the Histopaque solution-plasma interface. The LAPF treatment increased BW, ADG, and ADFI compared to the control diet. With control diet, the LPS challenge (T3) increased immune cells and expression of TNF-α and IL-6 compared to saline challenge (T1). Whereas with saline challenge, LAPF treatment (T2) increased WBCs and $CD4^+$ compared to the control diet (T1). With LPS challenge, LAPF treatment (T4) decreased white blood cells, lymphocytes, $CD4^+$, $CD8^+$, and expression of TNF-α and IL-6 compared to the control diet (T3). LAPF treatment decreased expression of toll-like receptor 4 (*TRL4*) and nuclear factor kappa-light-chain-enhancer of activated B cells (*NFκB*) in PBMCs after LPS challenge, which leads to inhibition of *TNF-α,* interferon γ (*IFNγ*), *IL-6, IL-8,* and *IL1B1* and to induction of *IL-4* and *IL-10*. We suggested that LAPF improved ADG and ADFI and protected against LPS-induced inflammatory responses by regulating *TLR4* and *NFκB* expression in porcine PBMCs.

Key Words: *Lactobacillus acidophilus*; lipopolysaccharide; peripheral blood mononuclear cells

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159 Effects of copper source and level on growth performance and bone mineralization in pigs fed phytase-supplemented diets.

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It is well documented that high levels of trace minerals can inhibit phytase activity and that chelated trace minerals are highly stable, hence, less prone to interact with other dietary components. The objective of this trial was to study the effect of 2 Cu sources and levels in pig diets supplemented with phytase on growth performance and bone characteristics. A total of 144 pigs (initial BW: 42.9 ± 4.95 kg) were allocated (2 pigs/pen) to 6 treatments: 2 control diets with no supplemented Cu, without (NC) or with 500 FTU/kg of phytase (NC+Phy; CIBENZA® PHYTAVERSE®, Novus International, Inc., St Charles, MO), and 4 diets with 500 FTU/kg of phytase with

Cu sulfate ($CuSO_4$) or Cu- Cu methionine hydroxyl analog chelate (Cu-MMHAC, MINTREX®, Novus International, Inc., St. Charles, MO) at 2 different levels (80 or 250 mg/kg). Diets were corn-soybean meal-based, P deficient (STTD P = 0.31%) and were fed for 21 d. A contrast statement was used to determine the main effect of phytase (NC vs. NC+Phy). Data was also analyzed as a 2 × 2 factorial with 2 Cu sources and 2 Cu levels supplemented to phytase containing diets (Table 159). Phytase inclusion increased (NC+Phy vs. NC; $P < 0.01$) final BW and ADG 0–21 d (62.3 vs. 60.2 kg, and 0.943 vs. 0.844 kg, respectively), and bone content of ash ($P < 0.01$; 2.94 vs. 2.38 g/bone), P ($P < 0.01$; 0.507 vs. 0.383 g/bone), and Ca ($P < 0.01$; 0.937 vs. 0.726 g/bone). Growth performance parameters were not different among Cu supplemented pigs. Copper source (P = 0.033) and Cu level (P = 0.028) impacted bone P content, without an interaction between Cu source and level (P = 0.174). Highest bone P content was obtained with Cu-MHAC-80 (0.55 g/bone) and lowest with $CuSO_4$–250 (0.42 g/bone). Bone Ca was affected by Cu source (P = 0.039) and Cu level (P = 0.023), but there was no interaction (P = 0.180). Bone Ca was highest for Cu-MHAC-80 (1.02 g/bone) and lowest for $CuSO_4$–250 (0.77 g/bone). In conclusion, growth performance was not affected by Cu source. As expected, exogenous phytase improved growth and bone parameters. Likewise, Cu-MHAC supplemented at 80 ppm increased bone P and Ca.

Key Words: copper, phytase, growing pigs

Table 159. Effects of Cu source and level on bone measurements (g/bone)

	Bone ash	Bone P	Bone Ca
Cu-MHAC80	3.00	0.55a	1.02a
Cu-MHAC250	2.83	0.51ab	0.93ab
$CuSO_4$ 80	3.00	0.52ab	0.96ab
$CuSO_4$ 250	2.70	0.42b	0.77b
SEM	0.13	0.03	0.05
		P-values	
Cu source	0.618	0.033	0.039
Cu level	0.150	0.028	0.023
Interaction	0.573	0.174	0.180

160 The effect of feeding a phytogenic (Ambitine™FT) with and without added copper on late finishing pig performance.

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Eight hundred and eighty late finishing pigs (initial BW = 95.2kg) were used to evaluate the effect of feeding a commercially available phytogenic Ambitine Feed Technology (Ambitine FT) in corn-soybean meal-dried distillers grains with solubles (DDGS) diet on late finisher pig performance. Pigs were allotted in a randomized complete block design into mixed gender pens, with 11 replicates per treatment, 20 pigs per pen, and fed 1 of 4 dietary treatments. Dietary treatments were Control no medication, AmbitineFT (0.10%), AmbitineFT (0.10%) + Copper Chloride (150ppm), Copper Chloride (150ppm). Pigs were fed 2 dietary phases, phase 1 was fed from Day 0 to 20 and consisted of corn-soybean meal-12.5% DDGS formulated to 0.70% TID lysine, phase 2 was fed from Day 20 to 42 and consisted of corn-soybean meal-10% DDGS formulated to 0.65% TID lysine. Data were analyzed using the Mixed procedure in SAS. There were no difference in pig performance in period 1 d 0 to 20. Total gain for period 2 d 20 to 42 tended to be increased (P = 0.08) with AmbitineFT and AmbitineFT + Copper Chloride treatments when compared to the Control and the Copper Chloride treatment was intermediate (18.40, 19.99, 19.60, 19.24 kg, treatments respectively). Period 2 ADG was increased (P = 0.04) with AmbitineFT and AmbitineFT + Copper Chloride treatments when compared to the Control and the Copper Chloride treatment was intermediate (837.63, 908.91, 891.66, 862.15 g/d, treatments respectively). Period 2 ADFI was not different between treatments (2.979, 2.954, 2.912, 2.894 kg/d, treatments respectively). Period 2 Gain:Feed was increased (P = 0.01) with AmbitineFT, AmbitineFT + Copper Chloride, and Copper Chloride treatments when compared to the Control (0.281, 0.308, 0.306, 0.299, treatments respectively). Overall Day 0 to 42 ADG was not different between treatments (913.45, 941.60, 942.96, 929.34 g/d, treatments respectively). Overall ADFI was not different between treatments (2.840, 2.790, 2.802, 2.805 kg/d, treatments respectively). Overall Gain:Feed for Day 0 to 42 was increased (P = 0.03) with AmbitineFT and AmbitineFT + Copper Chloride treatments when compared to the Control and the Copper Chloride treatment was intermediate (0.322, 0.337, 0.337, 0.331, treatments respectively). Supplementation of AmbitineFT with or without copper chloride to late finishing pigs resulted in improved feed conversion.

Key Words: phytogenic, pig, copper

161 Effects of fiber, a direct-fed microbial, and feeding duration on ileal and total tract digestibility of energy and nutrients by pigs.

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Effects of fiber, a *Bacillus*-based direct-fed microbial (DFM), and feeding duration on apparent ileal (AID) and total tract digestibility (ATTD) of nutrients and energy by pigs were determined. Twenty-four barrows (initial BW: 31.5 ± 1.0 kg) were surgically equipped with a T-cannula in the distal ileum and randomly allotted to 4 treatments with 6 pigs per treatment and six 2-wk periods. Treatments were arranged in a 2 × 2 factorial

arrangement with 2 diet types (low- or high-fiber) and 2 levels of DFM [0 or 60 g DFM (2.4×10^{12} CFU/kg feed)/MT feed]. Pigs were fed their respective treatment diets during periods 2, 3, and 4, but during periods 1, 5, and 6, all pigs were fed the low-fiber diet without DFM. Each period lasted 14 d and involved a 5 d adaptation period, total collection of feces and urine from d 6 to 11, and ileal digesta collection on d 13 and 14. Contrasts were used to compare periods within each treatment group and results for all treatment groups for periods 2, 3, and 4 were analyzed as repeated measures using PROC MIXED of SAS. Results indicated AID of starch and ATTD of DM, GE, ADF, and NDF increased ($P \leq 0.05$) as period increased, regardless of diet type. This corresponded with an increase ($P \leq 0.05$) in DE and ME from 3357 to 3383 and from 3132 to 3199 kcal/kg, respectively, from periods 2 to 4. Pigs fed high-fiber diets during periods 2, 3, and 4 had reduced ($P \leq 0.05$) AID of most AA, ATTD of GE and NDF, and DE and ME compared with low-fiber diets fed during periods 1, 5, and 6. Addition of DFM to the high-fiber diet did not ameliorate the negative effects of fiber on digestibility, but addition of DFM to the low-fiber diet increased ($P \leq 0.05$) the AID of ADF, NDF, Lys, Phe, and Glu by 18.1, 21.7, 1.9, 2.5, and 2.2%, respectively. When DFM were withdrawn from the low-fiber diet, digestibility values were not maintained, indicating that DFM must be fed continuously to exert beneficial effects and that no carry-over effects are expected. In conclusion, AID of starch and ATTD of fiber and energy increased as pig BW increased, but digestibility values of energy and nutrients were reduced by increased fiber in the diets, although the AID of some nutrients were improved by addition of DFM to the low-fiber diet.

Key Words: dietary fiber, direct-fed microbial, pigs

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162 Improved growth performance of nursery pigs fed diets supplemented with a *Bacillus subtilis*-based direct-fed microbial feed additive.

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Three experiments were done to determine the efficacy of a *Bacillus subtilis*-based direct-fed microbial (DFM) feed additive for improving growth performance of nursery pigs. All experiments were done with PIC 337 × C29 terminal pigs weaned at approximately 20 d of age and 6 kg body weight. In all experiments, pens of pigs were blocked by weight and randomly allotted to experimental treatments from within block (replicate). Experiment 1 compared the DFM (Visano Nursery, JBS United, Inc.) to a control in corn-SBM diets with 14 replicates of 10–12 pigs/pen from 7 to 27 d postweaning. All pigs were fed a common complex Phase 1 nursery diet before the start of this experiment. Experiment 2 compared the DFM to a control in corn-SBM-DDGS diets with 11 replicates of 25–28 pigs/pen from 1 to 41 d postweaning. Experiment 3 compared the DFM to a control and a medicated feed additive (MFA)-containing treatment in corn-SBM-DDGS diets with 11 replicates of 10–12 pigs/pen from 1 to 38 d postweaning. The MFA consisted of 55 mg/kg carbadox from d 1–7, 441, and 38 mg/kg CTC and tiamulin, respectively, from d 8–21, and 28 mg/kg carbadox from d 22 to 38. The DFM was supplemented to final diets at 0.05% of complete feed from a premix of analyzed cfu concentration. Body weights, weight gain, feed intake, and feed efficiency metrics were collected in each experiment, and data were analyzed as a randomized complete block design. In Experiment 1, there was a trend ($P < 0.10$) toward a lower feed/gain ratio (1.4%; 1.41 vs. 1.39 kg/kg) in the DFM treatment group. In Experiment 2, supplementation of the *Bacillus* DFM increased ($P < 0.05$) growth rate by 5% (0.36 vs. 0.34 kg/d) and increased ($P = 0.06$) d 41 body weight by 0.5 kg. In Experiment 3, the *Bacillus* DFM increased ($P < 0.05$) growth rate by 10% over the control (0.29 vs. 0.26 kg/d) and reduced ($P < 0.05$) feed/gain ratio by 5% (1.45 vs. 1.52 kg/kg), while the medicated feed additive treatment showed 25% greater ($P < 0.05$) weight gains and 10% lower ($P < 0.05$) feed/gain ratios than the control treatment. Dietary inclusion of the *Bacillus*-based DFM was efficacious in increasing weight gain and improving overall growth performance in nursery pigs fed out to 6 wks postweaning.

Key Words: *Bacillus subtilis*, pigs, direct-fed microbial

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163 Utilizing feed sequencing to decrease the risk of porcine epidemic diarrhea virus (PEDV) cross-contamination during feed manufacturing.

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Since the introduction of porcine epidemic diarrhea virus (PEDV) into the United States, feed has been identified as a vector of transmission between herds. As with other biological hazards, biosecurity at feed manufacturing facilities plays a key role in preventing cross-contamination of finished feeds. One potential method for reducing introduction of PEDV into finished feeds is through batch sequencing of diets. Therefore, the objective of this study was to determine the effects of feed batch sequencing on PEDV cross-contamination between diets. A 50 kg batch of feed was inoculated with PEDV, mixed in a 0.11 m^3 electric paddle mixer and had a final concentration of 4.5×10^4 $TCID_{50}$ PEDV particles per g, cycle threshold (Ct) of 11. After mixing, the feed was discharged from the mixer into a bucket elevator and collected to mimic processing in a commercial feed mill. To simulate batch sequencing, 4 subsequent PEDV-free batch diets were processed through the system without equipment cleaning. Sequenced batches (1–4) were mixed, discharged, and sampled similar to the PEDV-positive

batch. Feed inoculation, processing, and batch sequencing was performed for 3 replicates with complete PEDV-decontamination of all equipment and facility between each replication. All collected feed samples were analyzed for PEDV RNA by quantitative PCR (qPCR) and infectivity by bioassay. Bioassay included a controlled challenge study using 30 crossbred 10 d old pigs to establish infectivity. All pigs (9/9) challenged with the positive treatment (feed Ct 31.7 ± 0.20 SEM) had fecal swabs with detectible PEDV RNA indicating PEDV infectivity. Infectivity was further confirmed with histopathology and immunohistochemistry (IHC). The discharge for the first sequence had less detectable PEDV RNA ($P < 0.01$, feed Ct 39.1 ± 3.4 SEM). Feed samples from the second, third and fourth sequence had no detectable PEDV RNA (Ct > 45). Infectivity was confirmed in 1 of 3 replicate batches for the first and second sequences. It is important to note, the 2ndsequence did not have detectable PEDV RNA in any feed sample. The results of this study confirm feed as a vector of PEDV transmission and is the first to demonstrate feed without detectible PEDV RNA can be infective. Furthermore, although subsequent feed batches had reduced quantities of PEDV RNA, they were still found to be infective. Therefore, feed batch sequencing should be considered a risk mitigation strategy but should not be considered a risk elimination strategy.

Key Words: feed, PEDV, sequencing

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164 Evaluating the effect of manufacturing porcine epidemic diarrhea virus (PEDV)-contaminated feed on subsequent feed mill environmental surface contamination.

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With the introduction of porcine epidemic diarrhea virus (PEDV) to the United States in 2013 and the subsequent identification of feed as a route of transmission, identifying sources of feedstuff contamination and methods to reduce the risk of transmission at feed mills has become paramount. As with other biological hazards, contaminated ingredients can easily lead to cross-contamination of finished feeds and contamination throughout the facility. Therefore, the objective of this study was to monitor equipment and environmental contamination after manufacturing PEDV-positive feed and after the production of subsequent PEDV-negative feed. PEDV-positive feed (50 kg with 4.5×10^4 $TCID_{50}$/g, Ct 11) was mixed in a 0.11m^3 paddle mixer, discharged into a bucket elevator, and collected. Following processing of the contaminated feed, 4 subsequent batches of PEDV-free feed (sequence 1–4) were processed through the mixer and bucket elevator with no decontamination between batches to mimic commercial feed production. Porcine epidemic diarrhea virus contamination of equipment and surrounding areas were monitored via the collection of swabs that were analyzed via quantitative PCR (qPCR) for PEDV RNA. Swabs were collected from equipment and facility surfaces prior and after processing contaminated feed and after processing subsequent sequenced batch diets. Monitored areas for equipment included the interior of the mixer and bucket elevator. Facility areas included high and low foot traffic areas (concrete), floor drain (concrete), worker boot bottoms (rubber), table (metal), and door (metal). Three replications of contaminated feed and subsequent sequence batch diet processing was completed, with equipment and facility decontamination between replicates. Following qPCR analysis, Ct values ≤ 40 were considered PEDV-positive and all numerical data was converted to ± for statistical analysis via PROC MIXED procedure of SAS. The interactions feed contact surface by sequence were found to be significant ($P < 0.01$). All swabs collected from equipment surfaces after processing of PEDV-positive feed were positive for PEDV, while 16 of 18 of the collected facility swabs were positive for PEDV RNA. Following processing of the first sequence batch diet, 100% of equipment surfaces and 88.9% of facility surfaces were positive for PEDV. Surprisingly, a large percentage of equipment and facility surfaces remained PEDV-positive through the processing of the subsequent sequence batch diets. Furthermore, all swabs collected from concrete and rubber surfaces remained PEDV-positive through all processing of all diets. This study demonstrates the extent of equipment and facility contamination that could occur in a feed manufacturing facility after processing of PEDV-contaminated feed.

Key Words: PEDV, feed mill, contamination

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165 To determine if hand held near infrared spectroscopy can be used to measure corn particle size, corn particle distribution and corn moisture.

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In swine production the effect of corn particle size on performance in pigs fed pelleted diets has shown that in general the finer the grind size the better the feed efficiency. Currently, to determine particle size, the most widely used methods are the onsite 3 pan sieve analysis because of its simplicity, cheapness and ease of interpretation or the 13 pan sieve analyses which is often tested off site at a laboratory. Near-infrared (NIR) spectroscopy is an analytical technique used for grain quality assessments due to its versatility and speed. Although the ability of NIR to estimate particle size is well documented, obtaining the full particle size distribution profile has not been studied in depth. The objective of this trial was to determine if a hand held near-Infra-red (HHNIR) spectroscopy could be used to measure corn average particle size, moisture and par-

ticle distribution. To develop this calibration, 95 corn samples resulting in 141 scans across 2 instruments (from roller and hammer mills) were collected, split and either tested using the corresponding particle size references by a 13 stage sieve analysis derived from the US standard Sieve Series (SV) using a sieve agent or scanned in triplicate on a hand held NIR (950–1,650 nm) spectrometer (NIRS). For average particle size and moisture there was a strong correlation between SV and NIRS (r^2 = 0.79; RPD = 2.2 and r^2 = 0.91; RPD = 3.3 respectively). The final prediction model on the NIRS shows the accumulation of sample which will remain in each sieve and the calibration comparison compared to the SV methodology (Table 165) with all sieves showing a strong correlation and RPD. Overall, the results confirm that a HHNIR can be used on site to instantly determine corn particle size, corn moisture and corn particle distribution.

Key Words: Particle Size, Corn, Near Infrared Spectroscopy

Table 165. Calibrations for individual sieve pans.

Sieve Pan	Mean	SD	RSQ	SECV	RPD
d6	0.13	0.07	0.67	0.07	1.7
d8	0.89	0.60	0.80	0.39	2.2
d12	3.99	2.71	0.80	1.69	2.2
d16	18.43	11.66	0.62	8.24	1.6
d20	40.06	13.72	0.80	8.57	2.2
d30	57.46	9.96	0.81	6.15	2.3
d40	68.28	6.94	0.81	4.59	2.3
d50	74.97	5.30	0.80	3.29	2.3
d70	78.98	4.65	0.80	2.82	2.2
d100	82.92	3.80	0.80	2.41	2.3
d140	86.12	3.18	0.82	1.95	2.3
d200	88.18	2.67	0.82	1.69	2.3
d270	89.54	2.43	0.83	1.45	2.4

166 (Young Scholars) Effects of feed truck unloading and swine barn feed line location on pellet quality and nutrient segregation.

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Two experiments were conducted at a commercial feed mill and 6 commercial wean to finish pig sites to determine the effects of feed truck unloading auger RPM on pellet quality and unloading time, and the effects of feed line location on pellet quality and nutrient concentration of intact pellets and their fines. In Exp. 1, pelleted feed was unloaded using 3 speeds (900, 1150, and 1400 RPM) from each of 8 compartments of a feed truck (Walinga Inc., Guelph, ON, Canada). Six samples per compartment were collected creating 16 replications/unloading speed. There was an unloading speed × trailer compartment interaction (P = 0.031; SEM = 17.4). The difference in unloading time from the front to rear compartment was greatest at the slowest unloading speed and similar at the 2 highest unloading speeds (70 vs. 35 and 37 s). The percentage of fines formed during unloading was not influenced by unloading speed, but tended to increase (quadratic; P = 0.081; SEM = 2.27) from the front (8.2%) to the rear compartment (10.7%). In Exp. 2, pelleted feed samples were collected during unloading into a commercial feed bin at 6 finishing pig sites with 2 feed lines, resulting in 12 replications per feed line location. Samples were collected from the feed line at 6, 35, and 76 m from the feed bin. There were no interactions between feed line location and nutrient profile of the fines and pellets. There was no effect of feed line location on pellet durability index, percentage fines, percentage fines formed, or the nutrient profile of pellets or fines. Across locations, fines had decreased (P < 0.05) CP (12.4 vs. 15.3%; SEM = 0.14) and P (0.37 vs. 0.40%; SEM = 0.006), but greater (P < 0.05) ADF (3.7 vs. 3.2%; SEM = 0.24), crude fiber (2.7 vs. 2.2%; SEM = 0.09), Ca (0.47 vs. 0.44%; SEM = 0.012), ether extract (6.2 vs. 5.2%; SEM = 0.11), and starch (47.4 vs. 44.7%; SEM = 0.42) for the fines and pellets, respectively. In conclusion, the front compartments closer to the truck cab resulted in fewer fines formed from loading to unloading. Decreasing unloading speed significantly increased the amount of time taken to unload a feed truck but did not alter fines formed. Feeder distance from the bin did not influence fines formation. There were significant differences in nutrient profile between fines and pellets. Understanding the location of fines creation during the feed delivery process may allow for alternative methods to reduce the formation of fines and subsequent nutrient segregation.

Key Words: feed mill, fines, pellets

167 Effect of ground corn fractionation on flowability.

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Particle size reduction is an important component of feed manufacturing that impacts pellet quality and animal feed efficiency. However, reducing particle size too fine often results in reduced flowability of the ground corn and finished feed, which creates potential handling and storage concerns at the feed mill and farm. The objective of this experiment was to determine how fractionation affected flowability of ground corn. Whole corn was received from a single source and ground to achieve 3 target particle sizes, 400, 500, and 600 µm, with actual results of 469, 560, and 614 µm. Each target particle size was fractionated into 3 fractions: coarse (> 630 µm), medium (< 630 µm and > 282 µm), and fine (< 282 µm) particles using a vibratory separator (model LS18SP3, SWECO, Florence, KY). Within each particle size, the percentage of ground corn as each fraction included: 400 µm: 57.5, 32.3, and 4.6% for coarse, medium, and fine, respec-

tively; 500 µm: 64.4, 30.1, and 1.80% for coarse, medium, and fine, respectively; and 600 µm: 71.2, 23.2, and 0.90% for coarse, medium, and fine, respectively. When the target particle sizes were fractionated, their particle sizes were: 400 µm: 744, 269, and 94 µm for coarse, medium, and fine, respectively; 500 µm: 815, 253, and 96 µm for coarse, medium, and fine, respectively; and 600 µm: 898, 220, and 99 µm for coarse, medium, and fine, respectively. Fractionated samples were analyzed for multiple flowability characteristics, including: angle of repose, critical orifice diameter, composite flow index (CFI), density, and compressibility. Treatments were arranged in a nested model with 3 replicates per treatment. Data were analyzed using the GLIMMIX procedure of SAS. When particle size was analyzed as a main effect, density affected flowability ($P = 0.014$) with the 400 µm having the lowest density. However, when fraction was nested within particle size, it impacted ($P < 0.001$) all measures of flowability, with the fine fraction (< 282 µm) of the 400 µm corn having the poorest flowability. In conclusion, reducing particle size resulted in the ground corn having poorer flowability characteristics, caused predominantly by particles that passed through 282 µm. Based on this data, producers may potentially grind corn to a lower particle size while maintaining flowability if fine particles (< 282 µm) are removed.

Key Words: corn, flowability, particle size analysis

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168 The evaluation of liquid disinfectants to reduce Salmonella contamination on animal food manufacturing surfaces. M. B. Muckey*, A. R. Huss, C. K. Jones, *Kansas State University, Manhattan.*

Recent research had demonstrated that *Salmonella* and Porcine Epidemic Diarrhea Virus have been isolated from feed, ingredients, and feed manufacturing equipment surfaces. However, there is limited data regarding the sanitation of animal food manufacturing surfaces. The objective of this experiment was to evaluate the effects of liquid chemical treatments to reduce *Salmonella* contamination of metal surfaces. Metal coupons (103cm^2, stainless steel 316; Built-so-Well, Manhattan, KS) were placed in sterile Petri dish, and inoculated with 1 mL of *Salmonella* Typhimurium Coupons were incubated overnight at 35°C, then subjected to treatments for 15 min: 1) no inoculation or sanitation treatment (positive control), 2) inoculated with no sanitation treatment (negative control), 3) inoculated and treated with a liquid alcohol-based commercial equipment sanitizer (DrySan Duo, Ecolab, St. Paul, MN), and 4) inoculated and treated with a liquid formaldehyde-based commercial product (SalCURB; Kemin Inc., Des Moines, IA). Immediately following treatment, excess material was removed by tapping. The coupon was then swabbed and the swab vortexed in neutralizing broth (EMD Chemicals, Darmstadt, Germany) before dilution. Samples were then serial diluted (10^{-1} to 10^{-6}) and spread to Trypticase Soy Agar plates. Plates were incubated at 35°C for 24 h, and then enumerated. The quantity of *Salmonella* colony forming units (CFU) are depicted as CFU/cm^2. Data were analyzed using the GLIMMIX procedure of SAS as a completely randomized design with 3 replicates per treatment. As expected, treatment affected ($P < 0.0001$) residual *Salmonella* concentration, and there was no growth on the positive control treatment. The liquid formaldehyde-based commercial product was highly effective, resulting in no detectable growth ($P < 0.05$). Treating metal surfaces with the liquid alcohol-based commercial equipment sanitizer reduced ($P < 0.05$) *Salmonella* concentrations by 2 logs compared to the negative control. Liquid sanitizer treatment of metal surfaces led to a reduction in *Salmonella*, and can be effective steps in bacterial contamination in feed and animal food manufacturing. However, liquid sanitizers have drawbacks because they may be corrosive and most feed manufacturing equipment is not designed as clean-in-place to withstand liquid sanitation. More research is needed to evaluate dry sanitation methods that are able to break biofilms and sanitize animal food manufacturing surfaces.

Key Words: feed, sanitation, *Salmonella*

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169 Effects of lactic acid bacteria complex and Enterococcus faecium DSM 7134 in weanling pigs. P. Y. Zhao*, H. N. Tran, H. Y. Shin, I. H. Kim, *Department of Animal Resource & Science, Dankook University, Cheonan, South Korea.*

As beneficial effects are observed, probiotics have been used as alternatives of antibiotics in swine industry. We conducted this study to compare the effect of lactic acid bacteria complex (*L. casei*, *L. rhamnosus*, *L. lactis*, *L. plantarum*, *S. thermophilus*, and *B. longum*) and *E. faecium* DSM 7134 on growth performance, nutrient digestibility, fecal microflora and characteristics in weanling pigs. A total of 120 weanling pigs (24 d) were used in a 5-wk feeding trial, and allotted into 3 dietary treatments: CON, basal diet; LA, CON + 0.1% lactic acid bacteria complex; EF, CON + 0.1% *E. faecium* DSM 7134. Pigs were weighed on d 0, 14, and 35 while feed consumption was recorded to calculate ADG, ADFI, and G:F. Fresh fecal samples were obtained on d 14 and 35 to determine the ATTD of DM, GE, and N by adding 0.2% chromium oxide. One gram of fecal sample was diluted with 9 mL of 1% peptone broth and then homogenized. Viable counts of bacteria were conducted by plating serial 10-fold dilutions onto agar plates. The pH value of each sample was measured using a pH meter. The same samples were then first air-dried at 60°C, followed by an equilibration and moisture determination at 105°C to determine fecal moisture. All data were subjected to the GLM procedures of SAS and differences among treatments were separated by Tukey's multiple range test with a $P < 0.05$ indicating a significance. The ADG (from Day 0 to 14, Day 15 to 35, and overall period) and G:F (overall period) was higher ($P < 0.05$) in EF than that in CON. On Day 14 and 35, the ATTD of DM, N, and GE was greater ($P < 0.05$), fecal *Lactobacillus* counts were increased (*P*

< 0.05), and fecal pH was decreased in LA and EF compared with CON. Results indicated that both lactic acid bacteria complex and *E. faecium* can increase nutrient digestibility and fecal *Lactobacillus* concentration, as well as decrease fecal pH. Additionally, *E. faecium*DSM 7134 have better effects on growth performance than lactic acid bacteria complex in weanling pigs.

Key Words: lactic acid bacteria complex, *Enterococcus faecium* DSM 7134, weanling pigs

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170 Effects of complex direct-fed microbial supplementation in different basal diets on growth performance, nutrient digestibility, blood profiles, fecal microbial shedding and noxious gas emission in growing pigs. W. C. Liu*[1], Y. H. Kim[1], M. G. Jung[1], J. H. Cho[2], I. H. Kim[1], *[1]Department of Animal Resource & Science, Dankook University, Cheonan, South Korea, [2]Department of Animal Science, Chungbuk National University, Cheongju, South Korea.*

Antibiotics which are used as feed additives can lead to the transmission and proliferation of resistant bacteria via food chain. Alternatives of antibiotics have focused on probiotics. Additionally, it is well suggested that the diet composition could influence the efficacy of probiotics. Hence, the objective of this study was to determine the effects of complex direct-fed microbial (*Bacillus subtilis* 1.0×10^7 cfu/g; *Saccharomyces cerevisae* 1.0×10^7 cfu/g) supplementation in different basal diets on growth performance, nutrient digestibility, blood profiles, fecal microbial shedding and noxious gas emission in growing pigs. A total of 100 crossbred pigs [(Landrace × Yorkshire) × Duroc] with an average initial BW of 24.88 ± 1.57 kg were used in a 6-wk experiment. Pigs were randomly allotted to a 2 × 2 factorial arrangement with 2 different basal diets (non palm kernel expellers (PKE) containing diet vs. 10% PKE containing diet) and 0 or 0.3% complex probiotics according to their BW (5 replicate pens, 5 pigs per pen). All experimental data were analyzed using the GLM procedure of SAS as a completely randomized 2 × 2 factorial design (SAS Inst. Inc., Cary, NC, USA), the pen was served as the experimental unit. At the end of experiment, pigs fed non-PKE containing diet increased final BW, overall ADG and G:F ($P < 0.01$), and decreased the fecal total mercaptans concentrations ($P < 0.05$). Moreover, the final BW ($P < 0.05$) and overall ADG ($P < 0.05$), as well as apparent total tract digestibility (ATTD) of dry matter ($P < 0.05$) and energy ($P < 0.01$), were improved when pigs fed the probiotic supplement. Dietary supplementation with probiotic increased fecal *Lactobacillus* concentrations and decreased *E. coil* concentrations ($P < 0.01$), respectively. The fecal NH_3, total mercaptans and H_2S emissions were reduced by feeding diets containing probiotic ($P < 0.01$). Additionally, interactive effects of different diets and probiotics were also observed on final BW, overall ADG and G:F ($P < 0.01$). In conclusion, *B. subtilis* and *S. cerevisae* complex could provide positive effect on growth performance, nutrient digestibility, intestinal microflora, and fecal gas emissions in growing pigs. Moreover, the use of probiotics in non-PKE containing diet was more favorable than in PKE containing diet.

Key Words: probiotics, different basal diets, growing pig

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171 Impact of hydrolyzed yeast product in nursery pig diets on growth performance and immune response. C. L. Levesque*[1], S. Jalukar[2], S. Gould[3], J. F. Patience[3], *[1]South Dakota State University, Brookings, [2]Arm and Hammer Animal Nutrition, Mason City, IA, [3]Iowa State University, Ames.*

CELMANAX SCP is an enzymatically hydrolyzed yeast product containing yeast culture and other complex carbohydrates. This study was conducted to assess the impact of CELMANAX SCP on weaned pigs' growth performance and immune response and to define the optimal dietary inclusion level in nursery diets containing antibiotics. Ninety-six nursery (6.29 ± 0.22 kg BW; $n = 12$ pens/treatment) pigs were assigned to one of 4 dietary levels of CELMANAX SCP (0.0, 0.01, 0.02, and 0.04%) in a 2-phase feeding program for 49d postwean. Pig weight gain and pen feed disappearance were measured weekly. Immune response was assessed based on dermal hypersensitivity to ovalbumin (OVA) and production of anti-OVA antibodies. Vaccinated pigs were immunized, by intramuscular injection, to induce antibody response and hypersensitivity on d 27 and 41 postweaning (0.5 mg OVA and 0.5 mg Quil A in 1 mL phosphate buffer). Blood samples were obtained on d 27, 41, and 49 for determination of anti-OVA IgG antibodies. Dermal hypersensitivity was determined on d 49 where all pigs were given 200 μg OVA in 50 μL saline by intradermal injection in the ear. Ear thickness measurements were made using a spring-loaded caliper at 2, 6, and 24 h after injection. All pigs performed similarly throughout the study where final BW was 32.2, 33.3, 31.9, and 32.0 ± 1.0 kg in pigs fed increasing levels of dietary CELMANAX SCP. Overall daily gain (0.51, 0.55, 0.52, and 0.53 ± 0.02 kg/d), feed disappearance (0.82, 0.86, 0.86, and 0.85 ± 0.02 kg/d), and gain:feed (0.62, 0.64, 0.61, and 0.62 ± 0.01) was not affected by increasing dietary inclusion of CELMANAX SCP. There was a linear effect of time ($P < 0.001$) on anti-OVA IgG where optical density increased with time. There was no effect of diet on anti-OVA IgG. There was a linear effect of time ($P < 0.001$) on ear thickness where ear thickness decreased over time from 2 to 24 h. There was a trend ($P = 0.084$) to an interaction between CELMANAX SCP inclusion and time on ear thickness where ear thickness was not different from 6 to 24 h in pigs fed 0.04% CELMANAX SCP and declined over time for all other groups. There was no quadratic effect of time, diet, or their interaction on anti-OVA IgG or ear thickness. Dietary inclusion of CELMANAX SCP did not affect pig growth performance but appears to posi-

tively impact immune response.

Key Words: immune response, growth performance, nursery pigs

172 Tri-strain probiotics improves performance, excreta microbial shedding and reduces noxious gas emission in broilers. M. M. Hossain*[1], M. Begum[1], J. H. Cho[2], Y. H. Kim[1], I. H. Kim[1], *[1]Department of Animal Resource & Science, Dankook University, Cheonan, South Korea, [2]Department of Animal Science, Chungbuk National University, Cheongju, South Korea.*

This study was conducted to evaluate the effects of *Bacillus subtilis*, *Clostridium butyricum* and *Lactobacillus acidophilus* (tri-strain probiotics, TSP) endospores in broilers. The TSP can benefit the host animal by increasing the nutrients absorption from the gastrointestinal tract and altering the intestinal ecosystem in the poultry. A total of 500 d old ROSS 308 mixed sex broiler chickens with an average initial body weight (IBW) of 46 g ± 0.5g were used in this 35-d feeding study. Broiler chickens were randomly allotted to 1 of 5 dietary treatments: 1) CON (antibiotic free diet), 2) ANT1 (CON + enramycin 5 ppm), 3) ANT2 (CON + avilamycin 5 ppm), 4) TSP1 (CON + 0.1% TSP) and 5) TSP2 (CON + 0.2% TSP) with 5 replications per treatment and 20 chicks per pen. Ileal and caecal contents were collected into Qorpak glass containers (118 mL) under CO_2 for enumeration of microbial populations. Data were statistically analyzed via ANOVA using the GLM procedure of SAS/STAT®9.2 (SAS Institute Inc., Cary, NC). The linear and quadratic effects of TSP among treatments were analyzed using a contrast statement. Orthogonal contrasts were used to the effects of treatments: ANT vs. TSP treatments. Broiler chickens fed on TSP1 and TSP2 diets linearly increased body weight gain (BWG) and decreased feed conversion ratio (FCR) than those on the CON diet (9,19, 9,55 vs. 8,86 g/chick; 1.828, 1.822 vs. 1.937, and 1945, 1965 vs. 1766 g/chick; 1.596, 1.600 vs. 1.655; $P <$ 0.05; d 21 to 35 and d 1 to 35, respectively). The dry matter (DM) and nitrogen (N) digestibility were linearly improved in the TSP1 and TSP2 treatments compared with the CON treatment at the end of study (77.43, 77.22 vs. 70.48%, and 69.49, 71.93 vs. 68.43%; $P < 0.05$). The inclusion of TSP1 and TSP2 treatments reduced meat lightness (L*) compared with CON and ANT1 and ANT2 treatments (linear, 51.2, 51.8 vs. 56.2, 53.2, 55.4; $P = 0.02$). The supplementation of TSP1 and TSP2 increased ileal and caecal *Lactobacillus* count ($^{log}_{10}$ cfu/g) compared with CON and ANT1 and ANT2 diets (8.83, 8.91 vs. 8.55, 8.65 and 8.62, and 9.71, 9.76 vs. 9.03, 9.47 and 9.25; $P < 0.05$). Excreta ammonia (NH_3) gas emission was lower in the TSP1 and TSP2 treatments compared with CON treatment (74, 70 vs. 80 ppm; $P < 0.05$) on d 5. In conclusion, the supplementation of TSP improved growth performance, nutrient digestibility, meat quality, ileal and caecal *Lactobacillus* count, and reduced noxious gas emission in broilers.

Key Words: ammonia gas emission, *scherichia coli*, eat lightness

173 Potentials of probiotics *B. subtilis* RX7 and *B. methylotrophicus* C14 strains as an alternative to antibiotics in *Salmonella* challenged weaning pigs. S. D. Upadhaya*, S. Mohana Devi, S. I. Lee, I. H. Kim, *Department of Animal Resource & Science, Dankook University, Cheonan, South Korea.*

Due to therapeutic use of antimicrobials, the emergence of antibiotic resistant strains in animals is a threat to human and animal health. Probiotics has been considered as one of the alternative to antibiotics. The objective of this experiment was to evaluate the potential of locally isolated probiotics in a Salmonella challenge model. A total of 40 pigs were used for *Salmonella* Typhimurium challenge model in a 6-wk trial. Pigs were randomly allotted to 4 experimental diets according to their initial BW (9.21 ± 1.1 kg) and sex (10 pigs per treatment; 5 barrows and 5 gilts) to evaluate blood profiles and fecal microflora after 12 h of challenge on d-21 of the experiment. Dietary treatments consisted of: CON; corn soybean meal based basal diet (without antibiotics and not challenged), SC; basal diet + oral *Salmonella* Typhimurium challenge once in Day 21 of experiment, T1; SC + 0.1% of 1×10^9cfu/g *Bacillus subtilis* RX7 and T2; SC + 0.1% of 1×10^9cfu/g *Bacillus methylotrophicus* C14. *Salmonella* Typhimurium was administered orally once at Day 21 at the dosage of 1 mL which contained 1×10^{11} cfu/mL *Salmonella* Typhimurium. Orthogonal contrasts were used to test the following:(i) the overall effect of different treatment versus control (CON vs. SC, T1, T2) and ii) overall effect of 2 strains of Bacillus supplementation in challenged animals versus Salmonella challenge without probiotics supplementation (SC vs. T1, T2). After 12 h of *Salmonella* challenge, the RBC, IgG and IgM, concentration were reduced ($P < 0.05$) whereas WBC and cortisol concentration increased ($P < 0.05$) in SC, T1 and T2 compared with non-challenged pigs. However, the concentration of RBC (6.34×10^6/μL vs. 6.77×10^6/μL, 6.88×10^6/μL), lymphocyte (21.0% vs. 29.8%, 30.97%), IgG (197.4 mg/dL vs. 246.9 mg/dL, 268.4 mg/dL) and IgM (24.2 mg/dL vs. 26.9 mg/dL, 27.7 mg/dL) were reduced ($P < 0.05$) in SC compared to T1 and T2 whereas haptoglobin (39.2 mg/dL vs. 34.5 mg/dL, 35.3 mg/dL) and cortisol (4.41 μg/dL vs. 3.78 μg/dL, 3.82 μg/dL) were increased ($P < 0.05$) in SC compared to T1 and T2. The supplementation of probiotics increased ($P < 0.05$) fecal *Lactobacillus* counts (7.49, 7.46 vs. 7.39 log 10 cfu/g) and decreased ($P < 0.05$) *Salmonella* counts (3.57, 3.69 vs. 3.87 log 10 cfu/g) in piglets after 12 h of challenge. Thus, the locally isolated *Bacillus* strain has a potentiality of being used as probiotics.

Key Words: *B. subtilis, B. methylotrophicus, Salmonella* Typhimurium

174 Efficacy of probiotics *B. subtilis* RX7 and *B. methylotrophicus* C14 strains as an alternative to antibiotics in weaned pigs. S. D. Upadhaya*, W. C. Liu, Y. H. Liu, I. H. Kim, *Department of Animal Resource & Science, Dankook University, Cheonan, South Korea.*

After weaning, piglets face environmental and nutritional challenges due to which the morphology and functions of gastrointestinal tract are remarkably impaired. This may be due to alteration in the microbial balance in the gastrointestinal tract favoring the colonization of pathogens such as Salmonella and *E.coli*. Probiotic supplementation may play a positive role in improving the health status of weaning pigs. Thus, an experiment was conducted with a total of 60 pigs by randomly allotting them to 1 of 3 experimental diets according to their initial BW and sex in a 42-d experiment to evaluate the efficacy of probiotics on the performance, digestibility, blood profiles, and fecal microflora. Each treatment consisted of 4 replicate pens with 5 pigs (3 barrows and 2 gilts) per pen. Dietary treatments consisted of: CON; corn soybean meal based basal diet (without antibiotics and probiotics), T1; basal diet + 0.1% of 1 × 10^9cfu/g *Bacillus subtilis* RX7 and T2; basal diet + 0.1% of C14 1 × 10^9cfu/g *Bacillus methylotrophicus*. The trial period was divided into 2 periods: period 1 of d 1–14 post weaning, and period 2 of d 15–42 post weaning. All data were subjected to the GLM procedures of SAS and differences among treatments were separated by Tukey's multiple range tests with a $P < 0.05$ indicating significance. At the end of the experiment the ADFI was reduced ($P = 0.01$) in T1 (646.5 g) and T2 (646.5 g) than CON (681.7 g) and co-efficient of digestibility of Energy was increased ($P < 0.05$) in T1 (0.844) and T2 (0.841) compared with CON (0.806) during d 14. The supplementation of probiotics led to reduction of *Salmonella* counts (2.41, 2.44 vs. 2.63 log 10 cfu/g) in the feces during d 14 and increase in *Lactobacillus* counts (7.46, 7.48 vs. 7.03 log 10 cfu/g)) during d 42. There were no significant differences in blood profiles of pigs treated with probiotic. In conclusion, probiotic supplementation reduced feed intake, increased energy digestibility and Lactobacillus counts and reduced Salmonella counts in weaning pigs.

Key Words: *B. subtilis, B. methylotrophicus, Salmonella* Typhimurium

175 Effects of *Lactobacillus acidophilus* fermentation product on growth performance, nutrient digestibility, and fecal microbiota in weanling pigs. R. X. Lan*[1], J. M. Koo[2], S. I. Lee[1], J. H. Cho[3], I. H. Kim[1], [1]*Department of Animal Resource & Science, Dankook University, Cheonan, South Korea,* [2]*Shinhan BioChem Co.,, Hwaseong, South Korea,* [3]*Department of Animal Science, Chungbuk National University, Cheongju, South Korea.*

Concerns of bacteria resistance to antibiotics and general human health issue, urged researches to find alternatives to reduce pathogen infection and improve animal health especially around the time of weanling. We conducted this study to evaluate the effects of LAFP (*Lactobacillus acidophilus* fermentation product; SynGenX®, Diamond V, Cedar Rapids, IA) on growth performance, nutrient digestibility, fecal microbiota and noxious gas emissions in weanling pigs. 140 pigs [(Yorkshire × Landrace) × Duroc] weaned at 25d of age and weighting 7.15 ± 0.21kg were fed 1 of 4 treatments for 6-wk. Dietary treatment groups were: (1) CON, basal diet; (2) T1, CON + 1 g/kg of LAFP; (3) T2, CON + 2 g/kg of LAFP; (4) T3, CON + 3 g/kg of LAFP. All pigs were feed in 2 dietary phases (Phase 1: d 1 to 14 and Phase 2: 15 to 42). Pigs were housed 5/pen with 7 replicates/treatment. Pigs were weighed on d 0, 14, and 42 while feed consumption was recorded to calculate ADG, ADFI, and G:F. Fresh fecal samples were obtained on d 14 and 42 to determine the ATTD of DM, GE, and N by adding 0.2% chromium oxide. One gram of fecal sample was diluted with 9 mL of 1% peptone broth and then homogenized. Viable counts of bacteria were conducted by plating serial 10-fold dilutions onto agar plates. All data were subjected to the mixed procedure of SAS. Orthogonal polynomials were used to assess the linear, quadratic and cubic effects of increasing dietary supplementation of LAFP. During the overall period, there was a significant linear improvement ($P < 0.05$) in ADG associated with the inclusion of LAFP. This resulted in a linear improvement on d 42 BW ($P < 0.05$). D 42 BW for CON, T1, T2, and T3 were 26.46, 27.65, 27.72, and 27.81 kg, respectively. On d 14, there was a significant linear improvement ($P < 0.05$) in DM digestibility, as well as a significant quadratic improvement in nitrogen digestibility associated with the inclusion of LAFP. On d 42, there was a significant linear improvement ($P < 0.05$) in fecal *lactobacillus* counts, as well as a significant linear decrease in *E.coli* counts associated with the inclusion of LAFP. The results of this study demonstrate that feeding LAFP can improve growth performance, digestibility and increase the gut balance of weanling pigs.

Key Words: *Lactobacillus acidophilus* fermentation product, growth performance, weanling pigs

176 The effects of feeding 15 or 30 ppm of narasin on the growth performance of pigs during the grower period.

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The purpose of this study was to determine the effects of 15 or 30 ppm of narasin (NAR; Skycis®, Elanco Animal Health, Greenfield, IN) on the growth performance of pigs from 26.7 to 70.5 kg. On day −7, one hundred eight pens each containing 20 to 21 pigs with a BW of 26.7 kg were blocked and balanced for weight within block and then treatments: Control (CON), NAR 15 ppm, or NAR 30 ppm were randomly assigned to pens within each block. Diet treatments consisted of 3 identical mash diets containing corn, soybean meal, and DDGS with the appropriate amount of NAR premix added to each. Pigs were weighed on d 0, 15, 29, 43, and 50 to determine initial weight, phase weights, and ADG. Feed issuance and volumetric feeder measures were recorded to determine ADFI and G:F. ADG of pigs fed NAR 30 or 15 was greater ($P < 0.05$) than that of CON on d 0 to 15 (0.81 or 0.79 kg vs. 0.73 kg), 16 to 29 (0.95 or 0.95 kg vs. 0.90 kg), 30 to 43 (0.98 or 0.98 kg vs. 0.94 kg), and 0 to 50. ADFI of pigs fed NAR 30 or 15 was greater ($P < 0.05$) than that of CON on d 0 to 15 (1.43 or 1.43 kg vs. 1.35 kg, 16 to 29 (1.91 or 1.94 vs. 1.81 kg), 30 to 43 (2.20 or 2.20 vs. 2.12 kg), and 0 to 50. G:F of pigs fed NAR 30 was greater ($P < 0.05$) than CON on d 0 to 15 (0.56 vs. 0.54) and d 0 to 50. In conclusion, growing pigs fed NAR 15 or 30 for 50 d have a greater ADG and ADFI than pigs fed CON, but only pigs fed NAR 30 have a greater overall G:F than those pigs fed CON.

Key Words: Narasin, Pig, Growing

Table 176.

Item	CON	NAR 15	NAR 30	SE	*P*
ADG, d 0 to 50	0.86[a]	0.90[b]	0.91[b]	0.005	< 0.01
ADFI, d 0 to 50	1.84[a]	1.92[b]	1.91[b]	0.014	< 0.01
G:F, d 0 to 50	0.47[a]	0.47[ab]	0.48[b]	0.002	< 0.05

[a,b]Means without common superscripts differ at $P < 0.05$.

177 Determining the impact of By-O-Reg+ in diets with or without feed grade antibiotic on growth performance of nursery pigs.

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A total of 717 nursery pigs (PIC C-29 × 28 and PIC L3 × 1040, initially 5.67 ± 0.05 kg BW) from 2 consecutive nursery groups were used in a 35-d growth study. The objective was to determine the impact of feeding increasing levels of By-O-Reg+ in diets with or without antibiotic on nursery pig growth performance. By-O-Reg+ is registered trademark of Advanced Ag Products, Hudson, South Dakota and is a unique mixture of essential oils primarily based on oregano. Dietary treatments were offered immediately after weaning at approximately 21 d of age and were organized in a 2 × 3 factorial with main effects of antibiotic (none vs. 55 mg/kg of Carbadox) and By-O-Reg+ (0, 0.05, or 0.10%). Experimental diets were fed for 21 d and then fed a common diet for the final 14 d. Pens of pigs (5 barrows and 5 gilts) were balanced by initial BW and randomly allotted to treatments with 12 pens/treatment. During the period when treatments were fed (d 0 to 21), there were no interactions observed between By-O-Reg+ and Carbadox but increasing By-O-Reg+ improved (quadratic, $P = 0.016$) G:F. Pigs fed diets with Carbadox had improved ($P < 0.007$) ADG, ADFI, and G:F. From d 0 to 35, there was an interaction (linear, $P = 0.031$) observed for ADFI with pigs fed diets without Carbadox having decreased ADFI as By-O-Reg+ level increased, whereas when pigs were fed diets containing Carbadox, ADFI increased with increasing By-O-Reg+. There were no main effects of By-O-Reg+ observed for the overall data; however, adding Carbadox for 21 d after weaning improved ($P < 0.015$) ADG, ADFI, and final BW and tended to improve ($P < 0.087$) G:F d 0 to 35. Overall, this study confirms the benefit of including a feed grade medication in nursery pig diets to improve growth performance. Increasing By-O-Reg+ in diets elicited few changes in performance, but during the test period the pigs fed 0.05% By-O-Reg+ had better G:F than those fed none or 0.10% By-O-Reg+.

Key Words: antibiotics, nursery pigs, oregano

Table 177.

							Probability, *P* <				
Antibiotic	-	-	-	+	+	+	—— By-O-Reg+ ——			—— Interaction ——	
Added By-O-Reg+, %	0	0.05	0.10	0	0.05	0.10	Linear	Quadratic	Carbadox	Linear	Quadratic
d 0 to 21											
ADG, kg	0.19	0.20	0.19	0.21	0.22	0.22	0.215	0.463	< 0.0001	0.455	0.105
ADFI, kg	0.26	0.25	0.25	0.27	0.26	0.28	0.984	0.353	0.007	0.186	0.564
G:F	0.74	0.80	0.77	0.81	0.82	0.82	0.128	0.016	< 0.0001	0.394	0.108

SEM = 0.006 for ADG, 0.021 for ADFI, and 0.051 for G:F

178 Evaluation of porcine IPEC-J2 cell line immune tesponse to *Escherichia coli* (0111:B4) lLipopolysaccharide. X. Wang[*1], T. C. Tsai[1], M. A. Sales[1], C. V. Maxwell[1], K. Novak[2], E. Davis[3], [1]*Department of Animal Science, Division of Agriculture, University of Arkansas, Fayetteville,* [2]*DuPont Nutrition and Health, Waukesha, WI,* [3]*Danisco A/S, Waukesha, WI.*

The objective of this study was to evaluate expression of genes associated with the proinflammatory immune response in IPEC-J2 cell line after exposure to pathogenic *E. coli O111:B4*-derived lipopolysaccharide (LPS). Upon confluence, IPEC-J2 cells were cultured in a penicillin-streptomycin-free medium for a week before LPS challenge. Afterward, cells were challenged with LPS based on a 4 × 5 factorial arrangement consisting of 4 levels of LPS (0, 0.1, 1, and 10 μg/mL) and 5 exposure durations (0, 1, 2, 4, and 6 h). At the end of the challenge, cells were lysed with TRIzol reagent and total RNA was extracted. Gene expression levels of granulocyte-macrophage colony-stimulating factor (GM-CSF), tumor necrosis factor-α (TNF-α), interleukin (IL)-1β, −6, −8, −10, toll-like receptor (TLR) −1, −2, −3, −4, −6, and −8 were evaluated using a two-step reverse transcription quantitative real-time polymerase chain reaction (qRT-PCR). No interaction between LPS concentration and culture time among genes was observed ($P > 0.10$). Results of contrast analysis showed that expression of TNF-α (Relative quantity = 0.82, 1.66, 2.12 and 2.70 at 0, 0.1, 1, and 10 μg/mL LPS; $P = 0.10$) and TLR-8 (0.61, 0.65, 0.74, 0.94; $P = 0.05$) was upregulated linearly with increasing LPS concentration up to 10 μg/mL. There was a tendency for quadratic increases of IL-8 (3.15, 4.18, 5.82, 5.39; $P = 0.09$) with greatest expression at 1 μg/mL LPS. Expression of GM-CSF (0.91 7.78, 13.12, 4.45 and 3.52 at 0, 1, 2, 4, and 6 h, respectively), IL-8 (0.60, 3.71, 7.03, 7.07, 4.77), and TLR4 (0.52, 0.43, 0.61, 0.95, 0.58) was significantly stimulated at longer culture times (Quadratic; $P < 0.05$), peaking at 2, 4, and 4 h after challenge, respectively. In addition, mRNA levels of TLR-2 (0.65, 1.00, 1.03, 1.13, 0.79) and −6 (0.71, 0.74, 1.11, 1.08, 0.64) tended to increase at extended culture times (Quadratic; $P \leq 0.10$) with the greatest levels at 4 and 2 h, respectively. TLR-3 (0.60, 0.40, 0.34, 0.46, 0.41), however, tended to decrease (Quadratic; $P \leq 0.10$) with extended culture time and reached the lowest level at 4 h. Expression of IL-6 decreased linearly (0.60, 0.55, 0.32, 0.26, 0.32; $P < 0.05$) as culture time increased. Results of the proinflammatory response when IPEC-J2 cell line under LPS challenge in current study indicate that the IPEC-J2 cell line may be used as an in vitro model to evaluate the impact of treatment on immune response.

Key Words: IPEC-J2, immunity, gene expression

179 Effect of topsoil exposure during lactation on subsequent performance and abundance of innate and adaptive immune cells in pigs. T. C. Tsai[1], H. J. Kim[1], M. A. Sales[*1], X. Wang[1], G. F. Erf[2], E. B. Kegley[1], F. G. Carbonero[3], M. van der Merwe[4], R. K. Buddington[4], C. V. Maxwell[1], [1]*Department of Animal Science, Division of Agriculture, University of Arkansas, Fayetteville,* [2]*Department of Poultry Science, Division of Agriculture, University of Arkansas, Fayetteville,* [3]*Department of Food Science, Division of Agriculture, University of Arkansas, Fayetteville,* [4]*University of Memphis, Memphis.*

Sows (PIC-29) with litter size > 10 ($n = 20$) were blocked by BW and parity and assigned to litters either managed conventionally in farrowing crates (C) or exposed to topsoil (S) from d 4 postpartum to early weaning (d21), when 5 unisex littermates were penned together. Pigs were fed common antibiotic-free corn-SBM-DDGS diets (NRC 2012). Intake and BW were recorded by phase throughout nursery and grow-finish periods to determine ADG, ADFI, and G:F. Backfat (BF) and longissimus muscle (LM) area at the 10th rib were evaluated at the end of nursery (d39) and each subsequent phase in the grow-finish periods. Peripheral blood mononuclear cells (PBMCs) were collected on d4, d15, d20, d36, d56, and d95 for immunophenotyping. Data were analyzed using SAS MIXED procedure for RCBD. Despite lower BW at weaning (6.87 vs. 7.40 kg, $P < 0.05$), S pigs had higher ADG throughout the nursery period (0.42 vs. 0.35 kg/d, $P < 0.01$), resulting in a 2.21-kg difference between S- and C-pigs at end of nursery ($P < 0.05$). At study completion, S pigs tended ($P > 0.10$) to be 4.6 kg heavier than C pigs. Moreover, S pigs had greater ADFI than C pigs for overall nursery (0.62 vs. 0.51 kg/d; $P < 0.01$) and grow-finish periods (2.90 vs. 2.74 kg/d; $P < 0.05$). G:F at combined nursery phases 1–2 was greater in S pigs (0.68 vs. 0.58; $P = 0.02$), but greater in C pigs at overall grow-finish (0.38 vs. 0.36; $P < 0.05$). Carcass composition ($P = 0.26$) and BF ($P = 0.10$) were not different, but a larger LM area (18.04 vs. 16.24 cm^2; $P < 0.01$) in S pigs resulted in 1.47 kg heavier lean tissue ($P > 0.05$) in S- compared to C-pigs at end of grower phase 1. Percentages of T-helper cells, $Foxp3^+$ regulatory T cells, dendritic cells, neutrophils, monocytes and NK cells varied ($P < 0.01$) with time. Time × treatment effects were evident on PBMC ($P < 0.01$) and granulocyte ($P < 0.05$) concentrations. PBMC concentrations were greater in S pigs on d4 and d15 but peaked in C pigs on d20 when levels decreased in S pigs (221 vs. 97 × 10^6 cells/mL). Granulocyte concentrations were greater in S pigs on d4 and d15, but greater in C pigs on d56 when concentrations peaked in both groups (132 vs. 118 × 10^6 cells/mL). Findings in this study suggest that dirt exposure during lactation may explain improved performance in outdoor-reared pigs observed in previous studies.

Key Words: dirt exposure, growth performance, innate and adaptive immunity

180 Effect of a 3-Strain *Bacillus*-based direct-fed microbial on relative tissue gene expression in nursery and finishing pigs fed low- or high-fiber diets. N. W. Jaworski*[1], M. C. Walsh[2], H. H. Stein[1], [1]*University of Illinois at Urbana-Champaign, Urbana,* [2]*Danisco Animal Nutrition, DuPont Industrial Biosciences, Marlborough, UK, United Kingdom.*

The effect of a *Bacillus*-based direct-fed microbial (DFM) on relative gene expression in nursery and finishing pigs was determined. Two hundred pigs (initial BW: 6.31 ± 0.73 kg) were randomly allotted to a 2 × 2 factorial arrangement with 2 diet types [low- (LF) or high-fiber (HF)] and 2 levels of DFM [0 or 60 g DFM (2.4×10^{12} CFU/kg feed)/MT of feed] with 5 pigs/pen. Phase 1, phase 2, grower, early-, and late-finisher diets were fed for 14, 29, 35, 35, and 24 d, respectively. The LF diets contained corn and soybean meal as main ingredients and HF diets contained corn, soybean meal, distillers dried grains with solubles (7.5, 15, and 30% in phase 1, phase 2, and grow-finish diets, respectively) and wheat middlings (10%). One pig/pen was euthanized at the conclusion of phase 2 and late-finishing. Tissue samples were collected from the ileum, cecum, rectum, and liver of pigs. Total RNA was isolated from frozen tissue samples, reverse transcribed, and transcript abundance was measured by qPCR. Primers for amplification of target *MUC2*, *MCT1*, *CD147*, *PEPCK*, and *GLP-2R* genes were obtained from literature. Housekeeping genes were *GAPDH* and *HMBS*. Data were analyzed separately for nursery and finishing pigs as a 2 × 2 factorial arrangement with fiber and DFM as 2 factors and block as the random effect using PROC MIXED of SAS. Nursery pigs fed DFM containing diets had increased G:F, while DFM and fiber had no effect on growth performance during grow-finish. Results indicated nursery pigs fed diets containing DFM had a 1.6% reduction ($P = 0.02$) in liver *GLP-2R* expression and a tendency for increased ($P = 0.09$) ileum *MCT1* expression. Nursery pigs fed HF diets had a 2.9% reduction ($P = 0.01$) in rectum *MCT1* and *PEPCK* tended to decrease ($P = 0.05$). A tendency for an interaction between fiber and DFM was observed ($P = 0.08$) for cecum *CD147* in nursery pigs. Finishing pigs fed HF diets had reduced ($P < 0.05$) expression of *MCT1*, *CD147*, and *PEPCK* in cecum tissue. Addition of DFM to diets reduced ($P = 0.03$) cecum *GLP-2R* by 1.6% in finishing pigs. High-fiber diets reduced ($P < 0.05$) *MCT1* and *GLP-2R* by 1.6 and 2.3%, respectively, in liver tissue of finishing pigs. In conclusion, DFM addition to diets reduced *GLP-2R* in the liver of nursery pigs and this may be associated with the improved G:F that was observed.

Key Words: dietary fiber, direct-fed microbial, gene expression

181 Effects of standardized ileal digestible isoleucine and valine:lysine ratio on growth performance of 12 to 25 kg nursery pigs. A. J. Gerhart*[1], E. D. Fruge[2], E. Hansen[3], S. Hansen[4], J. Less[5], C. W. Hastad[6], [1]*Hubbard Feeds, Mankato, MN,* [2]*Hubbard Feeds, Inc., Mankato, MN,* [3]*Hubbard Feeds Inc., Mankato, MN,* [4]*Hubbard Feeds Inc, Mankato, MN,* [5]*ADM Animal Nutrition, Decatur, IL,* [6]*New Fashion Pork, Jackson, MN.*

Two 21 d studies were conducted to determine the Ile:Lys and Val:Lys (Exp. 1) and Val:Lys ratios (Exp. 2) that optimized pig growth performance. Twenty-one days postweaning, a total of 2001 (1001, 12.9 ± 0.54 kg BW and 1000 pigs, 13.9 ± 0.43 kg in Exp. 1 and 2, respectively) mixed-sex pigs were allotted to 1 of 6 dietary treatments in a randomized complete block design using previous treatment and weight as blocking criterion. There were 27–28 pigs per pen with 6 replications per treatment. Experimental diets were corn-soybean meal based with 10% DDGS. In Exp. 1, treatments 1–3 contained 70% Val:Lys and 1) 60% Ile:Lys, 2) 55% Ile:Lys 3) 50% Ile:Lys and treatments 4–6 contained 60% Ile:Lys and 4) 60% Val:Lys; 5) 65% Val:Lys; or 6) 70% Val:Lys. Diets 1–5 were formulated to 1.1% SID Lys and treatment 6 to 1.3% SID Lys. In Exp. 2, treatments consisted of increasing levels of Val:Lys: 1) 70%; 2) 60%; 3) 63%; 4) 66%; 5) 69%; or 6) 72%. Treatment 1 was formulated to 1.1% SID Lys and treatments 2–6 were 1.30% SID Lys. In Exp 1, pigs fed increasing Val:Lys had improved ADG, G:F (quadratic, $P < 0.04$) and ADFI (Linear, $P < 0.05$). Pigs fed increasing levels of Ile:Lys showed an improvement in G:F (linear, $P < 0.05$). In Exp. 2, as Val:Lys increased from 60 to 72%, ADG, ADFI (quadratic; $P < 0.03$) and G:F (Linear, $P < 0.01$) were optimized. Mean separation indicates that Val:Lys ratios below 0.65 will result in reduced ADG and G:F, moreover Ile:Lys ratios below 0.55 will result in poorer G:F.

Key Words: Isoleucine, Valine, Pigs

Table 181.

Exp. 1, d 0–21							
Dig Lys, %	——— 1.10 ———					1.30	
Ile: Lys, %	60	55	50	60	60	60	
Val:Lys, %	70	70	70	60	65	70	SEM
ADG, g[2]	638[b]	629[b]	627[b]	521[a]	614 [b]	677[c]	12.02
ADFI, g[1]	931[b]	931[b]	954[b]	828[a]	907[b]	941[b]	16.78
G:F[2,3]	0.684[c]	0.676[c]	0.657[b]	0.629[a]	0.677[c]	0.719[d]	0.005
Exp. 2, d 0–21							
Dig Lys, %	1.11	——— 1.30 ———					
Val:Lys, %	70	60	63	66	69	72	
ADG, g[2]	669[c]	672[c]	695[b]	712[ab]	720[a]	710[ab]	7.78
ADFI, g[2]	995[bc]	975[c]	995[bc]	1017[ab]	1027[a]	1009[ab]	9.65
G:F[1]	0.673[c]	0.689[b]	0.698[a]	0.700[a]	0.700[a]	0.703[a]	0.004

[abcd] Within a row, means without common superscript differ ($P < 0.05$).
[1] Linear effect of Val ($P < 0.05$)
[2] Quadratic effect of Val ($P < 0.05$)
[3] Linear effect of Ile ($P < 0.05$)

182 Use of wheat gluten as an alternative protein source in nursery diets. C. M. De Mille*[1], D. J. Bloxham[1], C. R. Dove[1], S. Bassi[2], M. J. Azain[1], [1]*University of Georgia, Athens,* [2]*Manildra Group USA, Shawnee Mission, KS.*

Wheat gluten (WG) is a high-protein ingredient (75% CP) that is commonly used in pet food and milk replacers, but not commonly used in swine diets. Two studies were conducted to determine the effect of WG on growth performance of weaned pigs, and to determine if WG is an alternative for high cost ingredients such as fish meal (FM) and plasma protein (PP) in a phase 1 diet. Pigs were weaned at approximately 21 d and blocked according to weight. Bodyweight gain and feed disappearance were measured weekly in each experiment. All diets were formulated to meet or exceed the 2012 NRC standards. Exp. 1 utilized 36 pigs (IW = 6.2 + 0.2 kg, 12 pens, 3 pigs/pen). There were 3 dietary treatments: 1) 0% WG, 2) 5% WG, and 3) 10% WG. WG was added at the expense of corn and soybean meal. Diets were fed for 14 d postweaning, followed by a common diet for an additional 14 d. There were 4 dietary treatments (IW = 6.4 + 0.4 kg, 32 pens, 3 pigs/pen) in Exp. 2: a control diet (5% FM and 5% PP), 5% WG in place of FM, 5% WG in place of PP, and 5% WG replacing 1/2 of each FM and PP. Test diets were fed for 14 d, followed by a common diet for an additional 7 d. In Exp. 1, ADG in phase 1 (0–14 d) for pigs fed 5% WG (398 g/d) was greater than pigs fed 0 (331 g/d) or 10% WG (300 g/d, quadratic, $P < 0.01$). These differences were maintained when pigs were fed a common diet 14–28 d (ADG: 660, 720, and 633 g/d for 0, 5, and 10% WG respectively, quadratic, $P < 0.01$). In Exp. 2, pigs fed the diet with no PP had lower ADG than other treatments (ADG: 435, 423, 396, and 440 g/d for Control, WG for FM, WG for PP, and WG for 1/2 FM and PP, $P < 0.20$). Pigs fed the diet with WG replacing 1/2 of the FM and PP had improved G:F (0.84, 0.84, 0.83, 0.89 for Control, WG for FM, WG for PP, and WG for 1/2 FM and PP, $P < 0.02$). In Exp. 2, it was concluded that WG can substitute for FM, but not PP. Results indicate that WG fed at 5% of the diet may be a cost-effective, alternative protein source in phase 1 diets.

Key Words: Wheat Gluten, Nursery Pigs, Growth Performance

183 Interactive effect of dietary fermented corn and nutrient density of diets on growth performance, nutrient digestibility, ileal microorganisms and fecal noxious gas emission in growing pigs. H. L. Li*, P. Y. Zhao, J. H. Park, I. H. Kim, *Department of Animal Resource & Science, Dankook University, Cheonan, South Korea.*

We conducted this experiment to evaluate the effects of fermented corn (FC) on performance of growing pigs fed with different nutrient density diets. A total of 128 crossbred growing pigs [(Landrace × Yorkshire) × Duroc)] with an initial BW of 29.59 ± 1.34 kg were used in this 42-d trial. Pigs were distributed into 1 of 4 dietary treatments in a 2 × 2 factorial arrangement of treatments with 2 levels of nutrient density (high or low energy and crude protein density) and FC (0 or 20%) according to their BW and sex (8 pens/treatment and 4 pigs with 2 gilts and 2 barrows/pen). During the experimental period, individual body weight and feed consumption per pen were measured on Day 1 and 42 to monitor the ADG, ADFI and G:F. Apparent total tract digestibility (ATTD) was determined by adding chromic oxide (0.2%) as an indigestible marker in the diet 7 d before taking samples (during d 35 to 42). Fresh fecal samples collected from 2 pigs (BW approximate the pen average) per pen by rectal massage on Day 42 for nutrient digestibility and fecal gas emission analysis. The same 2 pigs were sacrificed to get the ileal digesta for microbial analysis (*E. coli* and *Lactobacillus*). All data were analyzed as a 2 × 2 factorial arrangement of treatments by using the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC). The final model included the main effects of FC and nutrient density, and their interaction. During the overall trial period, pigs fed with FC had a higher ($P < 0.05$) ADG than those without FC. The ATTD of dry matter, gross energy, and nitrogen in FC inclusion groups were significantly greater ($P < 0.05$) than those non-FC groups. Both low-nutrient-density and FC supplementation led to lower ($P < 0.05$) fecal NH_3 and H_2S emission content. Increased ileal *Lactobacillus* concentration and decreased *E. coli*concentration were observed with FC supplementation. An interactive effect between nutrient density diet and FC was observed on the ADG, ileal microorganisms, nutrient digestibility and fecal noxious gas content. In conclusion, both high-nutrient-density diet and FC supplementation could improve growth performance, nutrient digestibility, and ileal microorganisms balance in growing pigs. The beneficial effect of FC supplementation in growing pigs could be enhanced with the high-nutrient-density diets.

Key Words: fermented corn, growing pigs, nutrient density

184 Interactive effect of dietary fermented oat and density of diets on growth performance, nutrient digestibility, and ileal microorganisms in weaning pigs. H. L. Li*[1], T. S. Li[1], J. H. Cho[2], S. Kathannan[1], I. H. Kim[1], [1]*Department of Animal Resource & Science, Dankook University, Cheonan, South Korea,* [2]*Department of Animal Science, Chungbuk National University, Cheongju, South Korea.*

We conducted this experiment to evaluate the effects of fermented oat (FO) on performance of weanling pigs fed with different nutrient density diets. A total of 160 crossbred weanling pigs [(Landrace × Yorkshire) × Duroc), 28-d-old] with an initial BW of 8.01 ± 0.74 kg were used in this 42-d trial (phase 1: d 1 to 14, phase 2: d 15 to 42). Pigs were distributed into

4 dietary treatments in a 2 × 2 factorial arrangement of treatments with 2 levels of nutrient density (high or low nutrient density) and FO [0% or 5% (phase 1), 2.5% (phase 2)] according to their BW and sex [8 pens/treatment and 5 pigs (3 gilts and 2 barrows)/pen]. During the experimental period, individual body weight and feed consumption per pen were measured on d 1, 14, and 42 to monitor ADG, ADFI and G/F ratio. Fecal samples collected from 2 pigs (BW approximate the pen average) per pen by rectal massage (d 14 and 42) to analyze the apparent total tract digestibility (ATTD) by using chromic oxide (0.2%). The same 2 pigs were sacrificed to collect ileal ingest. *E. coli* and *Lactobacillus* content of ileal ingest were then analyzed. During the overall trial period (d 1–42), ADG of pigs fed FO diet was higher ($P < 0.05$) than pigs fed non-FO diet. During phase 1 (d 1 to 14), ATTD of dry matter and nitrogen in high-nutrient-density diet groups were significantly greater ($P < 0.05$) than low-nutrient-density diet groups. During phase 2 (d 15 to 42), FOt and high-nutrient-density diets interactively improved digestibility of energy and dry matter. ATTD of energy in FO groups was significant greater ($P < 0.05$) than non-FO groups during the whole experimental period. Pigs fed with FO had higher ($P < 0.05$) ileal *Lactobacillus* and lower ($P < 0.05$) *E. coli*counts compared with those fed with non-FO. In conclusion, high-nutrient-density diet mixed with FO could improve growth performance, nutrient digestibility and ileal microorganisms balance in wealning pigs.

Key Words: fermented oat, nutrient density, weanling pigs

185 Evaluation of SID lysine to energy ratio based on NRC or National Swine Nutrition Guide on pig performance.

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The objective of this study was to investigate standardized ileal digestible (SID) Lys to energy ratio based on NRC (2012) or National Swine Nutrition Guide (NSNG, 2010) on wean-to-finish pig growth performance. A total of 243 weaned piglets (BW 6.8 ± 0.9 kg, 18 d old) were blocked by weight and gender and assigned (9 pens/treatment, 9 pigs/pen) to 1 of 3 dietary treatments: NRC1, NRC2, and NSNG. Split-sex feeding was applied with 5 pens of barrows and 4 pens of gilts per treatment. Pigs were fed in a 6-phase (d 1–7, 7–21, 21–42, 42–77, 77–109, and 109–144) feeding program with a common diet from d 1 to 7. The SID Lys:ME ratios (g/Mcal) were, for NRC1, NRC2, and NSNG respectively, 3.672, 3.672, 3.780 (d 7–42); 2.970, 2.970, 3.282 (d 42–77); 2.636, 2.636, 2.925 (d 77–109); and 2.333, 2.333, 2.328 (d 109–144). Concentration of ME was 3.350, 3.685, 3.307 Mcal/kg from d 7 to 42, and 3.300, 3.465, 3.351 from d 42 to 144 for NRC1, NRC2, and NSNG, respectively. Ratios of SID Met, Met+Cys, Thr, or Trp to Lys were based on NRC (2012) for NRC1 and NRC2 and National Swine Nutrition Guide (2010) for NSNG. Pen was the experimental unit. The growth performance data are shown in Table 185. The interaction between gender and dietary treatment was not significant ($P > 0.05$). Significant differences ($P < 0.05$) in overall ADFI and feed efficiency were observed between treatments. In conclusion, at a similar level of ME, the NSNG-based SID Lys:ME ratios led to better feed efficiency than the NRC-based ratios, but the NRC-based ratios at a higher level of ME resulted in better feed efficiency compared with the NSNG-based ratios.

Key Words: lysine to energy ratio, growth performance, pigs

Table 185.

	NRC1	NRC2	NSNG
	ADG (kg/d)		
d 1–42	0.471 A	0.432 B	0.463 A
d 42–144	0.959	0.978	0.966
d 1–144	0.817	0.819	0.819
	ADFI (kg/d)		
d 1–42	0.751 A	0.626 B	0.735 A
d 42–144	2.880 Aa	2.566 B	2.743 Ab
d 1–144	2.259 A	2.000 C	2.157 B
	G:F		
d 1–42	0.628 B	0.690 A	0.632 B
d 42–144	0.334 C	0.382 A	0.353 B
d 1–144	0.363 C	0.410 A	0.381 B

Note: Means within a row without common upper ($P < 0.05$) or lower ($P < 0.1$) case letters differ.

186 Effects of dietary tryptophan:lysine ratio on the reproductive performance of primiparous and multiparous lactating sows.

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The objective of this study was to determine the effects of dietary tryptophan (Trp) to lysine (Lys) ratio on the performance of lactating sows. Thirty primiparous and 195 multiparouslactating sows (Landrace × Yorkshire) were allocated on the basis of parity, body weight, and backfat to 5 dietary treatments according to a randomized complete block design with 5 blocks of farrowing date. The 5 experimental diets contained 0.16%, 0.19%, 0.23%, 0.26%, or 0.29% standardized ileal digestible (SID) Trp and SID Lys level was identical (0.87%) for all the diets, with the SID Trp:Lys ratio being 0.18, 0.22, 0.26, 0.30, and 0.33, respectively. Sows received their assigned lactation diets from Day 109 of gestation to weaning. Litter size was standardized to 10 to 12 piglets within treat-

ment within 2 d after farrowing. The average lactation length was 18 d and no creep feed was provided. Changes of sow body weight and backfat during lactation, weaning-to-estrus interval, litter size and weight, litter weight gain, preweaning piglet mortality, and performance of subsequent parity (total born alive, stillborns, and mummies) were recorded. Average daily feed intake of the primiparous sows showed a tendency (4.53, 5.63, 5.52, 4.92, and 4.81 kg/d; $P < 0.10$) to a quadratic dependency on the SID Trp:Lys ratio with the ratio of 0.22 being associated with the highest feed consumption. A quadratic pattern of body weight loss (−15.75, −8.28, −5.48, −16.41, and −15.67 kg; $P < 0.05$) and backfat loss (−5.6, −4.4, −4.2, −3.9, and −5.1 mm; $P < 0.10$) with increasing Trp level was observed for the primiparous sows during lactation and the losses were minimized with the SID Trp:Lys ratio of 0.25 according to the broken-line model. Nevertheless, preweaning piglet mortality of the primiparous sows increased linearly and quadratically ($P < 0.05$) as Trp level increased. On the contrary, piglet mortality of the multiparous sows decreased linearly (11.1, 11.8, 6.8, 10.2, and 7.2%; $P < 0.05$) with increasing dietary Trp and the mortality was noticeably reduced when the SID Trp:Lys ratio reached 0.26. No differences ($P < 0.05$) were observed for the remaining parameters. In conclusion, our results indicate that the optimal SID Trp:Lys ratio could be 0.22 to 0.26 for lactating sows.

Key Words: lactation; tryptophan; lysine; sow; reproductive performance

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187 Effects of dietary inclusion level of distillers dried grains with solubles (DDGS) and high-protein distillers dried grains (HP-DDG) on the growth performance and carcass characteristics of wean-to-finish pigs.

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The objective was to evaluate the effect of dietary levels of DDGS (10% crude fat level) and HP-DDG (5% crude fat level) on the wean-to-finish growth performance and carcass and pork quality characteristics of finished pigs. A RCBD was used with a 3 × 4 factorial arrangement of dietary treatments: 1) HP-DDG inclusion level (0, 10, 20, and 30%) and 2) DDGS inclusion level (0, 15, and 30%). Six replicates with a total of 2448 pigs, housed in mixed-gender pens (50% barrows and 50% gilts) of 34 were used. Growth performance was evaluated from weaning (5.9 ± 0.10 kg) to wk 20 postweaning (107.6 ± 6.86 kg); pigs were sent for harvest to a commercial facility at a mean pen BW of 123.8 ± 1.48 kg. No carcass or pork quality data were collected for pigs on the 30% HP-DDG inclusion level because low weight at the end of the study period. There were HP-DDG by DDGS level treatment interactions ($P < 0.05$) for ADG and ADFI. For the 0% HP-DDG diet, there was no effect ($P > 0.05$) of DDGS inclusion level on ADG (0.775, 0.767 and 0.763 kg/d for the 0, 15, and 30% DDGS inclusion levels) or ADFI (1.87, 1.89 and 1.88 kg/d for the 0, 15, and 30% DDGS inclusion levels respectively); however, for the other HP-DDG inclusion levels, ADG and ADFI were linearly reduced with increasing DDGS level with the magnitude of the reduction increasing with HP-DDG inclusion level (ADG from 0.755 to 0.623 kg/d and ADFI from 1.87 to 1.513 kg/d from the 0% DDGS and 0% HP-DDG inclusion levels to the 30% DDGS and 30% HP-DDG inclusion levels respectively; $P < 0.05$). There was no effect ($P > 0.05$) of either HP-DDG or DDGS inclusion level on G:F. Increasing the dietary level of both HP-DDG and DDGS was associated with linear reductions ($P < 0.05$) in carcass yield (from 75.1 to 73.5% for the 0% and 20% HP-DDG levels, and 74.9 to 73.2% for the 0% and 30% DDGS levels), *Longissimus* muscle depth (from 6.46 to 5.98 and 6.29 to 6.14 cm for HP-DDG and DDGS, respectively), and belly flop distance (from 23.9 to 17.6 and 22.6 to 19.0 cm for HP-DDG and DDGS, respectively). These results suggest that DDGS can be included at up to 30% in diets without compromising growth performance of wean-to-finish pigs. However, growth performance was increasingly compromised at higher inclusion levels of both co-products and belly firmness was negatively affected by increasing levels of both DDGS and HP-DDG.

Key Words: pigs, growth, DDGS, high protein DDG

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188 Effects of low dietary inclusion levels of soybean meal and non-essential amino acid supplementation on the growth performance of late-finishing pigs.

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There has been limited research to establish if non-essential amino acids (NEAA) become limiting to growth performance in late-finishing pigs fed diets low in crude protein. The objectives of this study were to define the minimum dietary crude protein level in corn-soybean meal based diets to maintain growth performance and establish if NEAA become limiting in low crude protein diets for late-finishing pigs. Individually penned barrows ($n = 144$; initial BW 89.4 ± 5.16 kg) were randomly allotted to 8 dietary treatments in a RCBD with 18 replicates. Diets for Treatments 1 to 5 were formulated by reducing soybean meal inclusion levels (18.0, 14.0, 10.0, 7.0 and 3.0%), which resulted in dietary crude protein levels of 13.0, 12.0, 10.7, 9.5, and 8.4%, respectively. Diets were formulated to the same ME (3.3 Mcal/kg) and standard ileal digestible lysine (0.60%) levels and met or exceeded NRC (1998) recommendations for other nutrients. Levels of other essential AA were maintained constant across diets by the addition of crystalline AA sources. For Treatments 6, 7, and 8 the diets contained the same crude protein levels as Trt. 1 by the

addition of NEAA (50:50% mixture of glycine and glutamic acid) to Trt. 3, Trt. 4, and Trt. 5, respectively. Pigs had ad libitum access to experimental diets for a 4-wk period. Reducing crude protein levels resulted in reduced (quadratic, $P < 0.05$) ADG (1.147, 1.143, 1.156 and 1.118, and 0.999 kg, respectively), and reduced (quadratic, $P < 0.05$) G:F (0.352, 0.342, 0.350, 0.331, and 0.308, respectively). There was no effect ($P > 0.05$) of reducing dietary crude protein level on ADFI. Broken-line regression analysis suggested that the minimum crude protein inclusion level for ADG, and G:F was 9.76 and 10.32%, respectively. There were no improvements ($P > 0.05$) in growth performance with NEAA supplementation, regardless of dietary crude protein level. These results suggest that for late-finishing pigs fed corn-soybean meal based diets the minimum crude protein to maintain growth performance was between 9.76 and 10.32% and that NEAA were not limiting in the low crude protein diets evaluated.

Key Words: Low crude protein, non-essential amino acids, finishing pigs, growth.

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189 Effect of dietary inclusion level of high-protein distillers grains (HP-DDG) and of dietary excesses of branched chain amino acids (BCAA) on the growth performance of pigs.

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Previous research has shown a negative effect of feeding high levels of HP-DDG on growth performance of pigs. The objectives of this research were to first recreate the negative effects on growth performance of feeding diets with 30% HP-DDG inclusion and, second, investigate if this negative effect could be reproduced by adding excess BCAA (Leu, Iso, and Val) to corn-soybean meal based diets. Two studies, 1 with growing and 1 with finishing pigs (initial BW 42.36 ± 2.84 kg and 101.7 ± 2.86 kg, respectively) were performed as RCBD with the same 6 dietary treatments: 1) Positive Control (corn-soybean meal based diet); 2) Positive Control + supplemental Leu, Iso and Val; 3) Positive Control + supplemental Leu and Iso; 4) Positive Control + supplemental Leu; 5) Negative Control (30% HP-DDG inclusion); and 6) Negative Control + supplemental Val. For Trt. 2, 3, and 4, the respective synthetic BCAA were added to give the same total digestible levels as Trt. 5; Trt. 6 had the same Val:Leu ratio (0.56) as Trt. 1 by the addition of supplemental Val to the diet for Trt. 5. Diets were formulated to the same ME content (3.37 Mcal/kg); digestible lysine levels were 1.04 and 0.64% for Study 1 and 2, respectively. Both studies used 72 individually-housed pigs (12 replications) that were given ad libitum access to feed and water. In both studies, there was no effect ($P > 0.05$) of dietary treatment on final BW, ADFI, and G:F. In Study 1, the addition of BCAA's to dietary Treatments 2, 3, and 4 at the same digestible amino acid levels as Treatment 5 (2.00% Leu, 0.64% Iso, and 0.77% Val) resulted in a 8.7% reduction ($P < 0.05$) in average daily gain compared with Treatment 1 (0.977, 1.016, 0.992, 1.004 Vs. 1.090 kg, respectively, SEM 0.231; $P < 0.05$). In Study 2, Trt. 2, 3, 4, 5, and 6 had similar ADG ($P > 0.05$) than the Positive Control (Trt. 1). These results suggest that the negative effect on growth rate resulting from feeding diets with 30% HP-DDG can be recreated in growing, but not finishing, pigs by the addition of BCAA to corn-soybean meal based diets and that this reduced growth rate may be due to a dietary excess of leucine.

Key Words: branched chain amino acids, pigs, high protein dried distillers grain

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190 Efficacy of soybean meal in reducing the effects of a PRRSv challenge in weaned pigs.

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The objective of our trial was to determine the efficacy of dietary soybean meal (SBM) in reducing the effect of a porcine reproductive and respiratory syndrome virus (PRRSv) challenge in nursery pigs as measured by immune response and growth performance. The 2 dietary treatments differed by method of supplying amino acids: either by SBM or synthetic amino acids (SAA) with SBM. Seventy-two mixed sex, weanling pigs (21 d of age, 10.83 ± 0.82 kg) were allotted by weight and sex to 1 of 18 pens in a completely random design. There were 4 pigs/pen and 9 observations/treatment. All pigs were fed the same industry-standard diet for 14 d, and then were fed 1 of 2 experimental diets for 10 d. All pigs were then inoculated both intramuscularly and intranasally with 1 mL each of live PRRS virus MN-184 (1×10^6 fluorescent focus units (FFU)/mL dose) at 38 d of age (0 d post-inoculation, DPI). Blood was collected on 0, 3, 7, 14, and 28 DPI for determination of serum PRRSv load and cytokine concentrations. Pig BW and pen feed intake were recorded on blood collection days for the first 28 d and then bi-weekly until the termination of the trial at 125 kg BW. Pigs in the AA group tended to have lower TNF-α (Tumor Necrosis Factor-α) and IL-8 (InterLuekin-8) concentrations ($P = 0.100$ and $P = 0.100$) respectively on 0 DPI. At 3 DPI, pigs fed SBM vs. SAA had higher ADG (0.613 vs. 0.299 kgs) ($P = 0.005$) and G:F (0.603 vs. 0.336) ($P = 0.0007$). On 3 DPI, pigs fed the AA treatment tended to have lower IL-8 concentrations (117 vs. 145 pg/mL) ($P = 0.08$). Serum concentrations of INF-γ (Interferon Gamma) tended to be lower for the AA group at 7 DPI. At 14 DPI, serum concentrations of IL-4 (Interleukin-4) ($P = 0.025$) were higher in pigs fed the SBM treatment. Pigs fed the AA diets had higher INF-γ concentrations on 14 DPI ($P = 0.034$) and it tended to be higher ($P = 0.080$) at 28 DPI. Results observed for growth performance and blood parameters were not consistent between treatments throughout the trial. While initial growth responses were improved by SBM diets, an overall increase in immune response was observed from pigs fed the AA based diets. Therefore, ad-

ditional work needs to be done in clarifying the role of amino acid source in piglet growth and immune status

Key Words: Pigs, Soybean Meal, PRRSv

191 Impact of dietary protein and dried citrus pulp contents on gut morphology of weanling pigs.

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One hundred and eight barrows weaned at 21 d (5.82 ± 0.96 kg initial BW) were used to determine the effects of dietary CP and dried citrus pulp (DCP; rapidly fermentable carbohydrate source) contents on small intestinal morphology. Pigs were blocked by initial BW and randomly assigned to 1 of 4 treatments with 9 replicate pens per treatment and 3 pigs per pen in a randomized complete block design. Treatments were arranged in a 2 × 2 factorial, with 2 CP contents (high- and low-CP diets) and 2 DCP contents (0 and 7.5%, as-fed basis). The high-CP diets consisted of feeding 20 and 21% CP contents (as-fed basis) throughout phase I (0 to 14 d) and phase II (14 to 28 d), respectively. For the low-CP diets, CP contents were reduced by 4% units as compared with the high-CP diets in both phases. Dietary AA contents were balanced by supplementation with crystalline AA, such as L-Lys, DL-Met, L-Thr, L-Trp, L-Val, and L-Ile, to maintain an ideal AA pattern. On d 7 and 28 postweaning, 1 pig per pen was euthanized to collect duodenum, jejunum, and ileum samples for morphological evaluation. Data were analyzed as repeated measures using the MIXED procedure of SAS. There were no CP × DCP interactions for duodenal, jejunal, and ileal morphology on d 7 and 28 postweaning. Dietary treatments did not change duodenal and jejunal villus height. Pigs fed the low-CP diet, regardless of DCP inclusion, tended to have greater crypt depth (256.0 and 271.6 ± 5.81 μm for high- and low-CP diets, respectively; $P = 0.08$) and had decreased villus:crypt ratio (1.61 and 1.46 ± 0.04 for high- and low-CP diets, respectively; $P = 0.05$) in the duodenum on d 7, but not on d 28 postweaning. Decreasing dietary CP content also increased crypt depth (211.7 and 228.7 ± 3.98 μm for high- and low-CP diets, respectively; $P = 0.03$) and tended to decrease villus:crypt ratio (1.85 and 1.63 ± 0.06 for high- and low-CP diets, respectively; $P = 0.08$) in the jejunum on d 7, but not on d 28 postweaning. Neither CP content nor DCP inclusion altered ileal morphology on both d 7 and 28 postweaning. In conclusion, feeding diets containing 7.5% DCP does not affect gut architecture of weanling pigs. However, low-CP AA-supplemented diets were detrimental to intestinal morphology of pigs on d 7 postweaning.

Key Words: fiber, intestinal structure, nursery pigs

192 High inclusion of distillers dried grains with solubles as a dietary fiber source reduces cytokine levels in growing-finishing pigs.

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Dietary fiber plays an important role in the gastrointestinal inflammatory response. We hypothesized that the immune response is modulated differentially by the type of dietary fiber. Forty-six pigs (83.4 ± 6.7 kg) were divided into 4 groups and fed diets formulated with 3 different fiber sources: wheat straw (WS; $n = 11$), corn distiller's dried grains with solubles (DDGS; $n = 11$), and soybean hulls (SBH; $n = 12$). A corn-soybean meal diet was used as control (CON, $n = 12$). Test diets were formulated to contain approximately 17% NDF by adding 23% WS, 55% DDGS, or 30% SBH. Pigs were housed in metabolism cages, acclimated for 10-d and fed an amount equal to 2.5% of their initial BW for 14-d. Ileal tissue and blood samples were collected at euthanasia. To identify which genes expression in the ileum was changed, a commercial PCR array (Qiagen, PASS-011ZA) was used. The cDNA from the ileal RNA was pooled and expression of 84 immune markers; 5 housekeeping genes, and 7 quality controls were determined. Fold-change and statistical significance were calculated using Qiagen's RT2 analysis tool and β-actin as housekeeping gene. Results with $P < 0.001$ were considered significant. The greatest change observed was IL23A induction by WS (256 fold) vs. DDGS (12 fold). Compared with WS, DDGS induced 2 and repressed 39 genes. Compared with SBH, DDGS induced 53 genes and repressed IL5RA. When compared with SBH, WS induced 48 and repressed 5 genes. To determine whether the type of dietary fiber alters the overall immune profile, plasma concentrations of cytokines and chemokines were measured using a porcine immunoassay panel on a Luminex 200. Fluorescent intensity data were analyzed by curve-fitting of standards to calcu-

Table 192. Effects of dietary fiber source on the abundance of cytokine RNA in ileum.

Marker (pg/ml)	Fiber Source			
	CON	WS	DDGS	SBH
IFNγ[1]	1122.1	2044.7	1457.1	5443.7
IL-1α	29.7	13.9	5.5	40.89
IL-1β	642.7	130.8	31.3	355.4
IL-1RA	84.82[a]	152.8[a,b]	45.2[a,c]	139.1[a,b,d]
IL-2	217.1[a]	148.9[a,b]	70.3[a,c]	215.6[a]
IL-4	1212.6	460.0	125.4	1600.0
IL-6	264.2	83.9	84.6	99.4
IL-8	10.2	13.9	8.8	13.1
IL-10	193.5[a]	87.8[a,b,c]	47.2[b]	102.6[a,c]
IL-12	389.6	448.2	401.0	476.5
IL-18	849.8	525.4	360.1	561.2

[a,b,c,d] **Different superscripts within each row differ ($P < 0.05$)**

late sample concentrations. Group comparisons were tested by Mann–Whitney U test using GraphPad Prism 6. Overall, WS increased concentrations of cytokines while DDGS decreased them. Our results indicate that the immune response is modulated differently by type of dietary fiber source.

Key Words: DDGS, Dietary fiber, Immune response

193 Total body amino acid composition of two genetic lines of barrows and gilts from twenty to one hundred twenty-five kilograms of body weight.

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A study was conducted to investigate the whole body amino acid (AA) composition profile of barrows and gilts of 2 genetic lines with high and low lean growth rate (high-lea*n* = 375 g of fat-free lean/d; low lea*n* = 280 g of fat-free lean/d) from 20 to 125 kg of BW. A total of 120 growing pigs were slaughtered with a 2 (genetic line) × 2 (sex) × 5 (BW group) factorial arrangement of treatments. At 20 kg of BW and at 25 (or 30) kg BW intervals, 6 pigs of each genetic line and sex were slaughtered and body components were ground to determine the composition of water, crude protein (CP), fat, ash, and AA. Whole body AA composition was expressed as g/kg BW and g/100g CP. PROC MIXED procedure of SAS (9.4) and contrasts were constructed to analyze the data. Total body AA content for barrows and gilts were 119 vs. 119, 124 vs. 126, 116 vs. 121, 116 vs. 124, and 121 vs. 124 g/kg BW, for BW at 20, 45, 75, 100, and 125 kg, respectively. Total AA content for high- and low-lean genotype were 123 vs. 116, 131 vs. 120, 122 vs. 115, 127 vs. 113, and 129 vs. 115 g/kg BW, for the 5 BW stages. Between the barrows and gilts, the whole body composition (g/kg BW) of total essential AA and total AA was similar in all BW group except for 100 kg ($P < 0.05$). From 45 to 125 kg of BW, high-lean genotype showed greater AA content (g/kg BW) of all the essential AA and total AA in all the BW groups. The AA content (g/kg BW) changed in cubic pattern for most AA and total AA along with the increased BW ($P < 0.05$). The AA profile in whole body CP (g/100g CP) demonstrated a similar AA profile in whole body AA composition between barrows and gilts across BW groups. Genotype affected the AA profile (g/100g CP) for all the essential AA ($P < 0.01$) except for arginine. Compared with low-lean pigs, high-lean genotype exhibited greater concentrations of isoleucine, lysine, and methionine in CP in all the BW groups greater than 45 kg ($P < 0.05$). The results indicated that genotype and gender can affect the whole body composition and profile of AA. The genotype of high- and low-lean can impact the AA profile in whole body protein.

Key Words: amino acids, body composition, pig

194 Supplementation of feed grade essential and nonessential amino acids to control levels in pigs fed reduced crude protein (RCP) diets meeting the SID His:Lys ratio requirement maintained growth performance and carcass composition in growing/finishing swine.

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Previous research indicates aggressive feeding of AA to growing/finishing pigs results in reduced intake, gain, and fatter carcasses. This study investigated the role of dietary essential AA, nonessential AA, and electrolyte balance on these outcomes. PIC C29 × 380 pigs (*n* = 196) were blocked by BW and treatments assigned to gender-balanced pens within block. Treatments were: 1) corn-soybean meal diets formulated to meet a constant Trp:Lys ratio (20) without feed grade Trp (PC); 2) RCP diets meeting the His:Lys ratio requirement (32) without added feed grade His but with feed grade indispensable AA added to control levels (Met+Cys:Lys, 60 to 65; Thr:Lys, 65 to 68; Trp:Lys, 20; Ile:Lys, 73 to 78; Val:Lys, 79 to 88; His:Lys, 45 to 51; EAA); 3) as 2 but with feed grade Glu and Gly (67:33) added to the same N in PC (NEAA), or 4) as 3 but with diets formulated using $NaHCO_3$ to create the same dietary electrolyte balance as PC (dEB). All diets met the SID AA:Lys ratio requirement for each phase (23 to 41, 41 to 59, 59 to 82, 82 to 104, and 104 to 131 kg BW). Ractopamine (10 mg/kg) was fed during the last 3 wk. Pig BW and pen feed disappearance data were used to calculate ADG, ADFI, and G:F for each pen. HCW, LM and fat-depth (10th rib) were captured by Fat-O-Meter at slaughter. Pig growth performance and carcass composition were maintained by adding feed grade EAA to the RCP diet. ADG, ADFI, G:F and carcass characteristics did not respond to NEAA or $NaHCO_3$ additions. These results suggest the reduced performance of growing/finishing pigs fed RCP diets formulated to meet the His:Lys requirement without using feed grade His in previous studies may be attributed to improper AA:Lys ratios and not

Table 194.

	PC	EAA	NEAA	dEB	SEM	*P*-value
BW, kg	131.9	131.6	130.8	130.6	2.3	0.97
ADG, kg/d	0.89	0.88	0.88	0.88	0.02	0.96
ADFI, kg/d	2.32	2.36	2.38	2.37	0.04	0.66
G:F	0.31	0.30	0.30	0.31	0.01	0.98
HCW, kg	96.90	95.98	95.59	94.58	1.53	0.71
FFL, %	54.56	54.34	54.97	54.95	0.33	0.46
LM depth, mm	67.43	67.07	68.53	68.63	1.33	0.70

from total N or dietary electrolyte balance.

Key Words: amino acid supplementation, reduced crude protein, growing/finishing swine

195 Effect of energy restriction on feed efficiency, nutrient digestibility, and immune biomarkers of growing/finishing pigs. S. M. Barnett*[1], K. C. Moore[1], M. D. Trenhaile[1], A. T. Desaulniers[2], Y. S. Li[1], D. M. van Sambeek[1], H. Tran[1], B. R. White[2], T. E. Burkey[1], *[1]University of Nebraska, Lincoln, [2]University of Nebraska-Lincoln, Lincoln.*

Many factors affect control of feed intake and regulation of energy balance including external (e.g., environment) and internal (e.g., hormones) factors. The objective was to evaluate effects of nutrient restriction on feed efficiency, apparent total tract digestibility (ATTD), and an immune biomarker in growing-finishing pigs. Crossbred barrows (n = 36; initial BW = 52.3 kg) were randomly allotted to 36 individual pens with 2 dietary treatments in an 8 wk experiment. Treatments included a control (ADLIB; n = 16 pigs) diet formulated to meet or exceed 2012 NRC requirements and an energy restricted (RESTR; n = 16) diet. Pigs maintained on RESTR were provided feed representing a 50% (wk 1) or 25% (wk 2 to 8) reduction in amount of feed relative to amount of feed provided to ADLIB pigs. All diets were corn-soybean meal-based, fed in 2 phases (phase 1, wk 1 to 4; phase 2, wk 5 to 8) and contained 0.5% TiO_2 (digestibility marker). Feed disappearance and individual BW were measured weekly for determination of ADG, ADFI, G:F. At the end of each phase, fecal samples were collected from each pig twice daily for 3 consecutive days and pooled by phase. Feces were analyzed for DM, TiO_2, and GE. Blood samples were collected from each pig (wk 0, 1, 2, 4, 6, and 8) and serum analyzed for C-reactive protein (CRP). No differences in BW (P = 0.79) were observed on d 0 and RESTR pigs had lower (P < 0.001) BW compared to ADLIB at subsequent time points. Final mean BW was 100.5 and 112.0 kg, respectively for RESTR and ADLIB pigs. Overall, ADG (0.86 vs. 1.05 kg) and ADFI (2.65 vs. 3.44 kg) decreased (P < 0.001) and G:F (0.37 vs. 0.34 kg/kg) increased in RESTR compared to ADLIB pigs, respectively. With respect to ATTD, no differences were detected in phase 1; however, in phase 2, DM (83.45 vs. 81.62%) and GE digestibility (82.88 vs. 80.87%) was increased (P < 0.008) in RESTR compared to ADLIB pigs, respectively. For CRP, no overall differences were observed; however, CRP tended to decrease (P = 0.06) in RESTR compared to ADLIB pigs in wk 1. Pigs may compensate for nutrient restriction by becoming more efficient with respect to nutrient assimilation.

Key Words: digestibility, energy restriction, feed efficiency

196 Effects of feed grade L-methionine on intestinal redox status, intestinal development, and growth performance of turkey poults compared with conventional DL-methionine. I. Park*, T. J. Pasquetti, R. D. Malheiros, L. Zheng, P. Ferket, S. W. Kim, *North Carolina State University, Raleigh.*

This study was conducted to test the effects of supplemental L-Met (CJ Corp, Seoul, Korea) on redox status, gut development, and growth performance of turkey poults compared with supplemental DL-Met. Three hundred eighty five newly hatched turkey poults were weighed and randomly allotted to 5 treatments in a completely randomized design for 28 d, including a basal diet (BD), the BD +0.145% DL-Met or L-Met, the BD + 0.285% DL-Met or L-Met (representing 60, 75, and 90% of NRC digestible Met + Cys requirement). Feed disappearance and BW were measured weekly. Liver, duodenum, and jejunum samples were collected from 2 random selected birds in each cage on d 7 and 28. Hepatic tissue and duodenal mucosa were used to measure glutathione (GSH), total antioxidant capacity (TAC), protein carbonyl (PC), and malondialdehyde (MDA) as indicators of the redox status. Duodenal and jejunal tissues were used to evaluate morphology. Data were analyzed using the Mixed procedure in SAS. A multilinear regression analysis was used to evaluate the relative bioavailability (RBA) of L-Met to DL-Met. Overall, weight gain (690 to 746 g) and feed intake (1123 to 1248 g) were increased (P < 0.05) as increasing digestible Met + Cys levels from 60 to 90% of the NRC requirement. Birds with L-Met tended (P = 0.053) to have decreased F:G (1.70 to 1.63) compared with birds with DL-Met. Rates of decrease in F:G were different (P < 0.05) between birds with DL-Met and L-Met. Supplementing Met regardless of sources decreased (P < 0.05) MDA (3.29 to 2.47 μmol/g protein) in duodenal mucosa compared with birds in the BD. Supplementing L-Met tended (P < 0.094) to decrease MDA (1.27 to 1.16 μmol/g protein) in hepatic tissues compared with the supplementation of DL-Met. Other oxidative status markers including GSH, TAC, and PC were not affected by Met sources. Supplementation of Met either from DL or L forms did not affect morphology of duodenum and jejunum on d 7 and 28. In conclusion, supplementation of Met enhanced the growth performance and reduced oxidative stress in the gut of turkey poults during the first 28 d of age. Use of L-Met can potentially enhance feed efficiency and reduce systemic oxidative stress compared with the use of DL-Met in turkeys.

Key Words: growth performance, methionine, oxidative stress

197 Diet nutrient digestibility and growth performance of weaned pigs fed chickpea.

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Using alternative feedstuffs to replace soybean meal (SBM) and cereal grains in swine diets is economically important for pork producers. Chickpea may serve as an alternative source of protein and energy; however, little information is available regarding its dietary inclusion for weaned pigs. The effects of increasing dietary inclusion of chickpea by substituting SBM and wheat grain on nutrient digestibility and growth performance of young pigs were evaluated. Three hundred pigs (initial body weight 9.6 kg) weaned at 20 ± 1 d of age and housed in pens with 4 pigs were involved. Pigs were fed a SBM diet or diets with 7.5, 15, 22.5, or 30% Kabuli chickpea in substitution for up to 20% SBM and 10% wheat grain for 3 wk starting 2 wk postweaning. The chickpea sample contained (DM basis) 23.9% CP, 4.7% ADF, 5.2 mg/g trypsin inhibitor activity, and 0.4% tannin. Diets were formulated to provide 2.34 Mcal NE/kg and 5.1 g standard ileal digestible (SID) Lys/Mcal NE and were steam-pelleted. Increasing dietary inclusion of chickpea quadratically increased ($P < 0.001$) diet apparent total tract digestibility (ATTD) of DM and GE by up to 2.5%-units, quadratically increased ($P < 0.001$) DE and predicted NE value by up to 0.13 and 0.21 Mcal/kg, respectively, but quadratically reduced ($P < 0.001$) ATTD of CP by 4.6%-units. Overall (d 1–21), increasing dietary chickpea quadratically increased ($P < 0.05$) ADFI, quadratically increased then decreased ($P < 0.001$) ADG, and quadratically decreased ($P < 0.001$) G:F and final BW. Pigs fed 15% chickpea had increased ADFI by 66 g/d and ADG by 55 g/d, but similar G:F and increased final body weight compared with pigs fed diet with 0% chickpea. In conclusion, increasing inclusion of up to 30% chickpea in diets for weaned pigs reduced growth performance. Dietary inclusion of 15% chickpea increased feed intake and growth performance of weaned pigs and sustained feed efficiency.

Key Words: growth performance, pig, chickpea

Table 198.

Item	Treatments			SEM	*P*-value
	Ctrl	RCP-ME	RCP-NE		
Overall ADG, kg	0.46	0.44	0.47	0.02	0.403
Overall ADFI, kg	0.73	0.70	0.72	0.03	0.651
Overall Gain:Feed	0.64	0.64	0.65	0.02	0.765
Final BW, kg	24.4	23.8	24.7	1.0	0.404

198 Effects of aggressive feed-grade amino acid supplementation in reduced CP diets formulated on ME or NE basis on growth performance of nursery pigs.

H. J. Kim*[1], T. C. Tsai[1], J. J. Chewning[2], J. K. Apple[3], K. J. Touchette[4], J. E. Thomson[5], J. Less[6], C. V. Maxwell[1], *[1]Department of Animal Science, Division of Agriculture, University of Arkansas, Fayetteville, [2]Swine Research Services, Inc., Springdale, AR, [3]Department of Animal Science, University of Arkansas Division of Agriculture, Fayetteville, [4]Ajinomoto Heartland, Inc., Chicago, IL, [5]Evonik Degussa Corp, Kennesaw, GA, [6]ADM Animal Nutrition, Decatur, IL.*

Barrows and gilts (PIC 29 × 380, $n = 147$) were blocked by initial BW (6.42 ± 1.21 kg) at weaning (21 ± 3 d) and allotted to pens (7 pigs/pen) within each of 7 blocks to evaluate the effects of aggressive feed-grade AA supplementation with reduced CP (RCP) diets formulated on either a ME or NE basis on growth performance of nursery pigs. Pens within blocks were randomly assigned to 1 of 3 treatments: 1) corn-SBM-corn DDGS-based diets formulated to meet the Trp requirement without addition of feed-grade Trp (feed-grade Trp was added in phase 3 to increase the Trp:Lys ratio from 17 to 19; Ctrl); 2) RCP diets formulated to meet the His:Lys ratio requirement (His:Lys = 32) without added feed-grade His and formulated on a ME basis (RCP-ME); or 3) RCP diets to meet the His:Lys requirement without feed-grade His and formulated on a NE basis (RCP-NE). Feed-grade AA were added to diets to meet all SID AA:Lys ratio requirements (M+C:Lys, 58; Thr:Lys, 60; Trp:Lys, 17 in phase 1 and 2 and 19 in phase 3; Ile:Lys, 55; Val:Lys, 65 in phase 1 and 2 and 70 in phase 3; His:Lys, 32) during each phase. During phases 1 and 2, feed-grade AA in RCP diets completely replaced poultry byproduct and partially replaced SBM in Ctrl diets. In phase 3, feed-grade AAs were included at the expense of SBM. Poultry fat was reduced in NE compared to ME-based diets. Neither ADG, ADFI, G:F, nor BW at the end of phases 1 and 2, as well as the end of the study, were affected ($P \geq 0.40$) by high inclusion levels of feed-grade AA in either ME- or NE-formulated diets. These results indicate that similar performance can be achieved with either ME- or NE-based nursery diets formulated to meet the His:Lys ratio without adding feed-grade His when supplemented with high levels of essential feed-grade amino acids to meet the AA:Lys ratios.

Key Words: Reduced crude protein, Feed-grade amino acids, Nursery pigs

199 Effect of fish meal source on nursery pig performance.

A. M. Jones*, J. C. Woodworth, R. D. Goodband, M. D. Tokach, S. S. Dritz, J. M. DeRouchey, Kansas State University, Manhattan.

A total of 350 pigs (DNA Line 200 × 400; initially 6.5 ± 0.09 kg BW; 21 d of age) were used in a 14-d experiment to de-

Table 199.

Item	CTRL	IPC 790		Special Select		LT Prime		Source × Level	
		3%	6%	3%	6%	3%	6%	Lin.	Quad.
D 0–14									
ADG, g	249	266	288	279	239	268	264	0.003	0.059
ADFI, g	329	344	354	353	330	332	335	0.247	0.323
G:F	0.76	0.78	0.81	0.79	0.73	0.81	0.79	0.005	0.130
Final BW, kg	9.98	10.23	10.52	10.40	9.87	10.26	10.19	0.034	0.192

termine the effects of fish meal source on nursery pig performance. Pigs were randomly allotted to pens at weaning (d 0) and were fed a common starter diet for 7 d. On d 7, pens of pigs were randomly allotted by BW to 1 of 7 dietary treatments (10 pens/treatment and 5 pigs/pen) in a 2 × 3 + 1 factorial. Diets were corn-soybean meal-based that contained 10% dried whey and none (Control) or 3 or 6% fish meal from 1 of 3 sources (IPC 790 Fish Meal, The Scoular Company, Minneapolis, MN; Special Select Menhaden Fish Meal, Omega Proteins, Houston, TX; and Daybrook LT Prime Menhaden Fish Meal, Daybrook Fisheries, Morristown, NJ). All fish meal sources were from the 2014 catch year. All samples of fish meal contained less than 0.15% total volatile N suggesting high quality. A source × level interaction ($P < 0.05$) for ADG and final BW was observed as increasing levels of IPC 790 improved ADG; however, pigs fed Special Select and LT Prime fish meal only saw improvement when 3% was included. While no differences were observed between treatments for ADFI, there was a source × level interaction for G:F (Linear $P = 0.005$). This was a result of G:F linearly improving as IPC 790 increased, with pigs fed 3% Special Select or LT Prime having similar performance to 6% IPC 790, but no further improvement thereafter. In conclusion, adding 3% of any fish meal source improved ADG and G:F; however, only pigs fed IPC 790 had a further improvement in ADG when 6% was fed.

Key Words: fish meal, growth, nursery pig

200 Effect of corn germ meal inclusion level on the growth performance and carcass characteristics of wean-to-finish pigs. J. E. Estrada*[1], M. Ellis[2], A. M. Gaines[3], B. A. Peterson[3], O. F. Mendoza[3], *[1]University of Illinois, Urbana-Champaign, [2]University of Illinois, Champaign-Urbana, [3]The Maschhoffs, LLC, Carlyle, IL.*

The effect of corn germ meal (CGM) inclusion level on the growth performance and carcass characteristics of pigs reared under commercial conditions was evaluated with 2 studies. Both studies used RCBD with 2 CGM inclusion levels: 0 and 20%, and 0 and 25% for Study 1 and 2, respectively. A total of 952 (14 replicates) and 680 (10 replicates) barrows and gilts were used in Study 1 and 2, respectively, housed in mixed-sex groups of 34 pigs in Study 1, and single-sex groups of 34 pigs in Study 2. The studies were performed from weaning (6.4 ± 0.57 and 6.6 ± 0.53 kg BW for Study 1 and 2, respectively) to a final BW of 133.3 ± 1.62 and 127.1 ± 1.71 kg, respectively. An 8-phase dietary program was used with diets formulated to the same SID-lysine to calorie (ME) ratio within each phase and to meet or exceed nutrient requirements proposed by NRC (2012). Calculated NDF levels, averaged across all phases, were 6.91 and 12.47% for 0% and 20% CGM diets, respectively, in Study 1 and 7.98 and 13.48% for 0 and 25% CGM diets, respectively, in Study 2. Pigs had ad libitum access to feed and water. At the end of each study, pigs were harvested at a commercial facility and standard carcass grading measurements were collected. The pen of pigs was the experimental unit for all measurements; data were analyzed using PROC MIXED of SAS with the model accounting for the effects of CGM level, block, and replicate. For both studies, there was no effect ($P > 0.05$) of CGM inclusion level in the diet on overall ADG and ADFI. There was no effect of CGM on G:F in Study 1; however, in Study 2 G:F was decreased ($P < 0.05$) for pigs fed diets with 25% compared to 0% CGM (0.414 vs. 0.428 kg:kg, respectively). Carcass yield was reduced ($P < 0.05$) by feeding CGM (0.7 and 1.6% units in Study 1 and 2, respectively), which resulted in reductions in overall average daily carcass weight gain (2.4 and 4.7% lower in Study 1 and 2, respectively), and overall carcass weight G:F (2.3 and 6.2% for Study 1 and 2, respectively). The results of these studies suggest that inclusion levels of CGM of 20 and 25% in diets for wean-to-finish pigs reduces carcass yield and has a negative effect on growth rate and feed efficiency when measured on a carcass weight basis.

Key Words: Corn Germ Meal, Pigs, Carcass

201 Lysine requirement titration for barrows and gilts from 25- to 75-kg. J. L. Landero[1], M. G. Young[1], K. J. Touchette[2], M. J. Stevenson[3], A. B. Clark*[4], M. A. D. Gonçalves[4], S. S. Dritz[4], *[1]Gowans Feed Consulting, Wainwright, AB, Canada, [2]Ajinomoto Heartland, Inc., Chicago, IL, [3]Halchemix Canada Inc, Port Perry, ON, Canada, [4]Kansas State University, Manhattan.*

Lysine is the first limiting amino acid in practical swine diets, so it is important to optimize the dietary digestible lysine to maximize growth and profitability. Two experiments were conducted to estimate the standardized ileal digestible (SID) Lys requirement for pigs from 25- to 50-kg BW (Exp. 1) and 50- to 75-kg BW (Exp. 2) using ADG and G:F as criteria responses. A total of 1050 barrows and gilts (FAST F1 female × PIC380 boar line) were used in each experiment, blocked

by gender, with 10 pens per treatment and 21 pigs per pen. Experimental diets were formulated to contain 2.3 Mcal NE/kg and to meet or exceed all nutrient requirements except Lys, according to NRC (2012). Minimum ratios of 30% Met:Lys, 60% Met+Cys:Lys, 21% Trp:Lys, 70% Val:Lys, 55% Ile:Lys, and 102% Leu:Lys on a SID basis were used for all diets. The SID Thr:Lys ratio was 65 and 66% for Exp. 1 and 2, respectively. In Exp. 1, pigs were fed diets formulated to contain 0.72, 0.80, 0.88, 0.96 or 1.04% SID Lys whereas in Exp. 2 diets were formulated to contain 0.68, 0.75, 0.82, 0.89 or 0.96% SID Lys. Responses measured at the pen level were analyzed using general linear and nonlinear heteroskedastic mixed models. Dose response curves were evaluated using linear (LM), quadratic polynomial (QP), broken-line linear (BLL), and broken-line quadratic (BLQ) models. For each response variable, the best-fitting model was selected using Bayesian information criterion. Gender was used as covariate when significant. Increasing SID Lys content in the diet quadratically ($P < 0.01$) increased ADG and G:F in Exp. 1 and linearly ($P < 0.001$) increased ADG and G:F in Exp. 2. From 25- to 50-kg, the best-fitting models for ADG and G:F were the LM and QP, respectively, with the maximum response estimated at > 1.04% SID Lys. From 50- to 75- kg BW, the best-fitting model for ADG was the BLQ estimating the requirement at 0.83% (95% confidence interval [CI]: [0.80%, 0.86%]) SID Lys, with 99% of maximum achieved with 0.82%. For G:F, the BLL was the best-fitting model and the SID Lys requirement estimated at 0.85% (95% CI: [0.75%, 0.94%]) with 99% of maximum achieved with 0.80%. In conclusion, the SID Lys requirement for 25- to 75-kg pigs may be higher than the recommendation from NRC (2012).

Key Words: lysine, requirement, grower pig

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202 High levels of soybean meal reduces medical treatment in nursery pigs affected by PRRS.

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High levels of soybean meal (SBM) may modulate the response to a respiratory disease challenge by reducing systemic viral replication and modulating the immune system. A total of 2112 pigs (BW 5.99 ± 0.10 kg) were placed into 2 nursery rooms of 48 pens each (22 pigs/pen) under commercial conditions to evaluate the potential of SBM levels (low, medium, or high) in combination with phytase (Quantum Blue, AB Vista; 560 or 1415 analyzed FTU/kg) to improve growth and health of weaned pigs originating from a porcine reproductive and respiratory syndrome (PRRS) affected sow farm. Pigs were fed a 3-phase feeding program, with each period being 10, 10, and 22 d, respectively. Inclusion of SBM was 15.0, 22.5 and 30.0% (1.50% SID lysine; 23.6, 25.8, and 28.0% CP) for phase 1 and 20.0, 27.5 and 35.0% (1.42% SID lysine; 23.1, 24.9, and 26.6% CP) for phase 2 for low, medium, and high SBM, respectively. For phase 3, pigs were fed a common diet. Stool firmness (0 = normal; 1 = soft; 2 = fluid; and 3 = completely liquid) was determined during the first 10 d of the study. Oral fluid samples were collected on d 20 and 42 and analyzed by PCR to assess viral load of PRRS. Data were analyzed as a RCBD in a 3 × 2 factorial arrangement of treatments with pen as experimental unit. No significant interactions or main effects ($P > 0.05$) were observed for ADFI, ADG or gain:feed. The percentage of pigs pulled for medical treatment declined linearly with increasing SBM levels (11.09, 9.15, 8.42%; $P = 0.04$). However, there was no reduction in mortality or improvement in the percentage of full value pigs (97.3, 97.4, and 97.3%; $P = 0.97$). Stool firmness decreased with increasing SBM during d 1 to 5 (linear, $P = 0.01$) and tended to decrease for d 1 to 10 ($P = 0.13$; 0.60, 0.60 and 0.71). Phytase tended to improve stool score for d 1 to 5 ($P = 0.06$) and d 1 to 10 ($P = 0.14$; 0.67 vs. 0.61). Soybean meal levels did not affect ($P \geq 0.31$) viral load of PRRS when determined on d 20 (Ct values of 30.1, 30.3, and 32.0) or d 42 (Ct values of 29.3, 30.1, 29.1). In conclusion, increased levels of SBM may be beneficial in health challenged pigs by reducing labor and cost associated with treatment for disease without impacting performance or viral load of PRRS. The tendency for high levels of SBM to cause stool looseness can be countered with a high phytase level.

Key Words: phytase, porcine reproductive and respiratory syndrome, soybean meal

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203 Performance responses of weaned pigs when fermented soybean meal (NF8) was replaced with a modified grain by-product (Gold Pro).

F. B. Sandberg*, S. J. England, M. R. Bible, *Furst McNess Company, Freeport, IL.*

The objective of this study was to determine in a commercial research environment if performance could be maintained when fermented soybean meal was replaced as a protein source, with a modified, fermented corn by-product (Gold Pro), at graded levels in the diet: 10% NF8 (NONE), 5% NF8 + 5% Gold Pro (PARTIAL) and 10% of Gold Pro (COMPLETE). The experiment involved 472 weaned pigs (21 d of age, 6.6 kg) that were allocated to either NONE, PARTIAL or COMPLETE replacement treatment diet, allocated by weight and weaning age, and blocked within the barn. A commercial wean to finish barn was used (29 pigs per pen, 4–6 pens per treatment) with a FANCOM feed system. To test the immediate postweaning effect of the protein replacement, pigs were placed immediately onto treatments on arrival; there was no adaptation period. Pens of pigs were weighed and feed disappearances were recorded on d 0, 7, and 21, which were used to calculate ADG, ADFI, and FCR. To replicate commercial production as closely as possible, pigs that did not respond to treatment with injectable antibiotic were tagged and removed to sick pens. At the end of the trial it was determined if pigs that were removed from trial had died (% mortality),

or remained as viable pigs (% morbidity). Medical treatments were recorded daily. Data were analyzed as a randomized complete block design using GLM procedure in Minitab with Tukey's test to determine differences between dietary treatments. There were no differences for ($P > 0.10$) for d 0–21 ADG, ADFI, or FCR. There were no differences ($P > 0.10$) observed for % morbidity/pen. However, pigs fed the PARTIAL and COMPLETE feed had a lower % mortality/pen ($P < 0.01$) in contrast with pigs fed the NONE treatment. There was a trend ($P < 0.10$) for pigs fed the NONE treatment to have more medical treatments/pen compared to pigs fed the PARTIAL and COMPLETE treatments. In conclusion, Gold Pro can be used as an alternative protein ingredient to replace fermented soybean meal in weaned pig starter rations without loss of growth performance, and may have benefits on health.

Key Words: Pigs, Protein, Ingredient

Table 203. Summary of Performance Day 0 to 21

	None	Partial	Complete	SE	P-value
ADG, g	303	296	303	19.3	0.829
ADFI, g	413	405	430	27.4	0.455
FCR	1.36	1.37	1.41	0.051	0.379
% Morbidity/pen	0.69	0.99	0.25	1.836	0.936
% Mortality/pen	3.80[a]	1.20[b]	0.00[b]	1.048	0.005
Treats/pen	4.8[c]	1.4[d]	1.7[d]	1.71	0.069

204 Responses to feeding higher levels of dried distiller grains and solubles (DDGS) of gilts and barrows, when supplemented with plant extracts (Lean Fuel).

F. B. Sandberg*, S. J. England, M. R. Bible, *Furst McNess Company, Freeport, IL.*

The objective of this study was to determine the effects of feeding a diet with 50% DDGS either unsupplemented (C) or supplemented with 1251 mg Lean Fuel (LF) per kg of complete feed in gilts (G) and barrows (B) from a high lean genetic. The experiment lasted for 83 d and was conducted at a commercial research facility with 986 pigs (493 G and 493 B), weighing 37.6 kg at the beginning of the trial, and allocated to C-B (n = 8 pens), C-G (n = 8 pens), LF-B (n = 9 pens) and LF-G (n = 9 pens), where pens were blocked by weight, sex, and location in the barn. A FANCOM feed weighing system measured feed delivered to the individual pens, and weight of pigs and feed disappearance were measured on d 0, 14, 28, 42, 56, 70, and 83. Weights and feed were used to calculate ADG, ADFI, and FCR. Data were analyzed as a completely randomized design as a 2x2 factorial using GLM in Minitab with Tukey's test to determine differences between dietary treatments. For d 83 BW, there was a treatment × sex interaction. The C-G (104.5 kg) weighed less ($P < 0.001$) than C-B (110.7 kg), LF-B (110.7 kg), and LF-G (107.9 kg). For d 0–83, the pigs fed LF (862 g) tended ($P < 0.10$) to have a higher ADG than the pigs fed C (842 g). Also, the B (879 g) gained more ($P < 0.001$) compared to the G (826 g). There was a treatment by sex interaction ($P < 0.05$) for d 0–83 ADG. The LF-B (880 g) and C-B (875 g) gained more weight than the LF-G (844 g), and the LF-G had a higher ADG compared to the C-G (807 g). The B (2562 g) had a higher ADFI ($P < 0.001$) compared to the G (2378 g). The pigs fed the C (2432 g) consumed less feed ($P < 0.05$) compared to the pigs fed LF (2509 g). There was no treatment × sex interaction ($P > 0.10$) for ADFI. There were no significant effects on FCR (C-B = 2.90, LF-B = 2.94, C-G = 2.88, LF-G = 2.88; $P > 0.10$) for d 0–83. In conclusion, in high DDGS diets LF significantly improved growth rate of G, and could be used as a tool to allow higher levels of DDGS to be fed to G, to reduce feed input costs, without loss of performance.

Key Words: Pigs, Plant Extracts, DDGS

205 Effect of increasing sow feeding level in late gestation on piglet quality and sow body condition.

M. T. Knauer*, *North Carolina State University, Raleigh.*

The objective was to determine the effect of increasing feeding level in late gestation on piglet quality and sow body condition. Parity 2 PIC Landrace × Large White sows (n = 67) were randomly assigned to 1 of 2 feeding levels (1.82 or 2.73 kg) from 100 d of gestation until farrowing. Gestation diets were formulated to 0.68% total lysine and 2979 kcal ME per kg. All other nutrients met or exceeded NRC (2012) requirements. Housing consisted of individual gestation stalls with ad libitum access to water and natural ventilation. Sow body condition was monitored at the last rib with the sow body condition caliper. Sows farrowed near Plymouth, NC in late June of 2015. Piglets were individually weighed and identified within 1 d of birth and at 21 d of age. All reproductive traits were calculated as those of the biological dam. Feeding level did not impact ($P \geq 0.44$) total number born (13.05 vs. 13.08), total litter birth weight (14.8 vs. 14.7 kg), average piglet birth weight (1.16 vs. 1.16 kg) or birth weight CV (20.0 vs. 21.2%). In comparison to the 1.82 kg feeding level, the 2.73 kg feeding level improved ($P \geq 0.15$) litter size at weaning (9.14 vs. 9.71), litter weaning weight (50.6 vs. 55.5 kg), average weaning weight (5.57 vs. 5.82 kg), weaning weight CV (21.3 vs. 18.7%) and piglet survival (71.8 vs. 73.6%) and tended ($P = 0.10$) to increase the number of piglets (8.56 vs. 9.59) weighing greater than 3.2 kg at weaning. Across both treatments sows lost ($P < 0.01$) body condition from 100 d of gestation to farrowing and from farrowing to weaning (caliper scores of 14.5, 13.1 and 11.1, respectively). When compared to the 1.82 kg feeding level, sows fed 2.73 kg in late gestation lost less ($P = 0.33$) body condition from 100 d of gestation to farrowing and less ($P = 0.02$) body condition from 100 d of gestation to weaning. Results indicate increasing feeding level in late gestation does not increase piglet birth weight but would improve sow body condition at weaning and may increase the number

of quality weaned piglets.

Key Words: feed intake, gestation, sow

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206 Effects of dietary calcium concentrations on the apparent total tract digestibility and the balance of calcium, phosphorus, and nitrogen in growing pigs. Y. She*, X. S. Piao, L. Liu, D. F. Li, *State Key Laboratory of Animal Nutrition, Ministry of Agriculture Feed Industry Centre, China Agricultural University, Beijing 100193, China.*

This study was conducted to determine the total endogenous Ca output and to determine the effects of dietary Ca concentrations on endogenous Ca outputs, the true total tract digestibility (TTTD), and balance of Ca, P, and N in growing pigs. Thirty-six growing barrows (initial BW: 42.2 ± 2.0 kg) were placed in metabolism crates and allotted to a randomized complete block design with 6 diets and 6 pigs per diet. Diets were based on cornstarch and casein, and were formulated to provide the following levels of total Ca: 0.13, 0.31, 0.50, 0.68, 0.87, and 1.05%, and the analyzed ratio of total Ca to total P was between 1.16:1 and 1.23:1. Calcitic limestone and monosodium phosphate provided the majority of the Ca and P in the diets. Feces and urine samples were collected from d 8 to d 12. Total endogenous Ca and P outputs and values for TTTD of Ca and P were determined using the regression procedure. Results indicate that the estimated total endogenous Ca and P outputs were 0.508 and 0.428 g/kg DMI, respectively. The TTTD of Ca in calcitic limestone was estimated at 76.8% and the TTTD of P in monosodium phosphate was estimated at 88.8%. It is concluded that the dietary concentration of Ca affects the retention of P significantly ($P < 0.01$), but does not affect the retention of Ca or N.

Key Words: calcium, endogenous losses, phosphorus

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207 Effects of proteinate complex zinc on trace elements concentrations, oxidative stress and immune functions in weaned piglets. Y. She*, X. S. Piao, L. Liu, D. F. Li, *State Key Laboratory of Animal Nutrition, Ministry of Agriculture Feed Industry Centre, China Agricultural University, Beijing 100193, China.*

This study assessed the effects of proteinate complex zinc (Zn) on oxidative stress, trace elements concentrations and immune functions in weaned piglets. Three hundred newly weaned barrows (Duroc × Landrace × Yorkshire), 28 d of age, were randomly allotted to 3 dietary groups of 5 replicate pens per group for 4 wk of feeding. Experimental diets were: (1) zinc deficient diet (ZnD, 24 mg/kg Zn supplementation from $ZnSO_4$), (2) inorganic Zn diet supplemented by 120 mg/kg of Zn from Zn sulfate ($ZnSO_4$), and (3) organic Zn diet supplemented by 120 mg/kg of Zn from proteinate complex Zn (PC-Zn). The Zn, Cu, Fe and Mn concentrations in the spleen and liver were measured using inductively coupled plasma–mass spectrometry (ICP–MS) technology. The activities of serous alkaline phosphatase (ALP), alanine transaminase (ALT) and aspartate transaminase (AST) were measured with a biochemical autoanalyzer. The concentration of malondialdehyde (MDA) was determined according to the thiobarbituric acid reactive substances (TBARS) assay and the activity of Mn and Cu/Zn superoxide dismutase (SOD) and glutathione peroxidase (GSH-Px) in the spleen and liver were analyzed according to the xanthine oxidase and ammonium molybdate chromogenic methods, respectively. The hepatic MT content was examined by the Cd/hemoglobin affinity assay The levels of splenic interleukin (IL)-2, IL-4, IL-10 and interferon (IFN)-γ were determined by IL-2, IL-4, IL-10 and IFN-γ enzyme linked immunosorbent assay (ELISA) kits, respectively. The proportions of $CD3^+$, $CD4^+$ and $CD8^+$ T lymphocyte were analyzed with ELISA methods. The results showed that the accumulation of Zn in the spleen, levels of SOD, GSH-Px, IL-4, IL-10, the proportions of $CD3^+$ and $CD4^+$ T lymphocyte, and the ratio of $CD4^+/CD8^+$ T lymphocyte were increased by organic Zn supplementation, while the levels of MDA, IFN-γ, and proportion of $CD8^+$T lymphocyte were lowered. These findings indicate that Zn can improve the antioxidant potential and immune functions related to T lymphocyte production in the spleen of weaned piglets.

Key Words: proteinate complex zinc, immune functions, weaned piglets

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208 Efficiency of Ca and P retention in growing pigs fed diets with different Ca:P ratios provided by monocalcium phosphate or phytase supplementation. M. Grez*, T. D. Crenshaw, *University of Wisconsin-Madison, Madison.*

The dietary Ca:total P ratio (Ca:tP) may affect Ca and P retention and interfere with phytase (Phy) activity. However, limited data are available on responses to Ca:tP less than 1. A 32-d experiment with 161 crossbred (1/4 Landrace × 1/4 Large White × 1/2 PIC Line 19) gilts and barrows (initial BW 26.1 ± 0.39 kg) was designed to determine Ca:tP and Phy effects on growth and bone accretion. Pigs were randomly allotted within weight blocks to 1 of 7 dietary treatments with 7 to 8 pigs/pen (sex balanced) to provide 3 pens per treatment. Dietary corn-SBM based treatments were arranged as a 2 × 3 factorial design with 2 Phy levels (0 vs. 650 FTU/kg diet from Ronozyme HiPhos (GT2700) and 3 Ca:tP (0.8:1, 1.1:1 or 1.5:1). Diets provided 90% of the tP requirements with additions of monocalcium phosphate (MCP) or Phy. A positive control (PC) diet provided 100% of tP requirements with MCP and 1.2:1 Ca:tP. On d-32, 2 pigs per pen were selected and scanned by dual energy X-ray absorptiometry (DXA) to determine whole body bone mineral content (BMC). BMC gain and ADFI were used to estimate Ca and P retention, and retention efficiency (RE, g retained/g consumed). Regardless

of the P source, ADG, ADFI, BMC gain, Ca and P retention were greater at 0.8:1 *vs.*1.5:1 Ca:tP. However, Ca and P RE decreased if Ca:tP increased. In contrast with MCP diets, no differences in ADG and BMC gain were detected among PC and diets with Phy at 0.8:1 or 1.1:1 Ca:tP. Pigs supplemented with Phy at 0.8:1 Ca:tP had the greatest Ca RE and a greater P RE than PC and MCP diets. In conclusion, a reduction in Ca:tP to 0.8:1 in Phy supplemented diets improved growth and bone traits as these pigs used dietary Ca and P more efficiently than pigs fed diets with 1.5:1 Ca:tP.

Key Words: phytase, calcium:total phosphorous ratio, growth, bone accretion, retention

Table 208.

	Phytase, FTU/kg							
	0	0			650			
	Ca:tP ratio							
Traits	1.2:1	0.8:1	1.1:1	1.5:1	0.8:1	1.1:1	1.5:1	SEM
ADG, kg/d	0.97^{ab}	0.94^{b}	0.91^{bc}	0.87^{c}	1.02^{a}	0.96^{ab}	0.92^{bc}	0.021
ADFI, kg/d	1.97^{ab}	1.95^{bc}	1.91^{bc}	1.87^{c}	2.06^{a}	1.96^{bc}	1.94^{bc}	0.044
Gain BMC, g/d	13.9^{a}	9.89^{b}	7.77^{c}	6.90^{c}	12.03^{a}	12.22^{a}	8.68^{bc}	0.722
Ca retention efficiency	0.39^{c}	0.47^{b}	0.31^{d}	0.21^{e}	0.75^{a}	0.52^{b}	0.29^{d}	0.027
P retention efficiency	0.32^{bc}	0.27^{c}	0.20^{d}	0.20^{d}	0.34^{ab}	0.38^{a}	0.27^{c}	0.020

Means within a row without a common superscript are different, $P < 0.05$.

209 Effects of extracted of rice bran supplementation on production performance, feed intake, egg quality and fecal microflora in laying hens. D. H. Nguyen*[1], J. H. Cho[2], H. S. Kim[1], H. N. Tran[1], I. H. Kim[1], [1]*Department of Animal Resource & Science, Dankook University, Cheonan, South Korea,* [2]*Department of Animal Science, Chungbuk National University, Cheongju, South Korea.*

A total of 288 Hy-line Brown (46-wk old) laying hens were randomly assigned to 1 of 3 treatments. The trial lasted for 6 wk. Treatments were: 1) CON, basal diet; 2) T1, CON + 0.01% extracted rice bran; 3) T2, CON + 0.02% extracted rice bran. There were 8 replicates per treatment with 12 birds per replicate. Egg production and feed consumption were recorded daily and weekly, respectively. The egg production was expressed as an average hen-day production. Egg quality was checked every week throughout the trial period. Eggshell breaking strength was evaluated using egg shell force gauge model II. Egg weight, yolk color, yolk height, and Haugh unit (HU) were evaluated using an egg multi tester. Finally, egg shell thickness of the large end, equatorial region, and the small end were measured using a dial pipe gauge. One gram of fecal sample from each cage was diluted with 9 mL of 1% peptone broth (Becton, Dickinson and Co., Franklin Lakes, NJ) and homogenized. Viable counts of bacteria in the fecal samples were then conducted by plating serially diluted samples (10-fold dilutions in 1% peptone solution) onto MacConkey agar plates (Difco Laboratories, Detroit, MI) and lactobacilli medium III agar plates (Medium 638, DSMZ, Braunschweig, Germany) to isolate *E. coli* and *lactobacillus*, respectively. All data were subjected to the GLM procedures of SAS and differences among treatments were separated by Tukey's multiple range test with a $P < 0.05$ indicating a significance. The results showed that egg production percentage increased linearly ($P < 0.05$) during wk 5 (CON = 88.1%, T1 = 90.8%, T2 = 92.3%), 6 (CON = 90.3%, T1 = 91.1%, T2 = 93.3%), and overall period of the experiment (CON = 89.6%, T1 = 91.0%, T2 = 91.7%). Any significant effect was not observed on feed intake during overall period of the experiment (CON = 108.5 g, T1 = 108.5 g, T2 = 109.1 g). Increasing levels of dietary extracted rice bran improved eggshell thickness linearly $P < 0.05$ (CON = 40.9 mm^{-2}, T1 = 41.1 mm^{-2},T2 = 41.2 mm^{-2}), but the other parameters of egg quality were not affected significantly. The results also showed that addition of extracted rice bran to the diet of laying hens decreased the count of fecal *E. coli* (CON = 6.63 log_{10}CFU/g, T1 = 6.47 log_{10}CFU/g, T2 = 6.37 log_{10}CFU/g) and increased the count of fecal *lactobacillus* (CON = 7.44 log_{10}CFU/g, T1 = 7.49 log_{10}CFU/g, T2 = 7.72 log_{10}CFU/g) significantly. In conclusion, dietary supplementation of 0.02% extracted rice bran improved egg production percentage and fecal microflora in laying hens.

Key Words: Extracted rice bran, egg quality, laying hens

210 Evaluating the effects of microencapsulated blends of phytobiotics in the diet of broiler chickens. M. Mohammadi Gheisar*, J. W. Park, S. Mohana Devi, I. H. Kim, *Department of Animal Resource & Science, Dankook University, Cheonan, South Korea.*

This study was conducted to determine the effects of supplementing diets with microencapsulated blends of phytogenics (MPH) on growth performance, carcass characteristics, fecal microbiota, blood constituents, and excreta noxious gas emission in broiler chickens. A total of 768 d-old Ross 308 (as hatched) broiler chicks with an average initial body weight of 40 ± 0.9 g were used in a 35-d growth assay. There were 4 treatments and each treatment consisted of 12 replications with 16 birds/pen, with food and water consumed ad libitum. Treatments were designed as a corn-soybean-meal-based diet with none, 0.025 and 0.05, and 0.075% of MPH. Data were analyzed as a completely randomized design via ANOVA using the GLM procedure described by SAS. Polynomial regression was used to describe the shape of the response to increasing concentration of microencapsulated blends of phytobiotics in the diet. Results indicated improvement in body weight gain (BWG) and feed conversion ratio (FCR) (linear effect, $P < 0.05$). Increasing concentration of MPH in the diet from none to 0.075% increased ($P < 0.05$) BWG at d 1 to 7, 7 to 21, and

1 to 35, and decreased FCR at d 7 to 21 and 1 to 35 ($P < 0.05$). Supplementing the diets with various levels of MPH had no effect on pH value of the breast meat, meat color and relative organ weights, but drip loss percentage decreased linearly ($P = 0.01$) on d 7 by increasing the concentration of MPH from none to 0.075%. Fecal microbiota assay indicated that supplementing the diets with 0 to 0.075% of MPH increased the fecal *Lactobacillus* count linearly ($P = 0.002$), but the *E. coli* count was not affected. Results demonstrated that whole blood cell counts, lymphocyte percentage and IgG concentration were not influenced, but concentration of haptoglobin dropped linearly ($P = 0.001$) by increasing dietary concentration of MPH. Thus, it was concluded that inclusion of MPH improved growth performance and positively manipulated fecal *Lactobacillus* population with no negative effect in broilers.

Key Words: Broiler, carcass characteristics, nutrient digestibility

211 Effect of soybean cultivar on growth performance of broilers. G. Hosotani*, M. S. Kerley, M. C. Shannon, *Division of Animal Sciences, University of Missouri, Columbia,.*

A 19-d study was conducted to compare soybean meal (SBM) from 10 soybean cultivars owned by Missouri Soybean Association on growth performance of broiler chicks. Soybean meal was prepared by laboratory-scale mechanical extraction. Two hundred and fifty 1-d-old male broilers (Ross 308) were randomly placed in battery cages and allocated to 10 dietary treatments with 5 replicates and 5 birds per replicate. All SBM sources were heated in a convection oven at 120°C for 20 min and included from 38.2 to 43.5% in the diets. Isocaloric diets were formulated to meet or exceed NRC (1994) and Aviagen nutrient requirements. Broilers were weighed and feed disappearance measured on d 7, 14, and 19. Statistical analyses were performed as a randomized complete block design using PROC GLM of SAS with significance level set at $P < 0.05$. No differences were observed in final body weight, body weight gain, feed intake, and feed conversion of broilers fed different SBM ($P > 0.05$). The body weight gain ranged from 552 to 595 g, resulting in 7.8% variation and feed conversion ranged from 1.42 to 1.36, resulting in 4.4% variation. Although there were no statistical differences in growth performance of broilers fed different soybean meals, the numerical difference in feed efficiency observed among treatments would affect the production cost margins. Nutrient digestibility may be the main factor of growth performance among the different SBM sources, suggesting further investigation.

Key Words: broiler soybean growth

212 Effect of crumbled diet on growth performance, market day age and meat quality of growing-finishing pigs. D. H. Nguyen*, S. Kathannan, Y. H. Liu, I. H. Kim, *Department of Animal Resource & Science, Dankook University, Cheonan, South Korea.*

This study was conducted to determine the effect of crumbled diet on growth performance, market day age, and meat quality of growing-finishing pigs. A total of 120 crossbred pigs [(Landrace × Yorkshire) × Duroc] with an average initial body weight (BW) of 25.89 ± 1.93 kg were randomly allotted to 2 experimental diets based on initial BW (15 replicate pens per treatment, 4 pigs per pen). The trial lasted for 120 d. Dietary treatments included: 1) T1 (mash diet); 2) T2 (crumble diet). Individual pig BW and pen feed consumption were recorded at the end of 6, 12, and 18 wk to calculate the average daily gain (ADG), average feed intake (ADFI), and gain to feed ratio (G:F). Backfat thickness of all pigs was measured at 6 cm off the midline at the 10th rib using a real-time ultrasound instrument (Piglot 105; SFK Technology, Herlev, Denmark). Reflectance spectrometry measurements of lightness (L*), redness (a*), and yellowness (b*) values were determined using a Minolta CR410 chroma meter (Konica Minolta Sensing, Inc., Osaka, Japan). The pH values of each sample were measured with a pH meter (Fisher Scientific, Pittsburgh, PA). The areas of pressed sample and expressed moisture were delineated and determined with a digitizing area-line sensor (MT– 10S; M.T. Precision Co. Ltd., Tokyo, Japan). All data were subjected to the GLM procedures of SAS and differences among treatments were separated by Tukey's multiple range test with a $P < 0.05$ indicating a significance. During the overall study period pigs fed the T2 (crumble diet) had significant greater ($P < 0.05$) average daily gain (ADG) (T1 = 803 g, T2 = 839 g) and gain to feed ratio (G:F) (T1 = 0.346, T2 = 0.359). Moreover, the number of pigs fed crumble diet reached the marketing age on d 177 is higher than the pigs fed mash diet. No significant difference was observed in back-fat thickness, meat color, sensory evaluation (including: color, firmness, marbling), cooking loss, drip loss, water holding capacity, and longgissimus muscle area (LAM) between T1 and T2 groups. Our results revealed that the growth performance was significantly enhanced in pigs fed with the crumble diet. In addition, crumble diet reduced market day age of growing-finishing pigs.

Key Words: Crumble form, mash form, growing-finishing pigs

213 Effects of creep feed pellet diameter on suckling and nursery pig performance. A. B. Clark*, J. A. De Jong, J. M. DeRouchey, M. D. Tokach, S. S. Dritz, R. D. Goodband, J. C. Woodworth, *Kansas State University, Manhattan.*

A total of 26 litters of pigs (PIC 327 × 1050; initially 3.2 kg BW and 10-d of age) were used to evaluate the effects of creep feed pellet diameter on suckling pig and nursery growth performance. On d 10 of suckling, litters were allotted to 1 of 2 dietary treatments by parity and BW in a randomized complete block design with 13 replications per treatment. Starting on d 10 of lactation, pigs were fed common pelleted creep feed processed using either a 3.2 mm (small) or a 12.7 mm (large) die. Chromic oxide was included as a fecal marker and fecal swabs were taken on d 14, 17, and 21 to determine percentage of pigs consuming creep feed. On d 21, pigs were weaned and re-allotted to nursery treatments for 21-d and fed in 2 phases. Phase 1 (d 0 to 7 postweaning) treatment diets were the same diets fed during the suckling period with 50% of the pigs remaining on their previously allotted pellet diameter treatment and the other 50% of pigs were re-allotted to the opposite pellet diameter treatment in the nursery. A common meal form diet was fed from d 7 to 21 postweaning. During the suckling phase (d 10 to 21), litters of pigs fed the large creep pellet had decreased ($P < 0.03$) pre-weaning mortality (0 vs. 2.54%; SEM = 0.008) and increased ($P < 0.05$) ADFI from d 17 to 21 (30.8 vs. 17.6 g; SEM = 4.41). There were no significant differences in suckling pig BW gain (3.21 vs. 3.25 kg; SEM = 0.107, for small and large pellet treatments, respectively) or percentage of pigs consuming creep feed (58 vs. 59%; SEM = 0.008, for small and large pellet treatments, respectively). During the nursery phase, pigs fed a large nursery pellet, regardless of creep feed treatment, had increased ($P < 0.01$) ADFI from d 0 to 7 (138 vs. 153 g; SEM = 3.6). Pigs fed the large creep feed pellet, regardless of nursery pellet diameter, had improved ($P < 0.03$) ADG (67 vs. 50 g; SEM = 5.0) and G:F (0.452 vs. 0.334; SEM = 0.0349) from d 0 to 7 postweaning, as well as improved G:F overall (0.828 vs. 0.779; SEM = 0.0129). There were no significant differences in ADG or ADFI during the common or overall period. In summary, feeding a large creep feed pellet improved late suckling creep ADFI and nursery G:F, while feeding a large nursery pellet increased ADFI during the first week in the nursery.

Key Words: creep feed, nursery pigs, pellets

214 Stability of commercial phytase products under increasing thermal conditioning temperatures. J. A. De Jong*[1], J. M. DeRouchey[1], M. D. Tokach[1], R. D. Goodband[1], J. C. Woodworth[1], C. K. Jones[1], C. R. Stark[1], C. L. Bradley[2], J. A. Loughmiller[3], J. R. Bergstrom[4], *[1]Kansas State University, Manhattan, [2]AB Vista Feed Ingredients, Marlborough, United Kingdom, [3]Maverick Nutrition, Fairmont, MN, [4]DSM Nutritional Products, Parsippany, NJ.*

The objective was to determine the stability of 4 commercial phytase products exposed to increasing thermal conditioning temperatures. The 4 commercial products used were: Quantum Blue 5G (AB Vista, Marlborough, United Kingdom); Ronozyme Hi Phos GT (DSM Nutritional Products, Parsippany, NJ); Axtra Phy TPT (Dupont, Wilmington, DE), and Microtech 5000 Plus (Guangdong VTR Bio-Tech Co., Ltd., Guangdong, China). The phytase products were mixed as part of a corn-soybean meal-based swine diet at a concentration recommended by the manufacturer to provide a 0.12% aP release. Diets were exposed to each of 4 thermal conditioning temperatures (65, 75, 85, and 95°C) for approximately 40 s and the entire process was repeated on 4 consecutive days to create 4 replicates. Samples were taken while feed exited the conditioner and before entering the pellet die. Phytase activity was determined from complete feed samples before conditioning to establish a baseline diet phytase activity level for each product. Phytase stability was measured as the residual phytase activity (% of initial) at each conditioning temperature. There were no product × temperature interactions for conditioning temperature, throughput, or residual phytase activity. As expected, as the target temperature was increased, conditioning temperature increased (linear, $P < 0.001$) and conditioner throughput decreased (linear, $P < 0.001$). As target temperature increased, phytase activity decreased (linear, $P < 0.001$) for each product. There was a significant phytase product main effect which was primarily caused by Microtech 5000 Plus having decreased ($P < 0.05$)

Table 214. Effect of conditioning temperature and phytase product on residual phytase activity1

	Conditioning temperature, °C					Probability, $P <$	
Item	65	75	85	95	SEM	Linear temperature	Product main effect
Residual phytase activitiy,[2%]							
Quantum Blue 5G	99.0	78.2	37.9	21.1	8.80	0.001	0.001
Ronozyme Hi Phos GT	87.5	59.7	43.3	22.9			
Axtra Phy TPT	80.6	62.0	36.2	33.1			
Microtech 5000 Plus	37.6	21.4	3.5	3.5			

[1] Within each of 4 conditioning runs at each temperature, a composite sample consisting of 4 subsamples was used for analysis for each product.

[2] Stability was measured as the analyzed post-conditioning phytase concentration divided by phytase concentration before conditioning.

phytase activity when compared to all other products at all conditioning temperatures. In summary, increasing conditioning temperatures decreased phytase stability regardless of product. In addition, Microtech 5000 Plus had decreased residual phytase activity (% of initial) when compared to all other products.

Key Words: conditioning temperature, pelleting, phytase stability

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215 Effects of grinding corn through a 2-, 3-, or 4-high roller mill on pig performance and feed preference of nursery pigs. J. T. Gebhardt*[1], J. A. De Jong[1], M. D. Tokach[1], J. C. Woodworth[1], J. M. DeRouchey[1], R. D. Goodband[1], K. F. Coble[2], C. R. Stark[1], C. K. Jones[1], S. S. Dritz[1], *[1]Kansas State University, Manhattan, [2]New Fashion Pork, Jackson, MN.*

A total of 410 pigs were used in 2 experiments to determine the effects of grinding corn through various roller mill configurations on feed preference and performance of nursery pigs. In Exp. 1, 320 pigs (DNA 400 × 200; initial BW = 10.7 kg) were randomly allotted to 1 of 4 dietary treatments with 16 pens/treatment and 5 pigs/pen for a 21-d growth trial. The 4 dietary treatments used the same corn-soybean meal-based formulation that were mixed from the same batch of ingredients. Corn was ground through the same 4-high roller mill, but using different roller configurations including feed with corn fraction ground to 650 µm using 2 sets of rolls (2-high), feed with corn fraction ground to 495 µm using 3 sets of rolls (3-high), feed with corn fraction ground to 340 µm using 4 sets of rolls in a fine grind configuration (4-high fine), and feed with the corn fraction ground to 490 µm using 4 sets of rolls in a coarse grind configuration (4-high coarse). In Exp. 2, 90 pigs (PIC 327 × 200; initial BW = 12.2 kg) were randomly allotted to 1 of 3 diet comparisons to determine feed preference. The 3 diets compared were the 2-high, 4-high fine, and 4-high coarse configurations. Each pen contained 2 feeders, each containing 1 of the 3 treatment diets. Feeders were rotated once daily within each pen for the 7-d study, with 5 pigs per pen, and 6 pens per comparison. In Exp. 1, there were no differences in ADG, ADFI or G:F between roller mill configurations. Similarly, no differences were observed for caloric efficiency or economics among roller mill configurations. In Exp. 2, when given a choice, pigs consumed 67% ($P < 0.05$) of the diet containing corn ground through the 2-high roller mill when compared to the diet containing 4-high fine corn. There was no difference in feed consumption comparing diets with 2-high roller mill corn or corn from the 4-high roller mill in a coarse configuration. When comparing corn from the two 4-high configurations, pigs consumed 63% ($P < 0.05$) of the diet manufactured in the coarse configuration and 37% when manufactured in the fine grind configuration. When given a choice, pigs preferred diets manufactured using a mill configuration producing coarser ground corn (490 to 650 µm) to fine ground corn (340 µm); however, roller mill configuration did not affect performance.

Key Words: roller mill, nursery pigs, feed preference

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216 Coating dog kibble with a commercial liquid acidifier reduces the risk of *Salmonella* cross-contamination. A. R. Huss*[1], A. Deliephan[1], J. C. Fuller, Jr.[2], C. K. Jones[1], *[1]Kansas State University, Manhattan, [2]Metabolic Technologies Inc, Ames, IA.*

In recent years, several pet food recalls have been attributed to *Salmonella* contamination. In addition to the negative impacts on animal health, pet foods contaminated with *Salmonella* have been linked to infection in humans. To help reduce the risks to humans, the Food and Drug Administration has set forth a zero-tolerance policy for *Salmonella* in pet foods. Typically, the preconditioner and extruder operate at sufficient temperatures to destroy pathogenic bacteria. However, there is the potential for post-processing cross-contamination to adulterate the product. One potential method to reduce the risk of *Salmonella* cross-contamination in pet foods is through the addition of chemical additive coatings. The objective of this research was to evaluate the ability of the liquid acid, β-hydroxy-β-methylbutyric acid (HMB; Metabolic Technologies Inc, Ames, IA), to reduce cross-contamination of dry extruded dog kibble with *Salmonella*. Liquid HMB was applied to a single formula of dog kibble at inclusion levels of 0, 0.9 and 1.5% (w:w) using a laboratory-scale mixer. The coated kibbles were then inoculated with *Salmonella enterica* subsp. *enterica* Serovar Enteritidis (ATCC 13076), grown in trypticase soy broth (TSB). Inoculated kibbles were enumerated for *Salmonella* on d 0, 1, 2, 7, and 14 post-inoculation. For enumerations, a subsample was collected, serial diluted and spread plated to Xylose Lysine Deoxycholate (XLD) agar. All inoculated plates were incubated at 37°C for 24 h, after which black colonies, typical for *Salmonella*, were counted and cfu/g calculated. The effects of HMB concentration, enumeration day and their interaction were all significant ($P < 0.0001$) on the resulting *Salmonella* concentration. *Salmonella* counts from Day 0 were 6.99, 5.59, and 4.88 $\log_{10}$ cfu/g for 0, 0.9 and 1.5% HMB, respectively. For HMB levels of 0.9 and 1.5%, counts were below the detectable limit for d 1, 2, 7, and 14. For 0% HMB, the *Salmonella* counts were found to decrease over time to 4.80, 3.99, 2.80, and 3.14 $\log_{10}$ cfu/g for d 1, 2, 7, and 14, respectively. Overall, the HMB coating was effective at reducing *Salmonella* artificially inoculated to dog kibbles. Further research is warranted to evaluate the minimum effective dose of HMB to reduce *Salmonella* in dog and cat kibbles.

Key Words: Salmonella, cross-contamination, petfood

217 Proof-of-concept method to sanitize a feed mill contaminated with Porcine Epidemic Diarrhea Virus. A. R. Huss*, L. L. Schumacher, R. A. Cochrane, E. Poulsen, J. F. Bai, J. C. Woodworth, S. S. Dritz, C. R. Stark, C. K. Jones, *Kansas State University, Manhattan.*

Porcine Epidemic Diarrhea Virus (PEDV) has been linked to transmission by livestock feed or ingredients. Measures to exclude pathogens, prevent cross-contamination, and actively reduce the pathogenic load of feed and ingredients are being developed. However, research thus far has focused on the role of chemicals or thermal treatment to reduce PEDV RNA in feedstuffs, and has not addressed potential residual contamination within the manufacturing facility that may lead to continuous cross-contamination of finished feeds. The objective of this experiment was to evaluate the use of a standardized protocol to sanitize an animal feed manufacturing facility contaminated with PEDV. Environmental swabs were collected throughout the facility during the manufacturing of a swine diet inoculated with PEDV. To monitor facility contamination of the virus, swabs were collected at 5 decontamination steps: 1) baseline before inoculation, 2) after production of the inoculated feed, 3) after application of a quaternary ammonium-glutaraldehyde blend cleaner, 4) after application of a sodium hypochlorite sanitizing solution, and 5) after facility heat-up to 60°C for 48 h. The feed mill was contaminated and decontaminated 3 separate times for a total of 3 replications. Collected swabs were analyzed via RT-qPCR and categorized by surface (plastic, rubber, concrete, and metal), type (equipment and structural), and zone (1, 2, and 3). Decontamination step, surface, type, zone and their interactions were all found to impact the quantity of detectable PEDV RNA ($P < 0.05$). As expected, all samples collected from direct feed contact surfaces (zone 1) contained PEDV RNA after production of the contaminated feed. Additionally, all swabs collected directly adjacent to direct feed contact surfaces (zone 2) were positive following production of the contaminated feed. Of the remaining swabs collected (zone 3), outside of zones 1 and 2, 88.9% had detectable RNA, emphasizing the potential role dust plays in cross-contamination of pathogens throughout a manufacturing facility. Application of the cleaner, sanitizer, and heat were effective at reducing PEDV RNA ($P < 0.05$), but did not completely eliminate it. Specifically, 29.6%, 14.8%, and 7.4% of zone 1 swabs had detectable PEDV RNA after decontamination with the cleaner, sanitizer and heat, respectively, during only replication 2. Due to this, decontamination was repeated with no PEDV RNA detected from subsequent swab collection. These findings do provide a method for facility decontamination of PEDV, however, the use of liquid cleaners, sanitizers, and/or facility heat-up may not be applicable for most commercial feed manufacturing facilities.

Key Words: PEDV, disinfection, feed mill

218 Characterization of variability in the U.S. pork supply. E. K. Arkfeld*[1], S. D. Shackelford[2], A. C. Dilger[1], D. D. Boler[1], *[1]University of Illinois, Urbana, [2]USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE.*

Improving consistency in the U.S. pork supply has long been a goal of producers and processors, though factors contributing to variability in pork composition and quality are ill-defined. Therefore, variability in pork quality and composition and correlations among compositional and quality traits were characterized in multiple studies. In boneless loins destined for export to a quality focused market ($N = 154$), subjective color and marbling scores at 1 and 28 d postmortem were not correlated with sensory tenderness ($P \geq 0.47$), chewiness ($P \geq 0.18$), juiciness ($P \geq 0.43$), or off-flavor ($P \geq 0.07$). In-plant loin firmness measures did not account for variability in sensory characteristics ($P \geq 0.08$). In a larger study, 7864 pigs were used to quantify variability in carcass traits attributable to marketing group (MG), sex, season (hot or cold), and production focus (lean growth or superior meat quality). The Levene's test was used to determine differences in variability among MG, sex, season, and production focus. The mivque0 option of PROC VARCOMP was used to evaluate the proportion of variability each effect contributed to total variance. Marketing group contributed 4.1% and sex contributed 1.4% of the variation of HCW. Variation in fat depth was attributed to production focus (26.7%), sex (17.6%), and season (4.5%). Variation in loin depth was attributed to production focus (20.0%), season (16.1%), MG (2.0%), and sex (1.4%). Production focus (34.6%), sex (15.8%), and season (10.2%) were large contributors to total variation in percent lean. However, the random effect of pig contributed the greatest proportion of total variance to carcass traits (93.5% of HCW, 51.2% of fat depth, 60.5% of loin depth, and 39.4% of percent lean). Barrows had greater variability than gilts for fat depth and percent lean ($P \leq 0.01$), but variability between sexes was not different for HCW and loin depth ($P \geq 0.09$). Variability was greater in the hot season for HCW, but was less for fat depth and percent lean compared with variability of pigs from the cold season ($P \leq 0.01$); loin depth was not different ($P = 0.23$). Variability was greater in pigs from the quality production focus than the lean focus for HCW, fat depth, and loin depth ($P \leq 0.03$). Variability was different among MG for HCW, fat depth, and percent lean ($P \leq 0.01$) but not loin depth ($P = 0.20$). While segregating pigs by MG or production focus may limit variability in carcass composition, a larger amount of variability is attributed to sex, season, and pig, which are more difficult to control.

Key Words: pork composition, quality, variability

219 Requirements for digestible Ca by growing pigs. J. C. González-Vega[*1], C. L. Walk[2], H. H. Stein[3], *[1]University of Illinois, Urbana, [2]AB Vista, Marlborough, United Kingdom, [3]University of Illinois at Urbana-Champaign, Urbana.*

Nine experiments were conducted toward developing a system for determining digestible Ca requirements in growing pigs. In Exp. 1, it was demonstrated that there is a considerable loss of absorbed Ca in the intestinal tract, which indicates that values for digestible Ca need to be based on standardized digestibility. Experiment 2 was conducted to determine where in the intestinal tract Ca is absorbed and results indicated that Ca is absorbed in the small intestine and no absorption of Ca takes place in the large intestine. No differences were observed between ileal and total tract digestibility values, therefore, total tract collections can be used to determine digestibility of Ca. Experiments 3, 4, and 5 were conducted to establish standard total tract digestibility (STTD) values of Ca in a number of feed ingredients without and with microbial phytase. Results indicated that microbial phytase increases STTD of Ca in calcium carbonate and fish meal, but not in dicalcium phosphate and monocalcium phosphate. Experiments 6 and 7 were conducted to determine the STTD Ca requirements by 11 to 25 kg pigs. Six diets were formulated to contain 0.32, 0.40, 0.48, 0.56, 0.64, or 0.72% STTD Ca and 0.36% STTD P. Results indicated that the concentration of STTD Ca in the diets needed to maximize bone ash was 1.33 times the concentration of STTD P. Experiments 8 and 9 were conducted to determine the requirement for STTD Ca and STTD P by 25 to 50 kg pigs. A total of 20 diets were formulated to contain 0.13, 0.27, 0.42, 0.57, or 0.72% STTD Ca and 0.15, 0.31, 0.39, or 0.47% STTD P. Results indicated that the concentration of dietary STTD Ca needed to maximize growth performance was between 1.06 and 1.43 times the concentration of STTD P, but to maximize bone ash, dietary STTD Ca needs to be between 1.47 and 1.80 times the concentration of STTD P. In conclusion, diets for growing pigs may be formulated using values for STTD of Ca in feed ingredients. If diets are formulated to meet STTD Ca and STTD P requirements, it is expected that the utilization of both minerals is maximized. Additional research is needed to determine the STTD Ca requirements by pigs above 50 kg BW.

Key Words: digestible calcium, requirements, pig

220 Digestible calcium requirements for 25 to 50 kg pigs. J. C. González-Vega[*1], C. L. Walk[2], H. H. Stein[3], *[1]University of Illinois, Urbana, [2]AB Vista, Marlborough, United Kingdom, [3]University of Illinois at Urbana-Champaign, Urbana.*

Currently, diets for pigs are formulated using total Ca values to meet Ca requirements. However, feeding excess Ca has negative effects on the digestibility of P, which may result in reduced growth performance. There is, therefore, a need to determine Ca digestibility in feed ingredients and then to determine the requirements for digestible Ca by different groups of pigs. Therefore, the objective of this experiment was to determine the digestible Ca requirement by 25 to 50 kg pigs. Two hundred and forty pigs (initial average BW: 24.70 ± 1.27 kg) were randomly allotted to 20 diets in 6 blocks with 1 pen per diet in each block using a 4 × 5 factorial design. There was 1 gilt and 1 barrow in each pen. Twenty corn-soybean meal based diets were formulated with diets containing 4 levels of standardized total tract digestible (STTD) P (0.15, 0.31, 0.39, or 0.47%) and 5 levels of STTD Ca (0.13, 0.27, 0.42, 0.57, or 0.72%). Pigs were allowed ad libitum access to feed for 28 d and individual BW of all pigs was recorded at the beginning and at the conclusion of the experiment. Results indicated that G:F linearly decreased ($P < 0.05$) as the STTD Ca increased if diets contained 0.15% STTD P (Breakpoint = 0.33 ± 0.14% STTD Ca; plateau = 0.43kg/kg). Increasing levels of STTD Ca did not affect the G:F if diets contained 0.31% STTD P. The G:F linearly increased ($P < 0.05$) as the STTD Ca increased if diets contained 0.39% STTD P (Breakpoint = 0.55 ± 0.25% STTD Ca; plateau = 0.49kg/kg) or 0.47% STTD P (Breakpoint = 0.29 ± 0.05%; plateau = 0.49kg/kg). In conclusion, increasing levels of STTD Ca had a negative effect on G:F if diets contained 0.15% STTD P, but that was not the case if diets contained 0.31% STTD P. If diets contained 0.39 or 0.47% STTD P, G:F was maximized at 0.55 or 0.29% STTD Ca, respectively. These observations indicate that the requirement for STTD P and Ca for 25 to 50 kg pigs may be greater than currently estimated.

Key Words: digestible calcium, growth performance, requirements

221 Impact of increasing dietary energy concentration through graded levels of corn oil or choice white grease on carcass characteristics in pigs. T. Kellner[*1], S. Wisdom[2], G. Gourley[3], J. F. Patience[1], *[1]Iowa State University, Ames, [2]Swine Graphics Enterprises, Webster City, IA, [3]Gourley Research Group, Webster City, IA.*

When the cost per unit of energy is advantageous, dietary fat is included as a concentrated source of energy. Increasing the dietary energy concentration can increase efficiency and fat deposition in the live pig, which can alter carcass characteristics and quality. The objective was to investigate the effects on carcass characteristics across 2 dietary fat sources (FS) and 3 fat inclusion levels (FL) over 134 d. A total of 1213 pigs (PIC 15 × PIC Camborough 42; PIC, Hendersonville, TN) with an initial BW of 32.0 ± 0.4 kg were randomly allotted to 1 of 6 treatments in a 2 × 3 factorial: corn oil (CO; IV = 123.2) versus choice white grease (CWG; IV = 66.8) and fat levels of 2, 4 or 6%. There were 10 pens per treatment. Pigs were harvested in 3 groups based on BW on d 105, 117, and 134 at Tyson Foods Inc (Storm Lake, IA). Data were analyzed using PROC MIXED with FS and FL as fixed effects, room as a random effect, and pen as the

experimental unit. No FS × FL interactions were statistically significant for any measured carcass characteristic ($P \geq 0.330$). Hot carcass weight was not affected by FS (CO = 105.0, CWG = 105.1 kg; $P = 0.792$) or FL (2% = 104.5, 4% = 105.4, 6% = 105.4kg; $P = 0.157$). Increasing FL tended to increase carcass yield (2% = 74.7, 4% = 75.1, 6% = 75.1%; $P = 0.069$), but carcass yield was not altered by FS (CO = 74.9, CWG = 75.0%; $P = 0.276$). Increasing FL had no effect on backfat depth (2% = 1.97, 4% = 2.00, 6% = 2.03 cm; $P = 0.502$), loin depth (2% = 7.19, 4% = 7.18, 6% = 7.15 cm; $P = 0.712$), or percent lean (2% = 55.5, 4% = 55.4, 6% = 55.3%; $P = 0.478$). Dietary FS had no impact on backfat depth (CO = 2.02, CWG = 1.97 cm; $P = 0.320$), loin depth (CO = 7.18, CWG = 7.17 cm; $P = 0.840$), or percent lean (CO = 55.3, CWG = 55.4%; $P = 0.542$). In conclusion, both CO and CWG can be employed in swine diets without effect to hot carcass weight, yield, or percent lean. Increasing FL may slightly increase carcass yield, but have no effect on hot carcass weight or percent lean.

Key Words: corn oil, choice white grease, swine

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222 Impact of the source and level of dietary fat on growth performance as well as apparent and true total tract digestibility of acid hydrolyzed ether extract in growing and finishing pig diets.

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The pig industry utilizes a variety of fat sources and levels in pig diet to increase dietary energy content. The objective of this experiment was to investigate the impact of fat source (FS) a nd fat level (FL) on rate and efficiency of gain and to determine the apparent (ATTD) and true total tract digestibility (TTTD) of acid hydrolyzed ether extract (AEE). In a 134 d experiment a total of 1213 pigs (PIC 280 × PIC Camborough 42; PIC, Hendersonville, TN) with an initial BW of 32.0 ± 0.4 kg were randomly allotted to 1 of 6 treatments arranged as a 2 × 3 factorial: corn oil (CO; IV = 123.2) versus choice white grease (CWG; IV = 66.8) and fat levels of 2, 4 or 6%. Ten pens of ~20 pigs each were randomly assigned to each of the 6 treatments and provided with feed and water ad libitum. Titanium dioxide was included as an indigestible marker at 0.4%. Fecal samples were collected from multiple pigs directly on d 39 (~ 68 kg). These samples were then polled within pen for analysis. TTTD (%) of AEE was calculated via correcting ATTD of AEE for endogenous fat losses at 20 g of AEE/kg of dry matter intake. Data were analyzed via PROC MIXED with FS and FL as fixed effects, room as a random effect, and pen as the experimental unit. ADG was not affected by FS (mea*n* = 0.917 kg/d; $P = 0.928$) or FL ($P = 0.445$). FS did not alter ADFI (mea*n* = 2.53 kg/d; $P = 0.429$), or G:F (mea*n* = 0.361; $P = 0.120$). Increasing FL tended to decrease ADFI ($P = 0.094$), and increased G:F (2% = 0.349, 4% = 0.360, 6% = 0.374 g/d; $P < 0.001$). Increasing CO elicited a greater response in terms of ATTD of AEE than CWG resulting in a FS × FL interaction (2% CO = 66.2, 4% CO = 74.9, 6% CO = 79.2, 2% CWG = 65.3, 4% CWG = 75.4, 6% CWG = 75.7%; $P = 0.012$). TTTD of AEE of CO-based diets (94.1%) tended to be higher than that of CWG-based diets (92.4%; $P = 0.063$), but was not affected by FL (mea*n* = 93.4%; $P = 0.954$). In conclusion, increasing FL improved efficiency but not rate of gain. The TTTD of AEE tended to be higher in diets based on CO than CWG.

Key Words: fat digestibility, corn oil, choice white grease

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223 Efficacy of supplemental liquid L-lysine for pigs in comparison to crystalline L-lysine HCl.

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A study was conducted to test the effects of liquid L-Lys supplementation on growth performance in growing-finishing pigs compared with crystalline L-Lys HCl. A total of 126 pigs at 70 d of age (29.5 kg BW) in 42 pens were randomly allotted to 7 dietary treatments which were, CON: a control diet without supplemental Lys meeting 75% of SID Lys requirement, Level 1 diets with crystalline L-Lys HCl (C1) or liquid L-Lys (L1) meeting 82% of SID Lys requirement, Level 2 (C2 or L2) diets meeting 89% of SID-Lys requirement and Level 3 (C3 or L3) diets meeting 96% of SID Lys requirement. Each treatment had 6 pens (3 barrow and 3 gilt pens) with 3 pigs/pen. All 7 diets were formulated to contain nutrients meeting the requirements suggested by NRC (2012) except for SID Lys. Pigs were fed experimental diets for 9 wk based on 3 phases until 90 kg BW (30 to 45, 45 to 75, and 75 to 90 kg BW, respectively). All experimental diets were pelleted. Body weight and feed disappearance were measured to calculate ADG, ADFI, and G:F. Data were analyzed using the MIXED procedure in SAS. A mutilinear regression analysis was used to evaluate the relative bioavailability of liquid L-Lys to crystalline L-Lys HCl. Increasing Lys from 75 to 96% of SID Lys requirement improved ($P < 0.05$) ADG from 0.83 to 1.00 kg/d and G:F from 0.384 to 0.430 without affecting ADFI. Forms of Lys (crystalline vs. liquid) did not affect performance of pigs. Rates of increases in ADG and G:F of pigs fed diets with liquid L-Lys was not different ($P = 0.803$ and 0.336) from that of pigs (39.4 vs. 37.0 g/g daily intake of supplemental Met and 0.00828 vs. 0.00696/g daily intake of supplemental Met) fed diets with crystalline L-Lys HCl. This study demonstrates that efficacy of liquid L-Lys is not different from that of crystalline L-Lys HCl for performance of pigs from 30 to 90 kg.

Key Words: growth performance, liquid lysine, L-lysine HCl

224 Diet nutrient digestibility and growth performance of weaned pigs fed canola meal samples varying in nutritive quality. L. F. Wang*[1], E. Beltranena[1,2], R. T. Zijlstra[1], [1]*Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, AB, Canada,* [2]*Alberta Agriculture and Forestry, Edmonton, AB, Canada.*

Canola meal (CM) is a supplemental protein feedstuff for swine, but its nutritive quality varies more than SBM. The implications of variation in CM quality on diet nutrient digestibility and growth performance of weaned pigs are unclear. Thus, 240 pigs (BW, 9.6 kg; 4 pigs/pen) were weaned at 19 d of age and were fed a 20% SBM diet or 4 diets containing 20% CM solvent-extracted from common dark-seeded *Brassica napus* starting 2 wk postweaning for 4 wk (d 1–28). The 4 CM samples were sourced from 4 crushing plants in Western Canada and contained (DM-basis) 39.7–46.2% CP, 3.4–4.1% ether extract, 17.5–21.4% ADF, and 1.2–8.0 µmoles/g total glucosinolates. Pelleted wheat-based diets were formulated to provide 2.3 Mcal NE/kg and 5.1 g standard ileal digestible (SID) Lys/Mcal NE. Inclusion of CM instead of SBM reduced ($P < 0.001$) diet apparent total tract digestibility (ATTD) of DM by 3.7%-units, of GE by 3.6%-units, and of CP by 4.0%-units. The DE value of CM diets was similar to, but their predicted NE value was 0.02 Mcal/kg greater ($P = 0.027$) than that of the SBM diet. Among the 4 CM diets, ATTD of DM, GE, and CP did not differ. Growth performance of pigs fed the 4 CM diets did not differ from pigs fed SBM except for greater ($P < 0.05$) G:F for d 1–7 and for the entire trial. Among the 4 CM diets, ADFI (973–1047 g/d) and ADG (650–686 g/d) differed ($P < 0.05$) for the entire trial. However, G:F did not differ among the 4 CM diets for the entire trial. In conclusion, inclusion of 20% CM from 4 crushing plants to replace SBM did not reduce feed intake, weight gain, or feed efficiency in weaned pigs indicating that variation in nutritive quality among the 4 *Brassica napus* CM samples did not affect growth performance of young pigs.

Key Words: growth performance, pig, canola meal

225 Prediction of the concentration of standardized ileal digestible (SID) amino acids among sources of distillers dried grains with solubles (DDGS) for growing pigs: A meta-analysis. Z. Zeng*, G. C. Shurson, P. E. Urriola, *Department of Animal Science, University of Minnesota, St. Paul.*

The concentration of SID AA is highly variable among DDGS sources. The range in SID Lys content for DDGS sources reported in the literature varies from 0.088 to 0.929% (DM basis). Therefore, accurate prediction of SID AA content in DDGS sources is essential to capture the greatest nutritional value and manage variability when formulating DDGS diets for swine. A meta-analysis was conducted using a database representing 19 published studies and 99 DDGS sources to predict the SID essential AA content of DDGS based on chemical composition. Samples of corn ($n = 85$), wheat ($n = 6$), sorghum ($n = 2$), corn-wheat ($n = 4$), corn-sorghum ($n = 1$), and rice ($n = 1$) DDGS were included in the analysis. Wheat DDGS had greater CP (39.8 vs. 30.9%), ADF (20.8 vs. 13.0%), and Trp (0.39 vs. 0.23%) content, but lower crude fat (4.9 vs. 9.7%), Lys (0.64 vs. 0.92%) and Lys digestibility (44.6 vs. 61.8%; $P < 0.05$) compared with corn DDGS, respectively. For all types of DDGS, the best predictor of SID AA content was the corresponding total AA content (R^2 ranged from 0.984 to 0.995). Fiber content (NDF, ADF or hemicellulose) had negative effects on SID content of AA, but the coefficient for fiber in prediction equations was small (−0.006 to −0.003 for NDF and −0.019 to −0.001 for ADF). For example, when NDF increased from 20.4 to 49.6% (minimum and maximum), the concentration of SID Lys and Thr decreased by 0.09 and 0.15%, respectively. The prediction models showed that the mean of radius (one-half the width) of the 95% confidence interval for the mean SID AA prediction was 0.030, 0.021, 0.024, and 0.012, respectively, for Lys, Met, Thr, and Trp. The radius of the 95% confidence interval provides a reference for establishing feed formulation safety margin coefficients. The prediction error and bias were 0.37 and 0.19 for Lys, 0.20 and −0.28 for Met, 0.32 and 0.48 for Thr, and 0.06 and −0.27 for Trp, respectively. In addition, internal validation of the model showed nonsignificant ($P > 0.10$) intercept (= 0) and slope (= 1) for established equations of predicted values against observed values for all SID AA. In conclusion, accurate prediction equations were developed for estimating individual SID essential AA content and suggested safety margins for DDGS from various grain sources.

Key Words: amino acids, distillers dried grains with solubles, meta-analysis, pigs

226 Amino acid digestibility of five samples of canola meal fed to ileal-cannulated grower pigs. B. V. Le Thanh*[1], X. Zhou[1], E. Beltranena[2], R. T. Zijlstra[3], [1]*University of Alberta, Edmonton, AB, Canada,* [2]*Alberta Agriculture and Forestry, Edmonton, AB, Canada,* [3]*Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, AB, Canada.*

Canola meal (CM) is an alternative for soybean meal (SBM), but CM quality varies among crushing plants. An 8 × 8 Latin square was conducted feeding 8 ileal-cannulated grower pigs (32 kg initial BW) to evaluate the standardized ileal digestibility (SID) of CP and AA in 5 *Brassica napus* CM samples from 5 Western Canadian crushing plants. Pigs were fed 8 diets (SBM, 5 CM samples, basal, and N-free). For SBM and CM diets, 40% of test feedstuff sample was mixed with 60% barley and wheat-based basal diet. Pigs were fed diets at 2.8 × maintenance (110 kcal of DE per kg of $BW^{0.75}$) divided

into equal 2 meals daily offered at 8:00 and 15:00 for eight 9-d periods. Digesta was collected on d 8 and 9. The SID of CP and AA was determined by subtracting basal endogenous AA losses. On DM basis, the SBM and 5 CM samples contained 51 and 39–45% CP; 7 and 24–27% NDF; and 4.70 and 4.73–4.82 Mcal/kg GE, respectively. The SID of Lys, other indispensable AA (except His), dispensable AA (except Glu) was greater ($P < 0.05$) for SBM than for the 5 CM samples. Among the 5 CM samples, the SID of Lys ranged from 75 to 80% ($P < 0.05$), of Thr from 70 to 76% ($P < 0.05$), and of Met from 82 to 86% ($P < 0.05$). In conclusion, the SID of most AA was lower in CM than in SBM likely due to the greater fiber content in CM. The SID of AA differed among the 5 CM samples, but could not be associated to changes in chemical composition. The range in quality of CM is sufficient to warrant establishment of rapid quality evaluation measurements to predict AA quality of CM.

Key Words: canola meal, digestibility, soybean meal

227 Amino acid digestibility in dairy proteins compared with plant proteins. J. K. Mathai*[1], Y. Liu[1], H. H. Stein[2], [1]*University of Illinois, Urbana,* [2]*University of Illinois at Urbana-Champaign, Urbana.*

An experiment was conducted to determine the standardized ileal digestibility (SID) of AA in whey protein isolate (WPI), whey protein concentrate (WPC), milk protein concentrate (MPC), skim milk powder (SMP), pea protein isolate (PPI), soy protein isolate (SPI), soy flour (SF), and wheat. Nine ileal-cannulated barrows (initial BW: 26.25 ± 1.57 kg) were allotted to a 9 × 9 Latin square design with 9 diets and 9 periods. A N-free diet was formulated to determine basal endogenous losses of AA and CP and to enable the calculation of SID of AA. The remaining diets were formulated with each test ingredient as the sole source of AA, with the exception that wheat was included in a diet that also contained SF to compensate for the low CP in wheat. The AID and SID values were calculated using the difference procedure for the wheat diet. The direct procedure was used for all other ingredients. The SID of Lys was greater ($P < 0.05$) in WPI and SPI than in SF and wheat (Table 227). The SID of Met was greater ($P < 0.05$) in WPI than in SMP, SPI, SF, PPI, and wheat. The SID of Trp was greater ($P < 0.05$) in WPI, WPC, and MPC than in SF, SMP, PPI, and wheat ($P < 0.05$). These data indicate that the SID of AA in most indispensable AA is greater in dairy proteins compared with plant proteins.

Key Words: amino acid digestibility, dairy protein, pigs

228 Effect of fat sources on ATTD of minerals. L. A. Merriman*[1], C. L. Walk[2], H. H. Stein[3], [1]*University of Illinois, Urbana-Champaign,* [2]*AB Vista, Marlborough, United Kingdom,* [3]*University of Illinois at Urbana-Champaign, Urbana.*

An experiment was conducted to determine the effect of supplementing diets fed to growing pigs with fat sources that differ in their concentrations of fatty acids on the apparent total tract digestibility (ATTD) of Ca, P, Mg, Zn, Mn, Na, and K. A basal diet based on corn and potato protein isolate was formulated that contained 7% sucrose. Five additional diets that were similar to the previous diet except that sucrose was replaced by 7% tallow, choice white grease (CWG), palm oil (PO), corn oil (CO), or soybean oil (SBO) were formulated. Diets were formulated to contain 0.70% Ca and 0.33% standardized total tract digestible P. Sixty growing barrows (initial BW = 15.99 ± 1.48 kg) were allotted to a randomized complete block design with 6 dietary treatments and 10 replicate pigs per treatment. Experimental diets were provided for 12 d with the initial 5 d being the adaptation period. Total feces were collected for 5 d using the marker-to-marker approach. The ATTD of Ca was greater ($P < 0.05$) for pigs fed diets containing SBO, CO, PO, or tallow than for pigs fed the basal diet or the CWG-diet, but pigs fed the diet containing tallow were not different from pigs fed a diet containing CWG (Table 228). ATTD of P was greater ($P < 0.05$) for diets containing SO or tallow compared with the basal diet or the CWG diet. The ATTD of Mg, Zn, Mn, Na, and K were not different among treatments. In conclusion, supplementation of CWG to diets fed to pigs does not change the digestibility of minerals, but tallow, PO, CO, and SBO may increase the digestibility of Ca and P, but not of other minerals.

Key Words: minerals, fat, pigs

Table 228. Apparent total tract digestibility (ATTD) of minerals in diets containing different fat sources

		Ingredient					
Item	Basal	Tallow	Choice white grease	Palm oil	Corn oil	Soybean oil	*P* Value
Ca	50.69^{c}	65.13^{ab}	54.07^{bc}	66.07^{a}	71.20^{a}	71.24^{a}	0.001
P	52.06^{c}	62.00^{ab}	53.52^{bc}	61.06^{ab}	59.24^{abc}	62.98^{a}	0.001
Mg	25.62	24.73	23.53	26.94	30.91	35.37	0.163
Zn	13.51	15.87	11.74	13.68	17.00	14.40	0.958
Mn	14.70	21.62	15.98	21.43	22.49	20.54	0.417
K	76.68	74.26	72.60	77.37	73.89	79.17	0.114
Na	90.40	90.99	90.66	90.69	91.30	91.95	0.363
S	81.70^{ab}	83.75^{ab}	81.31^{b}	83.98^{ab}	84.03^{ab}	84.40^{a}	0.011

229 Amino acid digestibility in six sources of meat and bone meal fed to growing pigs. D. M. D. L. Navarro*, N. W. Jaworski, H. H. Stein, *University of Illinois at Urbana-Champaign, Urbana.*

An experiment was conducted to determine the standardized ileal digestibility (SID) of AA by pigs in 6 sources of meat and bone meal (MBM). Eighteen ileal-cannulated barrows (initial BW: 69.3 ± 4.4 kg) were randomly allotted to a replicated 4 × 9 incomplete Latin square design with 4 periods and 9 diets, therefore, a total of 8 replications per diet. One diet included 33% soybean meal (SBM) as the sole source of AA and 6 diets contained 1 source of MBM included at 9% and SBM included at 22% as the only AA containing ingredients. A N-free diet was used to determine basal endogenous losses of AA. The last diet was unrelated to the experiment. The SID of AA was calculated using the direct procedure for the SBM diet. The difference procedure was used to calculate the SID of AA for all sources of MBM. The SID of Lys was greater ($P < 0.05$) in MBM 4 than in MBM 2, MBM 3, and MBM 6, but not different from MBM 1 and MBM 5. The SID of Met was greater ($P < 0.05$) in MBM 1 and MBM 4 than in MBM 3 and MBM 6, but not different from MBM 2 and MBM 5. The SID of Thr was greater ($P < 0.05$) in MBM 1 than in MBM 2, MBM 3, and MBM 6, but not different from MBM 4 and MBM 5. The SID of Trp was the least ($P < 0.05$) in MBM 3 among MBM sources. In conclusion, the SID of indispensable AA varies widely among MBM sources.

Key Words: amino acid digestibility, meat and bone meal, pigs

Table 229. Standardized ileal digestibility (%) of indispensable AA in meat and bone meal

	Meat and bone meal						Pooled	
Item	1	2	3	4	5	6	SEM	*P*-value
Arg	94.7^{a}	88.9^{ab}	76.6^{c}	90.3^{ab}	92.1^{ab}	85.2^{b}	3.31	< 0.01
His	93.1^{a}	81.3^{c}	63.6^{d}	89.7^{ab}	93.0^{ab}	83.7^{bc}	3.16	< 0.01
Ile	90.1^{a}	79.7^{bc}	67.8^{d}	87.1^{ab}	88.6^{ab}	75.7^{cd}	4.19	< 0.01
Leu	91.3^{a}	82.3^{ab}	66.6^{c}	87.5^{ab}	89.3^{a}	77.4^{b}	3.90	< 0.01
Lys	86.5^{ab}	77.1^{bc}	62.8^{d}	91.9^{a}	83.2^{ab}	66.6^{cd}	4.65	< 0.01
Met	86.6^{a}	83.0^{ab}	69.8^{c}	87.3^{a}	87.1^{ab}	79.8^{b}	2.94	< 0.01
Phe	91.9^{a}	82.4^{ab}	69.9^{c}	90.2^{ab}	90.6^{ab}	80.7^{b}	4.09	< 0.01
Thr	89.9^{a}	75.3^{bc}	63.2^{d}	80.8^{ab}	83.3^{ab}	67.6^{cd}	4.76	< 0.01
Trp	93.4^{a}	77.8^{b}	63.3^{c}	77.0^{b}	96.7^{a}	76.0^{b}	5.53	< 0.01
Val	87.0^{a}	79.2^{ab}	65.1^{c}	85.7^{a}	87.0^{a}	74.8^{b}	3.89	< 0.01

$^{a-d}$Means within a row lacking a common superscript letter differ (P < 0.05).

230 Effect of divergent selection for residual feed intake on whole body protein turnover in growing gilts fed either adequate or lysine deficient diets. D. J. Hewitt*[1], C. F. M. de Lange[2], T. Antonick[1], J. C. M. Dekkers[3], A. R. Pendleton[4], A. Rakhshandeh[1], *[1]Texas Tech University, Lubbock, [2]University of Guelph, Guelph, ON, Canada, [3]Iowa State University, Ames, [4]Amarillo College, Amarillo, TX.*

Protein turnover, representing both protein synthesis and degradation, is one of the most energy consuming processes in growing pigs, and may be one of the main factors contributing to variation in residual feed intake (RFI). RFI is a measure of feed efficiency that reflects differences in the efficiency of the use of feed for maintenance and growth. We previously observed that genetic selection for low RFI did not improve efficiency of dietary Lys utilization above maintenance for protein retention. Little is known about the effects of genetic selection for RFI on whole-body protein turnover rate. The current study evaluated the effects of divergent selection for RFI on whole-body protein turnover of growing pigs fed either adequate or lysine deficient diets. Twenty four gilts (BW 66 ± 5 kg) were selected from generation 9 of the low RFI (LRFI; $n = 12$) and high RFI (HRFI; $n = 12$) Iowa State University Yorkshire RFI selection lines, and were housed in metabolism crates at the Texas Tech University Swine Center. Six pigs from each genetic line were assigned to 1 of 2 levels of Lys intake (70 and 100% of estimated requirements) from diets in which Lys was first limiting among amino acids. The "single-dose end-product" approach was used for the measurement of protein turnover. Whole-body N flux was determined using an oral dose of [^{15}N]-glycine (7.1 ± 0.29 mg/kg BW) and measurement of ^{15}N enrichment in urinary ammonia or urea. There was no effect of line or of the interaction between line and Lys intake on N flux, protein synthesis, protein degradation, and protein deposition ($P > 0.05$). Lys intake increased N flux (from 119 to 149 SE 15.3 g/d), protein synthesis (from 98 to 117 g of N/d), protein degradation (from 84 to 100 g of N/d), and protein deposition (from 13 to 16 g/d; $P < 0.05$). The protein synthesis-to-retention ratio tended to be higher in the LRFI compared to the HRFI line (6.5 vs. 5.8 SE 0.62; $P = 0.06$). Collectively, these results suggest that divergent selection for residual feed intake is not associated with changes in whole-body protein turnover in growing pigs. Therefore, protein turnover does not appear to be one of the physiological mechanisms contributing to differences in RFI in these lines of growing pigs. USDA-NIFA grant number 2011–68004–30336.

Key Words: protein turnover, residual feed intake, growing pig

231 Superdosing phytase fed to mature boars improves semen concentration and reproductive efficiency.
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Phytate has been shown to be an anti-nutrient and that superdosing phytase breaks down phytate improving nutrient utilization and finisher pig performance, but little work has been done in mature reproductive pigs. The objective of this trial was to determine if feeding phytase (Quantum® Blue) at superdose levels (2000 FTU/kg) could enhance reproductive performance in mature boars. Thirty boars (PIC280) were randomly assigned to 1 of 2 dietary treatments: control (CON, n = 15) with 500 FTU/g phytase or test (PHY) with 2000 FTU/g phytase (PHY, n = 15). All boars were fed a common diet (2.25 kg/d) that contained 500 FTU/kg of phytase to release 0.15% AVP and 0.16% Ca. A top-dress (250 g/d) was then added with phytase or without phytase (placebo) to give the 2 final treatments (500 FTU/kg; CON and 2000 FTU/kg PHY). The dietary treatments were fed for 12 wk. For all boars, semen was collected weekly and evaluated for volume, concentration, and morphological abnormalities. A CASA system was used to evaluate motility, progressive motility, and mobility parameters of the sperm cells. An extended semen sample was retained at the stud and evaluated for motility using the CASA for 7 d. Every 4 wk, an extended semen sample was shipped and analyzed at an external lab 1d post collection for further assessment of semen quality; including additional morphological assessments, CASA motility, mobility estimations, and membrane integrity assays using flow cytometry at 0, 4, 8, and 12 wk. Phytase superdosing increased sperm cell concentration in the ejaculates ($74.58x10^9$ CON vs. $82.86x10^9$ PHY, P = 0.0006) without negatively effecting semen quality parameters at the time of collection. The percentage of live sperm cells 1d post collection did not differ by treatment (CON = 72.01 ± 0.56, PHY = 70.81 ± 0.57, P = 0.13). All semen samples shipped on wk 8 and 12 of the study had a reduction in the percentage of live sperm cells (P < 0.0001), an increase in distal midpiece reflex (DMR), tail abnormalities (P < 0.0001), and reduced motility (P < 0.0001) compared to wk 0 and 4. The PHY boars had increased DMR (11.2 ± 1.1% PHY vs. 6.9 ± 1.1% CON) and reduced motility (70.1 ± 1.4% PHY vs. 74.2 ± 1.4% CON) 1d post collection (P = 0.0065 and P = 0.0406, respectively), however, this was not seen at the time of collection. Over the course of the 12 wk study, boars fed phytase at 2000 FTU/kg had increased sperm cell concentration by 11% per ejaculate without negatively effecting semen quality or motility at collection.

Key Words: Boars, Phytase, Reproduction

232 Xylanase effects on apparent total tract digestibility of energy and dry matter with or without DDGS at 46, 54, and 70 kg bodyweight.
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The objective of this study was to evaluate the impact of xylanase supplementation on the digestibility of dietary energy with or without DDGS over 3 time points in growing pigs. Two groups of 16 individually housed gilts (37.3 ± 0.33 kg) were randomly allotted to 1 of 4 dietary treatments (n = 8) arranged as a 2 × 2 factorial with xylanase added at 0% vs. 0.4% and reduced-oil DDGS (6.83% fat, 24.54% NDF) included at 0% vs. 30% of the diet. Pigs remained on the same treatment throughout the trial. Pigs were fed 90% of estimated ad libitum intake, re-calculated after d12 and d22. Chromic oxide was added to the diets (0.4%) as an indigestible marker. Dietary treatments started d0 and fecal samples were collected via grab sampling at 3 different time points: d8– 9 (T1), d18–19 (T2), and d38– 39 (T3), corresponding to body weights 46.0 ± 0.39, 54.1 ± 0.40, and 70.3 ± 0.49 kg, respectively. Data were analyzed using PROC MIXED procedure of SAS with pig as the experimental unit, inclusion of xylanase and DDGS as fixed effects, and group as a random effect. DDGS decreased dry matter (DM) digestibility in all 3 time points, from 79.9 to 75.0%, 83.5 to 74.0%, and 84.9 to 78.5% for T1, T2, and T3 respectively ($P \leq 0.049$). Xylanase inclusion did not significantly impact DM digestibility (77.4%) or digestible energy (DE) value (3.28 Mcal/kg) of the diet at 46 kg BW (P = 0.9047). There was an interaction between enzyme inclusion and DDGS inclusion at 54 kg BW with xylanase inclusion decreasing DM digestibility from 76.9 to 71.0% and DE values from 3.37 to 3.09 Mcal/kg in 30% DDGS diets, and increasing DM digestibility from 81.7 to 85.2% and DE values from 3.38 to 3.54 Mcal/kg in diets with no DDGS (DM: P = 0.047) (DE: P = 0.044). At 70 kg, xylanase inclusion increased DM digestibility from 80.0% to 83.4% (P = 0.017) and increased dietary DE from 3.42 Mcal/kg to 3.57 Mcal/kg (P = 0.013). In conclusion, xylanase did not affect DM digestibility or DE in the smallest pigs, had mixed effects depending on diet composition at the intermediate weight and improved both in the heaviest pigs. The improvement at 70 kg was equal to 4.25%. The differing responses across BW provide further insight into the function and most effective use of xylanase.

Key Words: xylanase, DDGS-RO, digestibility

233 Evaluating the effects of sodium sesquicarbonate in the grow-finish phase fed during summer months.
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A total of 1177 pigs (14.30 ± 0.97 kg) in a commercial wean to finish facility were used to evaluate sodium sesquicarbonate

(SSQ) (S-Carb®; Tronox Specialty Alkali Corporation, Green River, WY) and its effects on dietary electrolyte balance (DEB) and growth performance. SSQ was added to corn/soybean meal/dried distiller's grains with solubles diets at 0, 0.15, 0.30 and 0.40% to alter DEB values to 0, < 150, 225–275, and > 350 DEB, respectively. Pigs were housed in groups of 24–25 for a total of 12 replications from May-October 2015 in Illinois. Diets were changed at 11.4–22.7, 22.7–45.5, 45.5–-68.2, 68.2–90.9, 90.9–113.6, and 113.6–129.5 kg BW. Data were analyzed as a randomized complete block design, with pen as the experimental unit and treatment as a fixed effect, as well as linear and quadratic contrasts for increasing DEB. During the study, 24 h barn temperatures ranged from 33.9–23.8°C to 24.4–20°C. During the initial phase, G:F tended to quadratically decrease (0.63, 0.62, 0.62, 0.64; $P = 0.08$) as DEB increased and ADFI tended to increase at 0.30% SSQ compared to the control (0.63, 0.62, 0.64, 0.64 kg/d; $P = 0.09$). In period 2, ADG (0.85, 0.86, 0.88, 0.87; $P < 0.01$), G:F (0.51, 0.52, 0.53, 0.53; $P < 0.01$), and BW (44.89, 44.89, 45.53, 45.42 kg; $P < 0.01$) increased as DEB increased. During period 3, the control pigs had increased ADG (0.95, 0.91, 0.92, 0.91 kg/d; $P < 0.01$), G:F (0.42, 0.41, 0.41, 0.42; $P < 0.01$) and a tendency for increased ADFI (2.26, 2.23, 2.22, 2.18 kg/d; $P < 0.10$) compared to pigs that were fed SSQ. There were no significant differences detected in growth performance during period 4. In period 5, there was a quadratic response (0.97, 1.00, 0.98, 0.95 kg/d; $P < 0.03$) for ADG to decrease as DEB level increased, as well as, a quadratic tendency (0.34, 0.35, 0.35, 0.34; $P < 0.10$) for an increased G:F as DEB level increased. During the market phase, ADFI was decreased for control animals compared to 0.15% SSQ (3.17, 3.30, 3.19, 3.18 kg/d; $P < 0.04$). Overall, there were no significant differences for growth criteria measured, likely due to contradicting responses to SSQ in periods 2 and 3. In this study, during periods of higher environmental heat, there was a quadratic response associated with SSQ. Additional work is needed to determine and quantify benefits of SSQ supplementation during the grow-finish phases of production.

Key Words: DEB, grow-finish, sodium sesquicarbonate

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234 Effects of exogenous xylanase on digestibility of dry matter, organic matter, neutral detergent fiber, and energy and the concentrations of digestible and metabolizable energy in rice co-products fed to weanling pigs.

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The objective of this experiment was to test the hypothesis that the apparent total tract digestibility (ATTD) of DM, OM, fiber, and GE by weanling pigs and the concentration of DE and ME in full-fat rice bran (FFRB), defatted rice bran (DFRB), brown rice, and broken rice are improved if microbial xylanase is added to the diet. Eighty barrows (initial BW of 13.6 ± 0.8) were allotted to 10 diets with 8 replicate pigs per diet in a randomized complete block design with 2 blocks of 40 pigs. A basal diet containing corn and soybean meal and 4 diets containing corn, soybean meal, and each of the 4 rice co-products were formulated. The rice co-products and corn and soybean meal were the only sources of energy in the diets. Five additional diets that were similar to the initial 5 diets with the exception that they also contained 16,000 units of xylanase (Econase XT-25, AB Vista, Marlborough, UK) were also formulated. All diets also contained 1500 units of microbial phytase (Quantum Blue 5G, AB Vista, Marlborough, UK). The DE and ME and the ATTD of DM, OM, fiber, and GE in diets and ingredients were calculated using the direct method and the difference method, respectively. Results indicated that the concentrations of DE and ME (DM basis) in FFRB and DFRB increased ($P < 0.05$) if xylanase was used. Broken rice had a greater ($P < 0.05$) concentration of DE and ME than FFRB and DFRB if no xylanase was added to the diets, but if xylanase was used, no differences in ME among FFRB, brown rice, and broken rice were observed. The ATTD of DM was greater ($P < 0.05$) in ingredients with xylanase than in ingredients without xylanase and there was a tendency ($P = 0.067$) for the ATTD of OM to be greater if xylanase was used. The ATTD of NDF in FFRB was greater ($P < 0.05$) when xylanase was added than if no xylanase was used, whereas the ATTD of NDF in DFRB was not affected by the addition of xylanase. In conclusion, if no xylanase was used broken rice and brown rice have greater concentrations of DE and ME than FFRB and DFRB, and these values were not increased by microbial xylanase. However, xylanase increased the concentration of DE and ME (DM basis) in FFRB and DFRB.

Key Words: digestibility, energy, rice bran, xylanase

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235 Xylanase solubilization of corn and wheat arabinoxylans in mixed growing pig diets subjected to upper gut in-vitro digestion and in ileal digesta.

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The objective of the present studies was to evaluate the efficacy of xylanase on solubilizing arabinoxylans (AX) in corn and wheat. In study 1, a corn (40% corn distillers dried grains with solubles–DDGs) and wheat based (5% wheat bran and 18% wheat midds) diet were formulated for growing pigs supplemented with or without 8000XU/kg xylanase. Triplicate samples of the diets were subjected to a 2 stage sequential in vitro digestion simulating porcine gastric and small intestine

conditions. A sample (10mL) of small intestine effluents was freeze dried and subjected to analysis of non-starch polysaccharides (NSP). There was no interaction ($P > 0.05$) between xylanase and diet type on the ratio of soluble to insoluble AX (RAX) and soluble to insoluble NSP (RNSP). The main effects were such that wheat diets had a higher ratio of RAX than corn diets (36.8 vs. 18.9%; $P = 0.001$). Xylanase increased RAX (32.4 vs. 22.4%; $P = 0.03$) and RNSP (75.1 vs. 52.6%; $P = 0.03$). In study 2, ileal digesta samples obtained from growing pigs (32.4 kg BW) fed 96% corn ($n = 5$) or wheat ($n = 5$) DDGS based diets (with 1.5% glycerol and 1% calcium carbonate) for 7 d were used to test dose response of xylanase on the release of soluble AX. Statistical analysis for both studies was conducted using the GLM procedure of SAS. The total NSP and AX concentrations in corn DDGs ileal samples were 378 and 174 g/kg, respectively and the corresponding values in wheat DDGS ileal digesta were 291 and 117 g/kg. The samples were subjected to a 2 (corn or wheat DDGS) × 3 (0, 2000 or 20,000 XU/kg) factorial design in vitro incubation experiment. Briefly, 100mg of sample was mixed with buffer (pH = 6) with or without xylanase and incubated for 2 h in a microplate shaker (1140 rpm) at 40°C. The solution was then centrifuged at 3000 rpm, 20°C for 10 min and the supernatant submitted for soluble AX analysis. There was no interaction ($P = 0.357$) between DDGS type and xylanase on the concentration of soluble AX. The main effects of the diet ($P < 0.01$) were such that wheat DDGS samples had twice the concentration of soluble AX relative to corn DDGS. Xylanase ($P < 0.01$) increased the release of soluble AX in a linear manner. Specifically, the concentration of soluble AX was 5027, 5919 and 6968 µg/mL in the control, 2000 and 20,000 XU, respectively. Our results illustrate clearly that supplemental xylanase solubilized AX independent of cereal source in the diet and in the digesta matrices.

Key Words: xylanase, cereal arabinoxylans, solubilization

236 Evaluating the efficacy of a novel phytase source.

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A total of 350 nursery pigs (PIC 1050 barrows, initially 15.1 kg BW) were used in a 21-d study to determine the available phosphorus (aP) release curve for a novel phytase product (Microtech 5000, VTR Bio-tech Co., Guangdong, China). Pigs were randomly allotted to pens at arrival to facilities and on d 0 of the trial pens were allotted to 1 of 7 treatments in a randomized complete block design. There were 5 pigs per pen and 10 pens per treatment. Pigs were fed corn-soybean meal-based diets formulated to contain 1.25% SID Lys. Experimental treatments consisted of 3 diets formulated to 0.12, 0.18, and 0.24% aP with the only source of added P being an inorganic source (monocalcium P). Then, phytase was added to the diet formulated to 0.12% aP at 4 levels (250, 500, 750, and 1000 FTU/kg). Diets were analyzed for phytase using the AOAC method, and analyzed concentrations were lower than formulated. Diets formulated to contain 250, 500, 750, and 1000 FTU/kg had analyzed concentrations of 155, 335, 465, and 780 FTU/kg, respectively. On d 21, one pig per pen was euthanized and fibulas were collected to determine bone ash weight and percentage bone ash. From d 0 to 21, increasing P from inorganic P or increasing phytase increased ADG (linear, $P < 0.01$), G:F (linear, $P < 0.01$ for inorganic P; quadratic, $P < 0.03$ for phytase), and final BW (linear, $P < 0.01$). Bone ash weight and percentage were increased (linear, $P < 0.01$) with increasing inorganic P and increasing phytase. Response criteria, which remained in the linear portion of the quadratic phytase curve (ADG, bone ash weight, and percentage bone ash), were used to calculate aP release curves. When analyzed phytase values and percentage bone ash are used as the predictor variables, aP release percentage for up to 780 FTU/kg of Microtech 5000 phytase can be predicted by the equation ($y = 0.000002766761x – 0.000000002225x^2 – 0.000201841391$; $r^2 = 0.948$), where x is the phytase concentration in the diet (FTU/kg).

Key Words: nursery pig, phosphorus, phytase

Table 236.

	Monocalcium P, % aP			Phytase, FTU/kg (analyzed)				
	0.12	0.18	0.24	155	335	465	780	SEM
ADG, kg	0.55	0.67	0.73	0.59	0.60	0.59	0.63	0.023
ADFI, kg	1.12	1.12	1.20	1.12	1.09	1.09	1.13	0.054
G:F	0.496	0.593	0.607	0.528	0.554	0.543	0.553	0.0116
Bone ash, g	1.17	1.40	1.66	1.14	1.27	1.22	1.38	0.083
Bone ash, %	33.50	36.20	39.23	32.81	35.02	35.2	36.04	1.892

237 Effect of combined xylanase and phytase supplementation on growth performance, carcass characteristics, and apparent total tract digestibility in pigs fed corn-based diets containing multiple by-products.

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Phytate has been shown to be an anti-nutrient and that feeding high levels of phytase can breakdown phytate improving nutrient utilization and pig performance. Dietary xylanase targets arabinoxylan breakdown improving energy utilization in pigs. However, the individual effects of simultaneous supplementation have not been clearly determined. Crossbred pigs ($n = 45$; mean initial weight: 26.4 kg) were allotted to 9 treatments to evaluate the effect of both xylanase (Econase XT; endo-1,4-β xylanase [EC 3.2.1.8]) and phytase (Quantum Blue) supplementation as follows: 1) positive control [PC]: a corn-SBM based diet with 15% each of corn distillers dried grains with

solubles, and wheat middlings and 13% of corn germ meal, 2) negative control [NC]: ME was reduced by 103 kcal/kg from the PC diet by replacement of fat with corn starch in each of the 4 feeding phases, 3) NC + phytase (500 FTU/kg diet), 4) NC + phytase (1000 FTU/kg diet), 5) NC + phytase (2000 FTU/kg diet), 6) NC + xylanase (24,000 BXU/kg diet), 7) NC + phytase (500 FTU/kg diet) + xylanase (24,000 BXU/kg diet), 8) NC + phytase (1000 FTU/kg diet) + xylanase (24,000 BXU/kg diet), 9) NC + phytase (2000 FTU/kg diet) + xylanase (24,000 BXU/kg diet). All diets were formulated to meet nutrient requirements before phytase and xylanase addition to the diets. Body weight and feed consumption were recorded to calculate growth performance, and pigs were ultrasonically scanned at the end of the experimental period to measure fat and loin depth. Fecal collection was performed in the final phase for 3 consecutive days to estimate apparent total tract digestibility (ATTD). There were no significant interactions between xylanase and phytase supplementation on growth performance, carcass characteristics and ATTD. Xylanase supplementation showed a nonsignificant numerical response in gain (+1 kg) and G:F ratio (+0.007). However, ADG ($P <$ 0.01, quadratic) and G:F ratio ($P = 0.04$, linear) for the overall period increased as phytase levels increased. Carcass lean percentage and lean gain increased ($P < 0.05$; linear) as phytase levels increased. The ATTD of DM, NDF, ether extract ($P <$ 0.05), and hemicellulose ($P = 0.05$) increased quadratically as phytase level increased. The ATTD of P increased as phytase supplementation levels increased ($P <$ 0.05, linear and quadratic). These results indicate that the improved nutrient digestibility, performance and carcass response to phytase supplementation is beyond P provision. However, xylanase usge alone or with phytase requires continued evaluation.

Key Words: phytase, pigs, xylanase

238 Impact of super-dosing phytase in diets fed to 40 kg, 60 kg and 80 kg pigs on phytate catabolism.

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Phytase is added to pig diets to release phytate-bound phosphorus, but may also release additional nutrients when fed at super-dosed levels. One possible benefit of super-dosed phytase is the release of free inositol which may then be available for a variety of functions, including as a precursor of compounds involved in neurological signals, structure and function of cell membranes, and insulin sensitivity. Three experiments were conducted to determine the impact of super-dosing phytase on phytate catabolism. Thirty-2 gilts were surgically fitted with t-cannulae at the terminal ileum and at average body weights of 39.7 ± 0.3 kg, 60.5 ± 0.5 kg, and 82.5 ± 0.7 kg, they were utilized in experiments 1, 2, and 3, respectively. The basal diets were based on corn and soybean meal with chromic oxide added at 0.4% as an indigestible marker. Feed was supplied at 3.2 times maintenance for 16 d in each experiment: 10 d adaption, 3 d fecal collection and 3 d ileal collection. The 4 dietary treatments contained phytase (Quantum Blue® 5G; AB Vista, Marlborough, UK) at 250 (CTL), 1000, 1750, and 2500 FTUs/kg, respectively. Feed and ileal digesta were analyzed for phytate and its catabolic derivatives. Data were analyzed using the MIXED procedure of SAS; pig was the experimental unit. In all 3 experiments, the concentration of phytate (IP_6) was reduced in a quadratic fashion with the addition of super-dosed levels of phytase. Concurrently, the concentration of inositol increased in a linear manner. As phytase levels increased, the concentration of IP_5 decreased in a quadratic fashion ($P < 0.001$). The concentrations of IP_4 and IP_3 increased at the lower levels of phytase and then decreased at the higher level. In conclusion, the addition of phytase to pig diets at super-dosed levels catabolizes phytate, resulting in increasing concentrations of inositol and reduced concentrations of phytate.

Key Words: phytate, phytase, inositol

Table 238. Impact of super-dosed phytase on phytate (IP_6) and inositol concentration in ileal digesta (µmol/g)

	Phytase levels, FTU/kg					P-values		
Molecule	CTL	1000	1750	2500	SEM	Treatment	Linear	Quadratic
40 kg								
IP_6	19.28	10.85	8.10	6.79	1.64	< 0.001	< 0.001	0.041
Inositol	3.20	5.31	9.93	9.04	1.19	0.002	< 0.001	0.219
60 kg								
IP_6	18.02	9.00	5.43	4.87	1.19	< 0.001	< 0.001	0.002
Inositol	2.69	4.42	8.50	11.46	1.77	< 0.001	< 0.001	0.633
80 kg								
IP_6	18.00	7.72	6.46	5.20	1.62	< 0.001	< 0.001	0.012
Inositol	1.56	4.31	5.12	6.12	1.02	< 0.001	< 0.001	0.178

239 Impact on growth performance and carcass characteristics of ìsuper-dosingî phytase in growing pig diets.

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Previous research has shown that super-dosing phytase may improve pig performance; however the response in grow-out has been inconsistent. This experiment was conducted to determine if performance could be improved by feeding phytase at super-dosed levels, and whether this response would be achieved if energy and amino acids were limiting. Two-thousand two-hundred pigs (36.6 ± 1.0 kg) were split by sex and blocked by initial BW, and randomly allotted to 5 dietary treatments (10 pens per treatment per gender): a fully balanced positive control (PC; SID lysine set at 98% of asymptote; 250

FTU Quantum Blue 5G/kg), a negative control (NC; PC with 15% less SID lysine and 1.5% lower NE), and 3 super-dosing treatments applied to the NC for a total of 1000, 1750, and 2500 FTU/kg. Feed and water were available ad libitum. Data were analyzed using the PROC MIXED procedure of SAS (9.4) with pen as the experimental unit and treatment as a fixed effect. Barrows grew faster than gilts (1.06 vs. 0.90 kg/d; $P < 0.05$), were heavier at marketing (123.6 vs. 120.6 kg; $P < 0.05$) and had a higher dressing percent (74.4 vs. 73.8%; $P < 0.05$). Barrows ate more feed (3.09 vs. 2.62 kg/d; $P < 0.05$) and were less feed efficient than gilts on PC (0.347 vs. 0.360) but not on NC diets (0.338 vs. 0.335 kg/d; Interaction: $P < 0.05$). Barrows responded to super-dosed phytase with improved feed conversion while gilts did not (interaction: $P < 0.05$). Compared to the NC, pigs on the PC were heavier at marketing (125.2 vs. 120.1 kg; $P < 0.05$) and grew faster (1.01 vs. 0.96 kg/d; $P < 0.05$). There was no difference in feed intake between the PC and NC ($P > 0.10$). Super-dosing phytase tended to improve final body weight compared with the negative control ($P = 0.058$). There was no effect of super-dosing phytase on growth rate, feed intake or carcass yield ($P > 0.10$). Super-dosing phytase tended to improve gain:feed on a liveweight basis ($P = 0.08$) although the interaction between treatment and sex was significant ($P < 0.001$): barrows (0.338, 0.339, 0.343, 0.344) vs. gilts: (0.335, 0.338, 0.337, 0.336 for NC, 1000, 1750 and 2500 FTU/kg, respectively); this was also true when feed efficiency was expressed on a carcass basis. In conclusion, super-dosing phytase tended to improve efficiency of gain, suggesting possibly enhanced energy and/or nutrient utilization.

Key Words: super-dose phytase, barrows, gilts

240 The effect of microbial phytase on the apparent and standardized total tract digestibility of calcium in feed ingredients of animal origin.

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An experiment was conducted to determine effects of microbial phytase on the apparent (ATTD) and standardized total tract digestibility (STTD) of Ca in meat and bone meal (MBM), meat meal (MM), poultry by product meal (PBPM), or poultry meal (PM). Four corn-potato protein isolate-based diets were formulated to contain 0.70% Ca using MBM, MM, PBPM, and PM as the sources of Ca. All diets also contained 0.33% STTD P with extra P being supplied by monosodium phosphate if needed. Four additional diets that were similar to the previous diets except that they contained 500 units of microbial phytase and a Ca-free diet were also formulated. Growing barrows ($n = 72$; initial BW = 14.91 ± 0.19 kg) were allotted to a randomized complete block design with 9 dietary treatments and 8 replicate pigs per treatment. Experimental diets were provided for 12 d with the initial 5 d being the adaptation period. Total feces were collected for 5 d using the marker-to-marker approach. Results indicated that if no phytase was used, the ATTD and STTD of Ca in PBPM were greater ($P < 0.05$) than in MBM and MM, but values for PM were not different from any other ingredients (Table 240). However, if phytase was added to the diets, no differences in ATTD or STTD of Ca among ingredients were observed. If no phytase was used, no differences among the 4 ingredients were observed for ATTD of P, but if phytase was added, the ATTD of P was greater ($P < 0.05$) for PBPM compared with MM. In conclusion, the addition of microbial phytase did not affect the digestibility of Ca and P in ingredients of animal origin, and only small differences among the 4 ingredients were observed.

Table 240. Apparent total tract digestibility (ATTD) of Ca and P and standardized total tract digestibility (STTD) of Ca in meat and bone meal (MBM), meat meal (MM), poultry product meal (PBPM), and poultry meal (PM).

Item	ATTD Ca	STTD Ca	ATTD P
Without phytase			
MBM	74.54[b]	76.83[b]	76.00[b]
MM	74.61[b]	76.97[b]	76.01[b]
PBPM	85.34[a]	87.76[a]	78.30[ab]
PM	80.74[ab]	82.41[ab]	80.12[ab]
With phytase			
MBM	79.66[ab]	81.94[ab]	80.48[ab]
MM	83.25[ab]	85.75[ab]	75.79[b]
PBPM	83.51[ab]	86.66[ab]	85.99[a]
PM	74.31[b]	76.06[b]	77.11[ab]

Key Words: calcium, phosphorus, pigs

241 Stability of commercial phytase products stored under different environmental conditions.

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A 300-d study evaluated the stability of 4 phytase products stored under varied environmental conditions. The 4 products were: 1) Quantum Blue 5G (AB Vista, Marlborough, United Kingdom); 2) Ronozyme HiPhos GT 2700 (DSM Nutritional Products, Parsippany, NJ); 3) Axtra Phy TPT (Dupont, Wilmington, DE); and 4) Microtech 5000 Plus (Guangdong VTR Bio-Tech Co., Ltd., Guangdong, China). Products were stored as pure forms at −20, 4, 22, or 35°C (75% humidity), or in a vitamin or vitamin trace mineral (VTM) premix at 22 and 35°C (75% humidity). Samples were stored in paper bags and sampled on d 30, 60, 90, 120, 210, and 300. Stability was determined as amount of residual phytase activity (% of initial). For pure forms, all interactive and main effects of product,

Table 241.

	Residual phytase activity, %[1]							
	Sampling, d							Probability, $P <$
Item	30	60	90	120	210	300	SEM	Storage form main effect
Pure product	95.1	96.8	97.2	93.5	90.7	82.0	5.30	0.001
Vitamin premix	106.9	100.8	100.4	96.6	88.3	77.9		
VTM	95.5	58.5	77.2	78.0	54.6	39.0		

[1] Stability was measured as the analyzed phytase concentration divided by d 0 phytase concentration.

time, and temperature were significant ($P < 0.05$). From d 30 to 300, products had similar reductions in phytase activity at the 3 highest temperatures; however, Quantum Blue 5G, Ronozyme HiPhos GT 2700, and Axtra Phy TPT had reduced ($P < 0.05$) phytase activity compared to Microtech 5000 Plus at −20°C. As storage time increased, residual phytase activity was reduced ($P < 0.05$) regardless of product and storage temperature. Also, when product was stored at 4 and 22°C, phytase activity was improved compared to −20 and 35°C. For vitamin and VTM premixes, a time×temperature × product interaction ($P < 0.05$) was observed as a result of, Axtra Phy TPT and Microtech 5000 Plus having reduced residual phytase activity ($P < 0.05$) compared to the other 2 products when stored at 22°C, while activity of Axtra Phy TPT was reduced ($P < 0.05$) even further than the other 3 products when stored at 35°C regardless of form. From d 30 to 300, Axtra Phy TPT and Microtech 5000 Plus had the lowest ($P < 0.05$) residual phytase activity compared to the other 2 products. The VTM had decreased ($P < 0.05$) residual phytase activity compared to the pure product and vitamin premixes. In conclusion, phytase stored for longer than 90–120 d at 35°C or −20°C in pure form, or when stored as a VTM premix had reduced residual phytase activity.

Key Words: phytase, storage, stability

242 Effect of a dry acidulant coating on the palatability of dry extruded dog food.

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In the pet food industry, *Salmonella* is getting greater scrutiny because it is considered a "reasonably foreseeable hazard" with the implementation of the Food Safety Modernization Act. Specifically, there is zero tolerance for any serotype of *Salmonella* in pet foods. *Salmonella* contamination was responsible for 78% of the Class I recalls in pet food according to the most recent Reportable Food Registry Report (FDA, 2015). One potential method of *Salmonella* mitigation shown to be effective was through coating the exterior of the kibble with a powdered dry acidulant, such as sodium bisulfate (SBS; Jones-Hamilton, Co.). Sodium bisulfate coating on both dog and cat kibbles was shown to provide complete mitigation of *Salmonella* within 14-d storage (Jeffrey et al., 2014). However, it is thought that the use of dry acidulant with a palatant for coating kibble may negatively impact palatability of a dry dog food. Therefore, the objective of this experiment was to determine if the use of a dry acidulant, SBS, would influence the palatability of a dry dog food. A single dry extruded all life stages dog food was collected from a commercial pet food manufacturer before the coating step. The kibble was coated with either 2.2% spray dried chicken liver + 0.2% SBS or 2.2% spray dried chicken liver + 0.2% powdered silica (control). A total of 20 beagles were used in a standard 2-bowl forced choice palatability test method for 2 d. Dogs were fed 400 g of both diets once per day, with bowls rotated daily to address side bias. Results were analyzed using the GLIMMIX procedure of SAS (Cary, NC). The inclusion of SBS did not affect daily preference of diet ($P = 0.23$). Furthermore, there was no effect of day ($P = 0.18$) or the interaction of treatment × day ($P = 0.98$). These results demonstrate that palatability is not affected by the inclusion of SBS with a palatant in the coating of dog food kibble. Considering that the inclusion of SBS has been shown to be effective at mitigating *Salmonella* in pet food and no negative effects on palatability were observed, the use of a dry acidulant in a dog food coating gives the industry a promising method to control *Salmonella* contamination of finished dog foods.

Key Words: dog food, palatability, *Salmonella*

243 Effects of a novel phytase on growth performance and metacarpal bone ash in weanling pigs.

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The objective of this experiment was to determine effects on growth performance and metacarpal bone ash of adding a novel next generation phytase (CIBENZA® PHYTAVERSE® G10) to diets for weanling pigs. A total of 160 pigs (initial BW: 9.79 ± 1.22 kg) were allotted to 4 diets with 10 replicated pens per treatment and 4 pigs per pen using a randomized complete block design. The experiment was conducted in 2 phases of 14 d each. Four diets within each phase were formulated based on corn and soybean meal, including a positive control (PC) that met or exceeded NRC (2012) nutrient requirements, a negative control (NC) that was similar to the PC diet with the exception that digestible P was reduced to 58% of the requirement in phase 1 and 56% of the requirement in phase 2. Two additional diets were formulated by adding 250 or 500 phytase units (FTU) per kg to the NC diet. At the conclusion of the experiment, 2 pigs per pen were euthanized and the third and fourth metacarpals from the right foot were collected. Data were analyzed by PROC GLM of SAS and means

were separated by LSDs. Means between the PC and NC diets were separated using PDIFF and linear and quadratic effects of supplemental graded levels of phytase were determined using orthogonal polynomial contrasts. Results indicated that pigs fed the PC diet had greater ($P < 0.05$) ADG, ADFI, and G:F during phase 1, phase 2, and the entire experimental period than pigs fed the NC diet. Inclusion of phytase linearly increased ($P < 0.05$) ADG, ADFI, and G:F during phase 2 and the entire experimental period. Pigs fed 500 FTU/kg of phytase had greater ($P < 0.05$) G:F than pigs fed 250 FTU/kg phytase in phase 2 and for the overall period. Pigs fed the PC diet had greater ($P < 0.05$) bone ash and bone P content compared with pigs fed the NC diet. Supplementation of phytase to the NC diet linearly increased ($P < 0.05$) bone ash weight (1.35, 1.57, and 1.68 g, respectively) and percentage (48.58, 49.71, and 50.70%, respectively) and bone P weight (0.48, 0.55, and 0.58 g, respectively). No differences were determined in bone measurements between 250 and 500 FTU/kg of phytase. In conclusion, both doses (250 or 500 FTU/kg) of CIBENZA® PHYTAVERSE®G10 supplementation to a P-deficient diet efficiently improved P utilization by weanling pigs.

Key Words: bone ash, phytase, weanling pigs

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244 The feed enzyme xylanase improves finish pig viability and carcass feed efficiency.

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This paper presents a novel find that the feed enzyme xylanase (XYL) improves pig viability. Xylanases break down cell wall arabinoxylans to shorter chain xylo-oligomers and these become a food source for beneficial gut microflora. In poultry, an increase in this substrate coincided with a balance shift toward more beneficial microflora. This is hypothesized to support intestinal barrier function and improved host health. A total of 2124 PIC castrate and female pigs (11.7 ± 0.2 kg) were used in a growth assay to approx. 137.9 kg (± 0.5 kg). Pigs were placed in a commercial research facility, blocked by gender and genotype, stratified by weight and allocated (34 pigs/pen, 0.70 m^2/pig) to diets with 0, 0.075, 0.150 or 0.225 g Danisco Xylanase/kg feed. Treatments were arranged as a 2 × 4 × 3 factorial (sex, diet, genotype) with pen being the experimental unit. Diets were composed of corn, soybean meal, corn DDGS (15.0%), wheat midds (10%) and soy oil (1.0%). Nutrient levels met or exceeded the requirement (PIC 2008). Early nursery diets were medicated, however diets were maintained medication free after 30 kg body weight. Paylean® (Elanco) was used at 5 and 10 mg/kg in the final 2 diets. Pigs were classified as moderately high health based on PRRS and PEDv negative status. Mortality and removal rate, for medical treatment, from 12 kg to harvest was 4.16%. Under these conditions, increasing XYL dose tended to reduce mortality (3.99, 3.51, 2.25, 2.39%, SEM = 0.98, linear $P = 0.175$). Death loss for pigs that remained in test pens (excluded medical pens) averaged 3.39, 2.32, 1.90, 1.62%, SEM = 0.82, linear $P = 0.126$). Carcass ADG and G:F ratio was computed as the difference between estimated initial carcass weight (0.74 × BW) and plant carcass weight. Carcass ADG was not improved but carcass FCR improved as XYL increased (0.286, 0.287, 0.291, 0.290, $P = 0.012$, SEM = 0.0015). This occurred, despite no improvement in whole-body G:F ratio, because carcass yield tended to improve with dose: 73.9, 74.0, 74.1, 74.3% ($P = 0.160$ linear). When gain was expressed on a pen basis (viable pigs × gain), whole-body and carcass gain improved in a linear manner ($P = 0.071$, $P = 0.047$); the latter averaged 2892, 2926, 3104, 3035 kg/pen (SEM, 66.4). This study is the first to show that the feed enzyme XYL improves pig viability and in a dose related manner; even under high health conditions and for progeny of 3 genotypes (line × trt, $P > 0.50$). This outcome has implications for animal well-being and reduced enteric antibiotic use.

Key Words: growing pigs, enzyme, xylanase, viability

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245 Xylanase responses on apparent ileal digestibility of nutrients, fiber and Energy in growing pigs fed corn, 30% corn co-products and soybean meal based diets as influenced by microbial phytase and ccclimatization period.

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Effects of fiber degrading enzymes on improving nutrient utilization are not well understood in the context of phytase and acclimatization period to the experimental diet. A total of 16 pigs (initial BW: 60.1 ± 2.8 kg) equipped with a terminal ileum T-cannula were used to evaluate the xylanase response as influenced by phytase and acclimatization period. Two basal corn, corn distillers grains with solubles, corn germ meal and soybean meal based diets were formulated, either with mono calcium phosphate or phytase (500 FTU/kg Axtra® PHY). The diets were fed with or without xylanase (4000 U/kg). Enzymes were supplied by Danisco UK Ltd. All diets had TiO2 as indigestible marker. The experiment was conducted in a 2 period changeover design. Periods 1 and 2 were 11 and 19d long respectively, and the last 2d in each period were for collection of ileal digesta samples. There were 4 replicates per diet in each period. Digesta samples were used to calculate apparent ileal digestibility (AID) of dry matter (DM), gross energy (GE), crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF) and starch. Data were subjected to GLM procedures of SAS in a model that included the main effects of phytase, xylanase, acclimatization period, and associated 2-way interactions. The 3-way interactions proved nonsignificant ($P > 0.10$) so were dropped from the model. Interactions were observed between period and xylanase for AID of CP (P

= 0.013) and phytase; and xylanase on AID of ADF ($P = 0.04$). Xylanase improved AID of CP in period 2 but not period 1, and AID of ADF was lower for the diet without additives. The AID of DM (66.5 vs. 63.1%, $P = 0.01$) and GE (68.0 vs. 64.5%; $P = 0.01$) were higher in period 1 than period 2. Phytase fed pigs had higher ($P < 0.05$) AID of DM, NDF and ADF relative to non-phytase fed pigs, but had no effect on AID of GE. Compared to control pigs, xylanase fed pigs showed 4.5% higher AID of GE (68.5 vs. 64%, $P = 0.002$) linked to increased AID of DM (66.2 *vs.* 63.4%, $P = 0.04$), CP (70.4 vs. 67.4%, $P = 0.04$), NDF (38.4 vs. 31.8, $P = 0.02$) and ADF (30.1 vs. 22.2, $P = 0.02$). In conclusion, the results showed that responses of supplemental xylanase on improvement of apparent ileal energy and fiber digestibility were independent of supplemental phytase and duration of the acclimatization period.

Key Words: digestibility, phytase, xylanase

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246 Sources and routes of administration of copper and vitamins A and D on metabolic status of these micronutrients in suckling piglets. J. J. Matte[*1], I. Audet[1], B. Ouattara[1], N. Bissonnette[1], G. Talbot[1], J. Lapointe[1], F. Guay[2], L. Lo Verso[1], M. Lessard[1], *[1]Agriculture and Agri-Food Canada, Sherbrooke, QC, Canada, [2]Universite Laval, Quebec City, QC, Canada.*

It has been recently shown that placental and colostral transfer of copper and vitamins A and D from dams to neonates is limited in pig species (Matte et al., 2014, JAS 92-Suppl. 2:153). The present study aimed to determine the efficiency of neonatal supplementation strategies for these micronutrients in piglets. Within litter from 14 sows fed conventional diets, 5 groups of 2 newborn piglets were formed. In each group, piglets received a combination of micronutrient source and route of administration as follows: oral vitamin D3, retinol-acetate and $CuSO_4$ (T1); oral 25-OH-D3, β-carotene and Cu-proteinate (T2); UVB light exposure (20 min, every second d during lactation), oral retinol-palmitate and Cu-gluconate (T3); intramuscular vitamin D3 and retinol-propionate and oral Cu-acetate (T4); oral saline (CTL). Oral or intramuscular provisions corresponded to 12 mg of copper and 70 and 12 MIU of vitamins A and D, respectively, partitioned between administrations at 2 (33%) and 8 d of age (67%). This design was repeated with 14 other sows fed extra daily supplements of 25-OH-D3 (4 MIU), β-carotene (24 MIU) and Cu-proteinate (45 mg) from 90 d of gestation to 21 d of lactation (weaning). Blood samples were collected on piglets at 2 and 8 d of age (before treatment administrations) and at weaning for plasma 25-OH-D3 determinations. At 23 d of age, 5 repetitions of a combination of sow and piglet factorial treatments ($n = 50$ piglets) were sacrificed for copper and retinol determinations in liver. For vitamin D, plasma 25-OH-D3 was increased by extra supplementation to sows (15.1 vs. 13.1 ng/mL, $P < 0.02$, SE = 0.6). Within piglet treatments, at 8 d of age, values were greater in T2 than CTL (24.3 vs. 6.8 ng/mL) and intermediate for other treatments whereas, at 21 d of age, the response was in favor of T3 vs. CTL (20.8 vs. 9.1 ng/mL, interaction piglet treatment × age, $P < 0.01$, SE = 0.9). Sow treatments did not influence liver copper and retinol. Liver copper concentrations in supplemented piglet treatments were globally 38% greater than CTL (93.8 vs. 68.1 µg/g, $P < 0.01$, SE = 8.0). For retinol, hepatic concentrations were 3 times greater with T1 than with CTL (321.5 vs. 103.8 µg/g) and intermediate for the other treatments (piglet treatment effect, $P < 0.01$, SE = 20.5). Therefore, marked increases of copper and vitamins A and D statuses can be achieved by the oral route of supplementation or UVB light to neonatal piglets. Moreover, for oral vitamins A and D, sources also matter.

Key Words: vitamins, trace minerals, neonatal piglets

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247 Effect of feeding protease at two soybean meal inclusion rates for nursery pigs. L. Greiner[1], A. Graham[1], B. Knopf[1], L. Ochoa[*1], R. J. Harrell[2], Y. Ma[3], *[1]Carthage Innovative Swine Solutions, LLC, Carthage, IL, [2]Professional Swine Management, Carthage, IL, [3]Novus International Inc., St. Charles, MO.*

Approximately 1200 PIC 337 × 1050 pigs (6.80 0.91 kg) were used to evaluate a protease enzyme (CIBENZA DP100, Novus International Inc., St. Charles, MO). This 21d study was performed as a RCBD (block = weight) with a 2 × 2 factorial arrangement of the following treatments: 1) Enzyme inclusion level (0 vs. 0.05%); and 2) SBM inclusion level [Low: 18 and 22% (phases I and II, respectively) vs. High: 25 and 30% (phases I and II, respectively)]. Changes in dietary phases occurred on d 7. There were no treatment effects in phase I for ADG, ADFI, or G:F ($P > 0.10$). From d 7 to 21, pigs fed low SBM levels grew slower ($P < 0.01$; 0.410 vs. 0.431 kg/d) and had lower G:F ($P < 0.01$; 0.720 vs. 0.750) than pigs fed high SBM levels. ADG of pigs not fed the enzyme was lower ($P < 0.01$; 0. 404 vs. 0.436 kg) and had a lower G:F ($P < 0.01$; 0. 723 vs. 0.746) compared to pigs fed the enzyme. There was a SBM × enzyme interaction ($P < 0.05$): Effects of enzyme supplementation were bigger ($P < 0.05$) in low SBM diets compared to high SBM diets for ADG (High SBM = 0.427 vs. 0.436 kg, vs. Low SBM = 0.381 vs. 0.436 kg, for 0 and 0.05% enzyme, respectively) and G:F (High SBM = 0.746 vs. 0.752, vs. Low SBM = 0.699 vs. 0.741, for 0 and 0.05% enzyme, respectively). At d 21, pigs not receiving the enzyme were lighter ($P < 0.001$; 13.9 vs. 14.3 kg) than pigs fed the enzyme. Pigs fed low SBM levels were lighter ($P < 0.01$; 14.0 vs. 14.2 kg) than pigs fed high SBM levels. For the overall period (d 0–21), there was a SBM × enzyme interaction ($P < 0.05$): Effects of enzyme supplementation were bigger ($P < 0.05$) in low SBM diets compared to high SBM diets for ADG (High SBM = 0.350 vs. 0.354 kg, vs. Low SBM = 0.318 vs. 0.354 kg, for 0 and 0.05% enzyme, respectively) and G:F (High SBM = 0.787 vs. 0.781, vs. Low SBM = 0.735 vs. 0.775, for

0 and 0.05% enzyme, respectively). Overall, there is a significant response to the enzyme in nursery pigs, although further work is needed to duplicate results and verify that there is no true response when the enzyme is fed in high SBM level diets.

Key Words: enzyme, nursery, pigs

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248 Sodium buffered formic acid improves sow and piglet performance when fed during lactation and the nursery periods. J. A. Jendza[*1], X. Yang[2], H. Y. Chen[3], A. Tekeste[2], S. K. Baidoo[2], *[1]BASF Corp., Florham Park, NJ, [2]Southern Research and Outreach Center, University of Minnesota, Waseca, [3]BASF SE, Lampertheim, Germany.*

A pair of experiments was designed to evaluate feeding sodium buffered formic acid (SBFA) to sows during lactation, and to their piglets in the subsequent nursery period. A total of 112 sows were blocked by parity and assigned to diets without (NC) or with supplemental SBFA (9 g/kg diet). Sows were farrowed in 2 equal groups, and all of the piglets from the first farrowing group (n = 252) were used for the subsequent nursery trial. Piglets were blocked by BW and sow treatment group and assigned to 2 nursery diets without (NC) and with SBFA (9 g/kg diet), such that there were in effect 4 treatments in the nursery period (NC/NC, NC/SBFA, SBFA/NC, SBFA/SBFA; Sow treatment/Piglet treatment). Feeding SBFA during lactation resulted in heavier piglet weaning weights at weaning (6.29 vs. 6.00 kg; $P < 0.05$), and tended to reduce the amount of BW lost by the sow during lactation (−10.6 vs. –15.9 kg; $P = 0.08$). This due to an increase in daily feed intake of SBFA fed sows. While average daily feed intake was not different between groups (6.5 vs. 7.0 kg; $P = 0.13$), repeated measures analysis of feed intake by day of lactation from d 1 to d 18 (first sows weaned at d 19) revealed higher FI on d 6, 10, 11, and 17, ($P < 0.05$) as well as a tendency toward higher FI on d 9, 12, 13, and 15 ($P < 0.10$) for SBFA fed sows. Broken line regression of daily FI indicate that SBFA fed sows achieved peak FI on d 11, and the NC fed sows on d 18. In the nursery trial, BW was not different across treatments on d 0, piglets from SBFA fed sows tended to be heavier at d 14 (+0.32 kg; $P = 0.10$), piglets fed SBFA directly were heavier on d 28 (+0.77 kg; $P < 0.05$) and tended to be heavier on d 42 (+0.5 kg; $P < 0.10$). Overall, SBFA improved G:F of nursery piglets whether fed to the sow during lactation (0.65 vs. 0.63; $P < 0.01$) or directly to the piglets during the first 42 d postweaning (0.65 vs. 0.63; $P < 0.05$). In conclusion, SBFA fed to sows can improve piglet weaning weights, subsequent performance of piglets post weaning, and may improve sow FI during lactation. Feeding SBFA to nursery piglets can improve piglet growth and feed efficiency.

Key Words: formic acid, lactation, nursery, performance, swine

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249 High lactose pellets fed from 4 d of age convey lifetime benefits when compared to a standard pre-weaning diet. P. Toplis[*1], I. J. Wellock[2], A. Stewart[3], M. Bailey[4], L. Salmon[5], *[1]AB Neo, Peterborough, United Kingdom, [2]Primary Diets, Melmerby, United Kingdom, [3]Harper Adams University, Newport, United Kingdom, [4]Bristol Veterinary School, Bristol, United Kingdom, [5]Premier Nutrition, Rugeley, United Kingdom.*

An experiment was conducted to assess the lifetime response and carcass characteristics of feeding a high lactose complex diet (HL) versus a standard commercial diet (C) from 4 d of age until weaning. The litter performance of piglets from d 4 of age was measured using a total of 32 sows with 16 litters per dietary treatment. At weaning the median 240 pigs (120 per trt) were selected from the total pool of 370 and 5 unisex pigs were penned together according to treatment (n = 24 per trt). Pen weights were equalised and variance within pen minimized. All pens were fed and managed the same way from wean to slaughter to ensure any difference in lifetime performance was due to pre-weaning treatment only. Pigs were first taken for slaughter at week 20 (139 d) with slaughter weight, age and treatment recorded individually. All remaining pigs were slaughtered the following week 21 (146 d). Analysis of variance was used to determine treatment effects with repeated measures analysis undertaken to assess the effect of time on results. There were no performance differences pre-weaning. In the nursery phase HL piglets had a higher DLWG during d 0–7, 7–14 and 0–28 compared with C piglets ($P = 0.007$, $P = 0.039$ and $P = 0.030$ respectively). Over the whole 36 d nursery phase the HL piglets grew at 31 g/d more than the C piglets reaching a BW difference of + 1.05 kg $P = 0.007$). During the grower-finisher phase HL pigs remained significantly heavier compared with the C fed pigs with HL pigs being +2.58kg heavier at week 20 (104.25 vs. 101.67 kg; $P = 0.019$). HL pigs tended to have heavier slaughter weights compared with the C pigs (107.8 kg vs. 105.6 kg respectively; $P = 0.052$). This tendency of the HL pigs to be heavier became a significant increase in both hot (81.45 kg vs. 79.31 kg $P = 0.001$) and cold carcass (79.83 kg vs. 77.7 2kg $P = 0.001$) weights due to an increased killing out% (75.69% vs. 75.14% $P = 0.003$). Backfat and estimated lean meat % were not affected by treatment. Analysis on a number of samples collected during this study at various slaughter points are being conducted to help elucidate the mode of action responsible for the increase in lifetime performance from feeding a HL diet pre-weaning.

Key Words: creep diet, lactose, lifetime performance

250 Evaluation of bovine plasma in early nursery pig diets.

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Eight hundred and two barrows and gilts (5.48 ± 0.57 kg) were used to evaluate the use of bovine plasma in early nursery phases. Treatments included a bovine plasma ration (4% in phase 1 ration and 2% in phase 2 ration) and a negative control diet with no animal plasma protein. Pigs were started on experimental rations on the day of weaning (~21 d of age) and arrival to the facility (d 0). A 3-phase nursery program was utilized, and diet changes occurred at 7, 20, and 39 d postwean. Pigs were penned in blocks of either 24 or 25 pigs/pen with a computerized feed system delivering feed to single-sided feeders. There were a total of 24 replications per treatment group. Treatment diets were fed until d 20, at which point all pigs were fed a common nursery 3 diet. Diets were formulated to meet or exceed nutrient requirements. Treatments were equalized across gender, and data were analyzed as a randomized complete block design using the PROC MIXED procedure of SAS with pen as the experimental unit and treatment as a fixed effect. There was a tendency for an improvement in ADG (P = 0.07) when pigs were fed plasma during the first 7 d. From d 7 to 20, ADG was significantly higher (P = 0.01) in pigs fed plasma. While G:F was not significantly different (P = 0.28), increased intake resulted in a heavier (P = 0.04) pig at d 20 when plasma was included in the diet. From d 20 to d 39, a common nursery diet was fed, and ADG and G:F were no longer significantly different based on treatment. Overall (d 0 to 39), there was a significant increase (P = 0.01 and 0.04, respectively) in ADG when pigs were fed plasma from d 0 to 20. Based on the results of this study, pigs that were fed plasma from d 0 to 20 have a higher ADG.

Key Words: nursery, pigs, plasma

Table 250. Evaluation of bovine plasma in early nursery diets

Item	Trt 1 Plasma	Trt 2 Control	SEM	Probability, P =
d 0 to 7				
ADG, kg	0.12	0.10	0.01	0.07
G:F	0.84	0.74	0.04	0.09
d 7 to 20				
ADG, kg	0.38	0.35	0.01	0.01
G:F	0.88	0.87	0.01	0.28
d 0 to 39				
ADG, kg	0.45	0.43	0.01	0.01
G:F	1.35	1.34	0.01	0.83
Final Wt, d 39	22.76	22.19	0.25	0.11

251 Effect of a *Lactobacillus acidophilus* fermentation product and dietary antibiotics, alone or in combination, on nursery pig performance and frequency of medical treatment.

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The objective of this study was to evaluate the effect of a *Lactobacillus acidophilus* fermentation product (LAFP: SynGenX®, Diamond V, Cedar Rapids, IA) and dietary antibiotics alone or in combination, on nursery growth performance and the frequency of injectable medications. A total of 424 weanling pigs (average BW = 5.81 ± 0.93 kg) were blocked by weight and assigned to 1 of 4 treatments delivered over 4 phases: treatment 1) a control diet (Ctl), 2) Ctl plus LAFP, 3) Ctl plus antibiotics (Ab), or 4) Ctl plus both LAFP and Ab (LAFP+Ab). LAFP was added at 0.10% in phases 1 to 3 and 0.05% in phase 4. For the antibiotic treatments, chlortetracycline (0.044%) and tiamulin hydrogen fumarate (0.0039%) were added in phases 1 and 2 only. The number of animal treatments was recorded. Data were analyzed using the MIXED and FREQ procedures of SAS. There were no differences in BW among Ctl, LAFP and Ab (P > 0.05). However, LAFP+Ab resulted in a higher BW (P < 0.05). Neither BW standard deviation nor coefficient of variation nor ADFI were different among treatments (P > 0.05). ADG and G:F ratio were greatest in LAFP+Ab (P < 0.05); neither product individually increased ADG or G:F (P > 0.05). The frequency of pigs medicated was not significantly different among treatments for phases 1, 3, and 4 (P > 0.10); in phase 2, LAFP+Ab tended to have lower medication frequency followed by Ab and LAFP, while Ctl had the highest medication frequency (P = 0.078). In conclusion, the *Lactobacillus acidophilus* fermentation product in combination with antibiotics can improve growth performance and decrease the number of medications in nursery pigs more effectively than either product alone.

Key Words: *Lactobacillus acidopholis* fermentation product, antibiotic, nursery

Table 251. Effect of dietary treatments on pig growth performance for the overall period.

Item	Ctl	LAFP	Ab	LAFP+Ab	SEM	P-value
d-0–35						
ADG, kg	0.366[b]	0.366[b]	0.376[b]	0.390[a]	0.010	0.002
ADFI, kg	0.58	0.58	0.59	0.59	0.018	0.372
G:F ratio	0.635[b]	0.639[b]	0.642[ab]	0.660[a]	0.009	0.043
Initial BW, kg	5.81	5.81	5.82	5.81	0.28	0.801
Final BW, kg	18.60[b]	18.68[b]	19.00[ab]	19.45[a]	0.60	0.010

[a,b,c.] Symbolize statistical significant differences among treatments $P \leq 0.05$

252 Oral *Salmonella* challenge alters feed preference in nursery pigs. N. C. Burdick Sanchez*[1], J. A. Carroll[1], P. R. Broadway[1], K. M. Yeater[2], B. De Rodas[3], D. Brown[4], S. D. Lawhon[5], *[1]USDA-ARS, Livestock Issues Research Unit, Lubbock, TX, [2]USDA-ARS Plains Area, Fort Collins, CO, [3]Land O'Lakes, Gray Summit, MO, [4]Purina Animal Nutrition Center, Gray Summit, MO, [5]Department of Veterinary Pathobiology, Texas A&M University, College Station.*

Common industry practice is to segregate sick pigs; however, the same diet is provided. Due to the higher nutrient demand of the activated immune system, we hypothesized pigs would choose diets differing in nutrient content during an immune challenge when given choices. This study examined pig feed preference changes in response to an oral *Salmonella* challenge. Pigs (n = 30; 6.9 ± 0.1 kg BW) had ad libitum access to water and a common antibiotic-free (AF) phase 1 diet that was provided in 4 feeders within each pen from d0 to 7 postweaning (pw). On d7 pw, pigs were provided 4 AF phase 2 diets differing in composition: 1) Control (CON); 2) High Fat (HF; 33.75Kcal/kg > CON; 3) Low Protein (LP; 1.22% < CON) and 4) Low Carbohydrate/High Protein (LCHP; 6.5% simple sugars < CON and 1.8% protein > CON). Pigs were provided the diets in 4 separate feeders within each pen, with order randomized within and between pens from d7 to 28 pw. On d 14 pw, pigs were separated into 2 treatments: 1) *Salmonella* (SAL; n = 24) were orally inoculated with 4.8 × 10^9 cfu/pig *Salmonella* Typhimurium; and 2) Negative control (NC; n = 6) were orally administered PBS. Pigs were weighed on d −1, 7, 14, 21, and 28 pw and feeders were weighed daily from d 7 to 28 pw. Before analysis, feed disappearance data was summed into 7-d intervals. Feed disappearance data were analyzed as a MANOVA using the GLM procedure in SAS; pen was the subject, treatment was a fixed effect, and significant weekly weight change was included as a covariate. There was a treatment × time interaction (P = 0.0003) for weight; SAL pigs weighed less than NC pigs at d21 (14.0 ± 0.3 vs. 16.4 ± 0.6 kg) and 28 pw (19.5 ± 0.3 vs. 22.3 ± 0.6 kg). There was a trend (P = 0.135) for an overall treatment × time effect. Specifically, SAL pigs consumed more LCHP diet than NC pigs during d 7 to 14 (P = 0.009; 1.4 ± 0.1 vs. 0.3 ± 0.2 kg) and d14 to 21 (P = 0.017; 1.3 ± 0.2 vs. 0.3 ± 0.3 kg); SAL pigs consumed less LP diet than NC pigs d 14 to 21 pw (P = 0.037; 0.8 ± 0.1 vs. 1.5 ± 0.3 kg); SAL pigs tended (P = 0.0815) to consume more CON diet than NC pigs during d21 to 28 pw (1.8 ± 0.2 vs. 0.9 ± 0.4 kg). These data suggest nursery pigs consumed more of a LCHP diet and less of a LP diet during a *Salmonella* challenge, and consumed more of a CON diet 7 to 14 d postchallenge compared to non-challenged pigs. Further research must be conducted to determine if these diet choices would enhance recovery and performance in pigs exposed to *Salmonella*.

Key Words: feed preference, pigs, Salmonella

253 Digestibility of energy and lipids, and metabolic oxidation status in nursery pigs fed various lipids. S. C. Lindblom*[1], G. C. Shurson[2], W. A. Dozier[3], B. J. Kerr[4], *[1]Iowa State University, Ames, [2]Department of Animal Science, University of Minnesota, St. Paul, [3]Auburn University, Auburn, AL, [4]USDA- ARS, Ames, IA.*

An experiment was conducted to evaluate the impact of lipid source on energy and lipid digestibility, and on metabolic oxidation status of nursery pigs fed diets containing 10% of soybean oil (SO), choice white grease (CWG), palm oil (PO), or 1 of 2 different sources of distillers corn oil (DCO1 and DCO2). Fifty-four barrows weaned at 28-d of age were fed a common starter diet from d 1 to 7, followed by group feeding their respective experimental diets (either 100% basal or 90% basal + 10% test lipid) from d 8 to 14 to adapt the pigs to their dietary treatments and to optimize subsequent feed intake. For the next 10 d (d 15 to 24), pigs were moved to metabolism crates for continued diet adaptation and to become accustomed to the twice daily feeding regimen in the metabolism crates. Following this period, a 4-d total fecal and urine collection occurred (d 25 to 29, final BW 11.03 ± 0.51 kg) to determine apparent total tract digestibility (ATTD) of energy and lipids, and to determine the DE and ME content of each lipid source. After an overnight fast of 12 h, urine was collected for 5 h, quantified, and subsequently analyzed for thiobarbituric acid reactive substances (TBARS) and isoprostane (IsoP) concentration. Following this collection, serum was obtained and analyzed for TBARS. Soybean oil had greatest (P < 0.05) DE (9388 kcal/kg) content compared with DCO1, DCO2, CWG, PO, and SO containing 8001, 8052, 8531, 8293, and 9388 kcal/kg lipid, respectively. Digestible energy as a percentage of GE was greatest ($P < 0.05$) for SO when compared to the other lipid sources (P < 0.05). The ATTD of EE averaged 85.0% and varied slightly (84.4% to 85.6%) among treatments. Differences in ME among lipids were similar to that for DE, with ME values for DCO1, DCO2, CWG, PO, and SO containing 7921, 7955, 8535, 8350, and 9408 kcal/kg lipid, respectively. Metabolizable energy as a percentage of DE did not differ between lipid sources. Pigs fed the diets containing lipids had higher (P < 0.05) plasma TBARS compared to pigs fed the control diet, but no differences were noted in urinary TBARS excretion among treatments. Urinary IsoP excretion differed among treatments (P < 0.01), but was highly variable (34.0 to 104.6 pg/ml). These results indicate that DE and ME values vary among lipid sources and appear to have variable effects on metabolic oxidation measures.

Key Words: digestibility, energy, lipids, pigs

254 Pigs inoculated with Porcine Epidemic Diarrhea Virus have decreased growth performance and tissue accretion compared with Controls after 42 d. S. M. Curry*, K. A. Gibson, E. R. Burrough, K. Schwartz, K. J. Yoon, N. K. Gabler, *Iowa State University, Ames.*

Porcine epidemic diarrhea virus (PEDV) is an *Alphacoronavirus* and was first identified in U.S. pigs in April 2013. It is known to affect the small intestine to produce clinical signs of diarrhea and dehydration and can be fatal in piglets. The objective of this study was to determine the longitudinal effect of PEDV infection on nursery pig growth performance and tissue accretion rates. Fifty Choice Genetics gilts and barrows (BW = 9.92 ± 0.49 kg) naïve for PEDV were allotted into 2 treatment groups with equal barrows and gilts distributed among 8 pens per treatment. The treatments were: 1) control (n = 8 pens) and 2) PEDV inoculated (n = 8 pens). At −3 d post inoculation (dpi), a subset of 1 pig per pen was scanned live to determine initial body composition using a dual-energy X-ray (DXA) absorptiometry machine. On 0 dpi, all 25 PEDV pigs were inoculated with 10^3 $TCID_{50}$/ml of PEDV via gastric gavage. During 2–14 dpi, 17 pigs per treatment were necropsied to monitor disease progression. On 14 dpi, 8 pigs per treatment remained. Over the 42 d experimental period, PEDV infection and naivety was confirmed via fecal PCR testing. Pen body weights, feed intake, and calculated G:F were recorded on dpi 2, 5, 7 and weekly thereafter. At 42 dpi, the same 8 pigs per treatment were DXA scanned again to determine final body composition and tissue accretion rates were calculated. Gain to reach 127 kg market BW was calculated from average BW at 42 dpi. All pigs were allowed free access to a corn-soybean meal diet and water. Treatment and time effects were determined using pen as the experimental unit. There was no difference (P = 0.344) in start BW between treatments. Overall, compared to the control pigs, PEDV reduced ADFI (0.92 verses 0.70 kg, P = 0.044) and tended to reduce ADG (0.74 verses 0.63 kg, P = 0.056). However, overall G:F was not altered (P = 0.625). Pigs inoculated with PEDV had decreased (P < 0.05) whole body accretion (g/d) for fat, lean, and protein compared to control pigs (24%, 20%, and 21% reductions, respectively). Pigs inoculated with PEDV would need to gain 7% more BW (P = 0.014) than control pigs to reach 127 kg market weight. In summary, we have shown that nursery pig exposure to PEDV has a long term negative impact on pig performance and whole body tissue accretion rates.

Key Words: porcine epidemic diarrhea virus, performance, pigs

255 [No Abstract]

256 Determination of additivity of acid-binding capacity in diets. N. Lu*, P. Arnaut, M. D. Lindemann, *University of Kentucky, Lexington.*

Manipulating dietary acid-binding capacity (ABC, mEq/kg) is considered a possible approach to optimize the gastric environment in nursery pigs. The objective of this study was to measure ABC and buffering capacity (BUF, mEq/kg/pH) of feed ingredients, and evaluate their additivity in mixed diets. Additivity is necessary for the values to be used in a formulation matrix. The measured feed ingredients included corn, soybean meal (SBM), spray-dried animal plasma (SDAP), fish meal (FM), dried whey (DW), L-lysine (Lys), DL-methionine (Met), dicalcium phosphate (DCP), and limestone. And the mixed diets were: 1) Corn/SBM; 2) Corn/SBM/DW; 3) Corn/SBM/SDAP; 4) Corn/SBM/FM; 5) Corn/SBM/DW/SDAP/FM; 6) Corn/SBM/DW/SDAP/FM/Lys/Met. Limestone and DCP were included in all diets with varied inclusion rates. Analyzed ABC was measured as the amount of acid required to lower pH to 3.0 for 1 kg of sample; analyzed BUF was calculated as ABC per unit drop in pH. Predicted dietary ABC and BUF were the sum of products of analyzed values of ingredients and their inclusion rates. Results showed that minerals had the highest ABC and BUF (limestone: 12,195 and 2282; DCP: 4019 and 1774); the next were protein ingredients (FM: 2107 and 545; SDAP: 1277 and 305; SBM: 1172 and 284), DW (925 and 237), and AA (Lys: 707 and 251; Met: 999 and 343); corn had the lowest capacity to bind acid (234 and 100). Analyzed ABC and BUF of mixed diets were generally lower than predicted values, but predicted and analyzed values of both ABC (P = 0.008, R^2 = 0.83) and BUF (P = 0.008, R^2 = 0.83) were highly correlated. In this study, the ABC or BUF values of ingredients lacked strict additivity in mixed diets. However, because the ratios of analyzed to predicted values ranged 92–97% and 89–93% for ABC and BUF across all diets, respectively; the predicted values can

Table 256. Difference between predicted and analyzed values of ABC and BUF of diets

	ABC, mEq/kg				BUF, mEq/kg/pH			
Item	Predicted	Analyzed	Ratio	*P* value	Predicted	Analyzed	Ratio	*P* value
Diet 1	843	795	94%	0.11	227	209	92%	0.10
Diet 2	905	838	93%	0.01	236	218	92%	0.02
Diet 3	793	730	92%	0.08	217	193	89%	0.03
Diet 4	808	768	95%	0.10	219	201	92%	0.03
Diet 5	824	772	94%	0.04	219	199	91%	0.01
Diet 6	796	773	97%	0.34	215	201	93%	0.09

Table 257. Summary of growth performance by treatment with main effect *P*-values

	Active	Stable	Complex	SimLac	Simple	PRRS	Diet	PRRS × Diet
BW, kg								
d 7	5.1[a]	6.4[b]	5.8	5.5	5.8	< 0.001	0.131	0.806
d 21	7.8[a]	9.8[b]	9.3[y]	8.5[z]	8.5[z]	< 0.001	0.008	0.707
d 7–21								
ADG, g	200[a]	240[b]	251[y]	210[z]	199[z]	< 0.001	0.002	0.444
ADFI, g	274	312	326	263	289	0.232	0.277	0.904
F:G	1.41	1.34	1.36	1.25	1.51	0.659	0.389	0.760
Mortality & Morbidity Per Pen, %	21.18[a]	1.10[b]	12.33	10.03	11.07	< 0.001	0.698	0.889

be used to estimate ABC and BUF.

Key Words: acid binding capacity, buffering capacity, nursery diets

257 Effects of Porcine Reproductive Respiratory Syndrome (PRRS) status (stable vs. active) on the performance of weaned pigs when fed either a complex diet, a simple diet or a simple diet with lactose.

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The objective of this study was to determine the relationship between diet complexity, and the effect of 2 different PRRS status, on performance in a commercial swine research facility. The experiment involved 1503 weaned piglets of 19 d of age, weighing on average 5.7 kg, with 21 to 35 pigs/pen. Pigs were blocked by BW and sow farm, then allocated randomly to dietary treatments. Pigs were of the same maternal and terminal genetic lines, that either came from PRRS active (Active, n = 16) or PRRS stable (Stable; n = 39) sow farm. Three types of diets were provided using a FANCOM feed weighing system: a complex commercial diet with plasma, fish meal, dried whey and lactose (Complex, n = 17), a simple vegetarian diet with added lactose (SimLac, n = 18), or a simple vegetarian diet with no added lactose (Simple, n = 20). There was a 1-wk acclimation period (d 0). Pens were weighed and feed disappearance was recorded on d 7, 14, and 21. Data were analyzed as a randomized complete block design in a 2x3 factorial design using the GLM procedure in Minitab. There were no PRRS × diet interactions for any recorded measure and results are reported as main effects for d 7–21 in Table 257. Active PRRS reduced ADG (P < 0.001), which was due to reduction in ADFI and FCR, respectively, compared to Stable PRRS. The Complex treatment had a greater ADG (P = 0.002) than both the SimLac and Simple treatments with no effects on ADFI or F:G. The Stable PRRS had a lower mortality and morbidity (P < 0.001) than Active PRRS. In conclusion, active PRRS has significant effects on performance and livability, and this trial has quantified those effects in a commercial wean to finish barn.

Key Words: Pigs, PRRS, Diet

258 Effects of supplementation with Aspergillus oryzae derived phytase (Ronozyme® HiPhos) and fiber degrading enzymes (Victusô® Swine Starter) on growth performance, intestinal morphology, leukocyte differential, and nutrient digestibility in nursery pigs.

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Pigs (n = 264; PIC C-29 × 380) were blocked by BW (6.06 ± 0.49 kg) and gender and allotted to 40 pens, each randomly assigned to 1 of 4 dietary treatments: 1) nutrient adequate corn-SBM-based diet meeting the P requirement using 400 FYT/kg of Ronozyme®HiPhos 2700 GT (DSM Nutritional Products, Inc., Parsippany, NJ) phytase (CTL); 2) as CTL, with 600 FYT/kg HiPhos added (total 1000 FYT/kg HiPhos, HiP); 3) as CTL, with 0.05% Victus-Swine-Starter (β-glucanase, xylanase, hemicellulose, polygalacturonase, α-amylase) added (VSS); and 4) as HiP with 0.05% Victus-Swine-Starter added (HPVS). TiO_2 was included (0.3%) in all diets fed throughout 3 diet phases (9, 14, and 14 d for phase 1, 2, and 3, respectively). On d 12, a median BW pig in each pen was administered fluorescein-isothiocyanate Dextran (3–5 kDa; FD) via oral gavage followed by blood collection 3 h later to determine FD absorption, and a subsample was obtained to measure leukocyte differentials. On d 13, duodenal and jejunal samples were obtained from the FD-treated pigs to evaluate intestinal morphology. Fecal samples were obtained at the end of phases 2 & 3 to determine ATTD of ash, P and Ca, and STTD of P was calculated using the equation from NRC 2012. Overall, ADG, ADFI, G:F, and final BW were similar among CTL-, HiP-, VSS-, or HPVS-fed pigs. Villus height, crypt depth, and villus height to crypt depth in both duodenum and jejunum were not different. However, plasma FD (1.19, 1.74, 2.47, 2.34 μg/mL; P = 0.05) and percentage lymphocytes (32.3, 38.5, 38.2, and 44.2%; P < 0.05) increased, while the percentage neutrophil (54.2, 52.6, 46.7, and 44.9%; P < 0.05) and neutrophil to lymphocyte ratio (195.8, 143.3, 129.3, and 108.8%; P = 0.02) decreased, in pigs fed HPVS compared to CTL, with those fed HiP or VSS being intermediate. In phase 2, HiP- and HPVS-fed pigs had higher STTD P

than CTL- and VSS-fed pigs (62, 66.1, 61.3, 67.8%; $P < 0.01$). For phase 3, ATTD of ash (91.2, 92.5, 92.3, 92.7%; $P < 0.01$) and STTD of P (84.8, 88.5, 86.1, 89.8%; $P < 0.01$) were higher in HiP- and VSS-fed pigs than CTL, with the highest STTD P observed in pigs fed HPVS. Both VSS- and HPVS-fed pigs had increased ATTD Ca compared to CTL (86.1, 87.2, 88.1, 88.7%; $P < 0.05$). Results of this study suggest that Victus-Swine-Starter and an increased level of HiPhos can modulate plasma levels of neutrophils and lymphocytes, and further improve nutrient digestibility in nursery pigs.

Key Words: Phytase, Fiber degrading enzymes, Nursery pigs.

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259 Effect of rearing strategies during lactation on growth performance and the population of innate and adaptive immune cells in pigs from pre-weaning to market. T. C. Tsai*[1], H. J. Kim[1], M. A. Sales[1], X. Wang[1], G. F. Erf[2], E. B. Kegley[1], F. G. Carbonero[3], M. van der Merwe[4], R. K. Buddington[4], C. V. Maxwell[1], *[1]Department of Animal Science, Division of Agriculture, University of Arkansas, Fayetteville, [2]Department of Poultry Science, Division of Agriculture, University of Arkansas, Fayetteville, [3]Department of Food Science, Division of Agriculture, University of Arkansas, Fayetteville, [4]University of Memphis, Memphis, TN.*

Four unisex littermates were selected at approximately 4 d of age from 20 litters with more than 10 piglets, blocked by BW, and assigned to 1 of 2 rearing strategies: sow (C) or milk replacer (MR). Sow-reared piglets remained with sows and received only sow milk, whereas MR-reared pigs were transferred to deck in isolated facility and offered milk replacer from d 4 and then together with creep feed from d 10 of lactation. At weaning (d 21), pigs from each rearing strategy were pooled (2 pigs/strategy/2 litters) in adjacent pens (10 pens of 4 pigs/pen), in an attempt to expose pigs to the same postweaning environment. All weaned pigs were fed Corn-S-BM-DDGS-antibiotic free diets for 8 feeding phase regimes (Nursery and Grow/finish) formulated to meet or exceed NRC 2012 nutrient requirements. Data were analyzed by PROC Mixed of SAS. There was no difference in BW at weaning (MR = 6.07 vs. C = 5.79), however, during the nursery period, MR pigs had greater ADG (0.48 vs. 0.41 kg/d; $P < 0.01$), and higher ADFI (0.61 vs. 0.59 kg/d; $P = 0.02$) and a lower G:F ratio (0.66 vs. 0.69) comparted to C. This resulted in 2.9 kg higher BW ($P < 0.01$) at the end of the nursery period and 4.1 kg greater BW at study completion compared to C. MR-reared pigs realized more rapid increases from d 4 for cytotoxic lymphocytes ($CD3^+CD4^-CD8^+$; 15.82 vs. 12.65%;) and T helper cells ($CD3^+CD4^+CD8^-$; 63.53 vs. 56.29%; $P = 0.04$) with higher percentages at weaning than C, but were no different for remaining trial The percentage of $Foxp3^+$ regulatory T cells decreased gradually from d 4 to weaning in C-reared pigs (8.84, 7.10, and 4.11% at d 4, 11, and 20, whereas a rapid reduction was observed for MR pigs (10.39 and 2.41% at d 4 and 11; agextreatment interaction, $P < 0.01$). Monocyte derived dendritic cells ($CD4^-CD172^+$) at weaning were higher in MR-reared pigs (7.98 vs. 4.51%) but were similar to C pigs postweaning (Age × treatment, $P < 0.01$). Monocyte-derived dendritic cells however, were not different between treatments during the lactation period but were lower in MR-reared pigs during the nursery period (53.48 vs. 73.57%; Age × treatment, $P < 0.01$). Results of this study indicates that rearing methods in early life of pigs not only impact growth performance, especially during the nursery period, but also modulate innate and adaptive immune cell populations.

Key Words: rearing strategy, innate and adaptive immune cells, pigs

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260 Insights into nutrient inputs that affect the initiation of bone lesions in pigs. L. A. Amundson*, *University of Wisconsin-Madison, Madison.*

Understanding the etiology of nutrients involved in the initiation of bone lesions is hampered by the inability to reproduce lesions under controlled conditions. Characterization of lesions associated with an accidental omission of vitamin D (D) in sow diets within our research herd catapulted my research career and led to an ability to consistently reproduce hypovitaminosis D induced kyphosis in young pigs. Kyphosis was induced by feeding D deficient diets to sows during gestation and lactation and subsequent nursery diets deficient in D, with marginal deficiencies in Ca and P. Our experiments characterized the influence of D on gross and molecular changes during the initial stages of bone lesions. Evidence of maternal dietary D carryover effects on subsequent pig bone development have been an exciting outcome. Sow diets included 0 (–D), 325 (+D), and 1750 (++D) IU D_3/kg diet. Although not specifically designed to evaluate effects of D on reproduction, no effects of dietary D were detected on live, still, and total birth numbers. At weaning pigs were fed diets with 0 (–D) or 280 (+D) IU D_3/kg and relatively minor modifications to dietary Ca and P to exasperate responses to dietary D. Only minor responses to maternal diets were detected in pig growth and bone mineral content (BMC) at birth and 3 wk. However at 8 wk pigs produced by–D sows had an 11% reduction in growth and a 25% reduction in BMC regardless of nursery diet. A significant interaction between maternal and nursery diets was also detected. Pigs fed–D, high P diets responded differently if produced by ++D sows. Significant maternal and nursery diet effects on mRNA expression of genes involved in D homeostasis (25-hydroxylase and 1α-hydroxylase) and bone metabolism (fibroblast growth factor 23 and osteocalcin) were also evident in pig tissues. Specific genes of interest are matrix metalloproteinases 9 and 13 and vascular endothelial growth factor as these D mediated genes may identify specific alterations that lead to the initiation of bone lesions. Our results with the hypovitaminosis D

kyphotic pig model has illustrated the importance of maternal diets on neonatal skeletal development. However, the design of our studies have not allowed discernment between gestation and lactation effects. Continued studies with this model will lead to a more complete understanding of the etiology of nutrient factors involved in the initiation of bone lesions, which apparently occur during fetal development.

Key Words: Vitamin D; Kyphosis; Maternal carryover

261 The evaluation of increasing lysine or feed amounts in late gestation on piglet birth weights.

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Camborough PIC sows (n = 255) were fed either increasing lysine levels or feeding amounts to determine the influence on piglet birth weight. Gestating sows (56 sows per pen) were fed with electronic sow feeding stations and had a body condition score of 3.00–3.25 on a 1–5 scale. One diet per pen was fed to minimize diet crossover. Litters were weighed within 16 h of birth. Sows were weighed at the initiation of the study, d 112 of gestation. Post-farrowing weight was calculated using a BW equation based on d 112 gestation weight. Data were analyzed using a randomized complete block design and treatment as the fixed effect, as well as, pairwise contrasts. In study one, females were fed 1 of 2 treatments (Control– 1.8 kg/d of feed (9 g SID lysine/d intake) or Bump– Control diet fed at 2.7 kg/d (14 g SID lysine/d)). P2 females were housed separately and were fed either Control (24 sows) or Bump (17 sows) diets for 2 wk due to pen allowance. P3+ females were fed diets for a period of 3 wk (40 Control and 45 Bump sows). For P3+ sows fed the Bump, 48-hr post farrow BW was higher (P = 0.02). Average piglet weight was not different (1.28 vs. 1.31 kg; P > 0.10). For the P2 females, average piglet weight (P > 0.10) and 48 h post-farrow body weight (181.8 vs. 189.7 kg; P > 0.10) was not different between treatments. Since there was no effect on bump feeding sows, primiparous females were fed 1 of 3 diets (Control– 1.8 kg/d (9 g SID lysine/d, 53 gilts); Bump– control diet fed at 2.7 kg/d (14 g SID lysine/d, 30 gilts); or High– 1.8 kg/d (13.5 g SID lysine/d, 46 gilts)) for 3 wk pre-farrow to determine the impact of different feeding programs on gilt litter performance in study 2. The Bump had lighter piglets at birth compared to the Control (1.12 vs. 1.24 kg; P = 0.04). However, this was likely due to the higher total born, which was not attributed to treatment (14.07 vs. 12.66 pigs). The High did not produce heavier piglets compared to the Control (1.28 vs. 1.24; P > 0.10) or reduce the percentage of < 0.90 kg pigs (10.11 vs. 11.32%; P > 0.10). Feeding increased Lys levels or additional feed to gestating animals in good body condition did not result in improved piglet birth weight.

Key Words: gestation, lysine, sow

262 Effect of natural betaine on estimates of semen quality in mature AI boars during summer heat stress.

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This study determined the effect of supplemental dietary betaine (BET) at 3 concentrations (0.0, 0.3 and 0.6%) on sperm and semen characteristics, quality of fresh semen and quality after storage on boars. The trial was conducted between July 22 and October 1, 2014 in a boar stud located in Oklahoma. Two genetic lines were used, a synthetic terminal line (n = 66) and a Large White line (n = 23) with an average age of 22.3 ± 10.2 mo. Treatments were allocated within genetic line and age range. The BET diets were fed over 10 wk, to ensure supplemental BET product (96% betaine) daily intakes of 16.3 and 32.7g, for BET 0.3% and BET 0.6%, respectively. Blood samples were collected from 89 boars at d 9, 45, and 73 after betaine supplementation started. Weekly ejaculates from 89 boars were evaluated (32, 27, and 30 boars of the control, 0.3 and 0.6% BET treatments). No significant differences were found for serum homocysteine concentration after 9 d of BET feeding. However, after 45 and 73 d of BET supplementation, serum homocysteine concentrations were reduced for boars receiving 0.3% and 0.6% treatments (42.3, 30.7, 35.2 at d 45 and 42.7, 33.1 and 39.3 μmol/l at d 73 for the 0, 0.3 and 0.6% BET treatments, P = 0.009 and P = 0.043, respectively). Rectal temperatures of the boars were unaffected by BET diets. There was a tendency for total sperm produced in the ejaculate to increase with BET supplementation (P = 0.093), the 0.3% treatment boars had 5.9% greater and the 0.6% BET boars had 12.9% greater total sperm than the control boars. Boars on 0.3% and 0.6% treatments had 59.2% and 54.5% greater seminal plasma BET concentrations than control boars (P = 0.046). Sperm morphology analysis showed a greater percent of sperm with distal midpiece reflex (P = 0.022) and tail (P = 0.091) abnormalities in BET 0.6% treatment. In conclusion, BET supplementation tended to increase total sperm production, increased BET seminal plasma concentration and decreased serum homocysteine concentration.

Key Words: Betaine, homocysteine, boar sperm, semen analysis

263 Effect of betaine supplementation during summer on sow lactation performance and subsequent farrowing performance. F. A. Cabezon*[1], A. P. Schinckel[1], B. T. Richert[1], K. R. Stewart[1], M. Gandarillas[2], W. A. Peralta[3], [1]*Purdue University, West Lafayette, IN,* [2]*Universidad Austral de Chile, Valdivia, Chile,* [3]*Agrìcola Super Ltda, Rancagua, Chile.*

The objective of this trial was to evaluate the effects of betaine supplementation during lactation in hot summer months on piglet growth and sow subsequent reproductive performance. The betaine feeding portion of the trial was conducted between December, 2014 and March, 2015 with subsequent litter data completed by July, 2015 in Rancagua, Chile. Dietary treatments were randomly allotted to concurrent farrowing rooms of sows. Sows were fed corn-soybean meal based diets supplemented with either 0% (n = 267, CON) or 0.3% of betaine-HCl (70.7% betaine, n = 251 sows, BET), from 2 d before their farrowing due date until weaning (avg. lactation length = 21.0 d). Betaine supplemented sows had a 2.96% greater average daily feed intake (ADFI) during lactation than control sows (P = 0.009). Treatment by parity interactions were significant for ADFI and bodyweight (BW) loss (P = 0.004 and P = 0.046, respectively). Parity 2 BET supplemented sows had greater ADFI (6.40 versus 6.13 kg/d) and 5.13 kg less BW loss than parity 2 CON sows (P < 0.001 and P = 0.024, respectively). The analysis of lactation ADFI for 4 lactation periods (1–5, 6–11, 12–16 and 17–21 d) indicated that ADFI was greater for BET sows from 6–11 d (6.57 vs. 6.27 kg/d, P < 0.001), 12–16 d (7.19 vs. 6.94 kg/d, P = 0.006), and 17–21 d (7.49 vs. 7.27 kg/d, P = 0.024). After the addition of piglets allowed to nurse as a linear covariate (P < 0.001), CON and BET sows had similar litter gain of 52.76 and 51.85 kg, respectively (P = 0.35). Wean to estrus intervals (WEI) were shorter for BET supplemented sows than CON sows (4.22 vs. 4.57 d, respectively; P = 0.001). There were shifts in the distribution of WEI between sows fed CON and BET supplemented diets (P = 0.035) with 2.0, 28.7, 11.4, 4.6 and 1.8% of the CON sows versus 3.6, 33.0, 10.7, 1.5 and 1.0% of the BET sows with WEI of 3, 4, 5, 6, and 7 d. No treatment differences were found for subsequent conception rate (CON: 96.38 versus BET: 94.84%, P = 0.43) and farrowing rate (CON: 90.95 versus BET: 90.61%, P = 0.90). No treatment differences were found for subsequent litter size (total born, born alive, P > 0.25). Betaine supplementation increased daily feed intake and reduced WEI during summer months in sows.

Key Words: sow, lactation, betaine, wean to estrus interval, feed intake

264 Effect of altered lysine:energy ratio during gestation on wean pig growth performance. A. Ampaire*, C. L. Levesque, *South Dakota State University, Brookings.*

To determine the effects of altering dietary Lysine: energy ratio in gilt diets during gestation on wean pig performance, a total of 51 gilts were randomly assigned to 3 feeding regimens: Control, 2.21 kg/d from breeding to d 112 (1.93 g Lys/Kcal ME; 3276 Kcal ME/kg); Bump feeding (Bump-f), the control diet at 2.21 kg/d from breeding to d 89 and 2.61 kg/d from d 90 to 112; Phase feeding (Phase-f), 2.21 kg/d from breeding to d 89 (1.81 g Lys/Kcal ME; 3275 Kcal ME/kg) and 2.61 kg/d from d 90 to 112 (2.46 g Lys/Kcal ME; 3290 Kcal ME/kg). During lactation sows received the same diet (3368 Kcal ME/kg, 0.88% SID Lys). Thirty-nine sows successfully farrowed at least 7 piglets and remained in the study (Control n = 9, Bump-f n = 13, Phase-f n = 14 sows). Litters were equalized to 10 piglets within 72 h of birth by cross fostering within the same treatment. At weaning (20 ± 2 d), 8 pigs/sow were placed into 2 pens such that initial BW variation was < 10%/pen. All pigs received a commercial pig starter crumble diet for the first week postweaning and an early grower mash diet in wk 2, 3, and 4. Feed intake and BW were measured weekly. Data were analyzed using the Proc MIXED procedure in SAS. Maternal diet did not affect average BW at weaning (6.2 ± 0.2 kg) or the postweaning growth performance. Final BW was 14.9 ± 0.5 kg and overall ADG, ADFI and gain: feed from weaning until d 47 was 321 ± 15 g/d, 467 ± 18 g/d, and 0.690 ± 0.020 g/d, respectively. During the transition from crumble diet to mash diet, all pigs suffered a setback in daily gain (−66.1, −26.1, and −17.5 ± 26.92 g/d in Control, Bump-f, and Phase-f pigs, respectively) but this was not affected by maternal feeding regimen in gestation. There was an increase (P < 0.001) in ADG and ADFI and a decrease (P < 0.001) in gain: feed over the 4 wk postwean period but gain: feed was not different between wk 3 and 4. In gilts, constant feeding, bump feeding or bump feeding with altered lysine: energy during gestation may result in equivalent piglet growth performance in the first 4 wk postwean.

Key Words: Lysine, Phase-feeding, Bump-feeding

265 Evaluating the impact of maternal dietary vitamin D supplementation on sow performance, serum 25OHD3, and subsequent pig performance. J. R. Flohr*[1], J. R. Bergstrom[2], J. C. Woodworth[1], M. D. Tokach[1], J. M. DeRouchey[1], S. S. Dritz[1], R. D. Goodband[1], [1]*Kansas State University, Manhattan,* [2]*DSM Nutritional Products, Parsippany, NJ.*

A total of 104 sows (PIC 1050; mean parity 2.2 ± 0.3) in 4 farrowing groups (25–27 sows per group) were used to determine the effects of gestational and lactational vitamin D supplementation on sow performance and serum $25OHD_3$. Sows

were allotted to 1 of 4 dietary treatments (800, 2000, or 9600 IU of D_3, or 50 µg of $25OHD_3$ [equivalent to 2000 IU/kg D_3, DSM Nutritional Products Inc., Parsippany, NJ] per kg of diet) in a CRD. There were 25 to 27 sows per treatment. Maternal performance was not impacted by treatments. Increasing dietary D_3 increased (linear, $P = 0.001$) sow serum $25OHD_3$. Sows fed 50 µg/kg of $25OHD_3$ had greater ($P < 0.001$) serum $25OHD_3$ than sows fed 800 or 2000 IU/kg, but decreased ($P < 0.004$) serum $25OHD_3$ compared to sows fed 9600 IU/kg. At weaning, increased maternal D_3 increased piglet serum $25OHD_3$ (quadratic, $P = 0.033$), and pigs from sows fed 50 µg/kg of $25OHD_3$ had greater ($P = 0.001$) serum $25OHD_3$ compared to pigs from sows fed 800 IU/kg D_3, but lower ($P = 0.001$) than pigs from sows fed 9600 IU/kg of D_3. A subsample population of pigs ($n = 448$; PIC 327 × 1050; initially 6.6 ± 0.3 kg; 21 d of age) from 52 litters (2 of 4 farrowing groups) were used in a split-plot design (maternal treatment = whole plot; nursery treatment = subplot) to determine the influence of maternal and nursery dietary vitamin D on postweaning growth. Once weaned, pigs were allotted to pens based on maternal treatment, maintaining pre-weaning BW differences, and pens were randomly assigned to 2 nursery diets (2000 IU D_3/kg or 50 µg $25OHD_3$/kg). There were 12 and 9 pens/treatment in nursery and finishing, respectively. Pen was the experimental unit. Growth performance was not influenced by nursery vitamin D. In the nursery, pigs from sows fed increasing D_3 had increased (quadratic, $P < 0.003$) ADG and ADFI. Throughout finishing, ADG and G:F increased (quadratic, $P < 0.05$) with increasing maternal D_3. Pigs from sows fed 50 µg/kg $25OHD_3$ had increased ($P = 0.002$) ADG compared to pigs from sows fed 800 IU/kg D_3. Overall, increasing maternal D_3 increased serum $25OHD_3$ concentrations, but more D_3 (on an equivalent IU basis) is needed to achieve similar serum $25OHD_3$ responses compared to feeding $25OHD_3$. Pigs from sows fed 2000 IU/kg D_3 grew faster after weaning compared to pigs from sows fed 800 or 9600 IU/kg D_3 and pigs from sows fed $25OHD_3$ had greater ADG compared to pigs from sows fed 800 IU/kg D_3.

Key Words: $25OHD_3$, sow, vitamin D

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266 Development of precision gestation feeding program using electronic sow feeders and effects on gilt performance. R. Q. Buis*[1], D. Wey[1], C. F. M. de Lange[2], *[1]Department of Animal Biosciences, University of Guelph, Guelph, ON, Canada, [2]University of Guelph, Guelph, ON, Canada*

Computer controlled electronic sow feeders (ESF) allow precision feeding (PF) of individual gestating sows housed in groups. A study was conducted to evaluate PF gestating gilts using the NRC (2012) nutrient requirement model. The NRC (2012) model was adjusted to estimate daily energy requirements of gestating gilts, based on a constant daily lipid deposition target of 105 g/d, observed BW at breeding, assumed litter size of 12.5 and mean birth weight of 1.4 kg. Eighty gilts were assigned at d2–8 post breeding to 1 of 2 dietary treatments, moved into group-housed ESF pens, and remained there until d101–107 of gestation. For half the gilts (PF), the feeding level and blend of 2 iso-caloric diets (NE 2518Kcal/kg; 0.80 vs. 0.20% SID Lys for high and low protein, respectively; diets HP and LP) were adjusted daily for each animal to accurately meet estimated energy and Lys requirements. The remaining gilts (CON) received constant amounts of feed throughout gestation: 1.32 and 0.88 kg/d of HP and LP diets, respectively (mean SID Lys 0.56%). Total feed allowance per sow (d3–105) was similar for both groups (PF vs. CON; 201 vs. 203 kg; $P = 0.66$), while sows on PF used 6 kg less of the HP diet. Between treatments (PF vs. CON), d3–105 gains of BW (60.9kg vs. 64.7kg, $P = 0.18$) and back fat (3.7 mm vs. 3.2 mm, $P = 0.47$) did not differ. Yet when ADG for early (d 5–32), mid (d 33–67) and late (d 68–103) gestation were compared, gilts on PF tended to gain less in early gestation (0.31 vs. 0.41 kg/d; $P = 0.096$), while ADG was similar during mid (0.71 vs. 0.73 kg/d; $P = 0.704$) and higher for PF during late (0.82 vs. 0.66 kg/d; $P < 0.01$) gestation. During the subsequent 21d lactation period, no treatment effects on performance were observed (litter size at birth 12.2 vs. 12.2; mean birth BW 1.52 vs. 1.47 kg/pig; litter growth rate 2.47 vs. 2.47 kg/d); voluntary ADFI was higher for PF (4.98 vs. 4.56 kg/d; $P = 0.045$) and ADG tended to be higher for PF (−0.78 vs. –0.98 kg/d; $P = 0.10$). In this study, PF gilts did not affect overall gestation BW and back fat gain. However, in PF gilts the pattern of sow BW gain followed more closely the gain of products of conception. Gilts on PF ate more and tended to loose less weight during the subsequent lactation, which may benefit long term reproductive performance.

Key Words: electronic sow feeders, gestating gilts, precision feeding

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267 What is "gut health" and how do you quantify/measure it? A. J. Moeser*, *North Carolina State University, Raleigh.*

In recent years, the term "gut health" has been become an increasing used buzzword, but what does it mean? Is gut health reflected by growth and feed efficiency responses, functional measurements of intestinal permeability, or morphological measurements? It's time to define what gut health means. Gut health can be defined as the optimal and efficient balance between the assimilation of water and nutrients into the body and the maintenance and rapid restoration of intestinal defense barriers, facilitating optimal health and survival of the host. The objectives of this presentation will be to: 1) further define key components of gut health, 2) review current research approaches and techniques to measure it and disadvantages and limitations of each technique, and 3) discuss how a combination of approaches and models can be used to provide a comprehensive assessment of gut health, with an emphasis on

the translation to animal performance and disease resistance.

Key Words: Gut health, Barrier function, Gastrointestinal system

268 New probiotic *Bacillus* strain improving gut health in piglets. B. K. Nielsen[*1], R. Cernat[2], *[1]Chr. Hansen A/S, H¯rsholm, Denmark, [2]Chr. Hansen A/S, Hoersholm, Denmark.*

The scheduled phase-out of specific antibiotic growth promoters in the US requires management changes in the pig industry and a need for cost-effective feed additives with high efficacy and thus the need for new probiotics. The objective of this work was to screen 260 new spore formers isolated from fermented food, healthy pig feces, soil and different culture collections, and to select 2 candidates for in vivo trials. One candidate is presented in this paper. The strain was identified as *Bacillus subtilis* subsp. *subtilis* by sequencing of 16S rDNA and *gyrB* and *rpoB* gene, its antibiotic susceptibility was measured by the minimal inhibitory concentration (MIC) and found to below the accepted breakpoints. Other analyses included bile and acid tolerance, growth in different media, sporulation and antimicrobial activity against *Clostridium perfringens Type A* and *Type C* as well as *Salmonella typhimurium* and *Staphylococcocus aureus*. In vitro adhesion to Caco-2 and HT-29 MTX cell lines was also investigated. For the in vivo trial 216 4-wk-old newly weaned piglets were randomly allocated to control or *Bacillus subtilis* (DSM25841) treatment group respectively balanced for sex and liveweight. Piglets were fed equal standard diets based on corn, soybean and barley strain or none *Bacillus* spp. Adhesion to Caco-2 cell line was 6.2 ± 1.3 in contrast to HT-29MTX, for which the selected strain showed a significantly higher coefficient (42.2 ± 5.6). Moreover, the selected strain showed higher adhesion to both cell lines when compared to another potential *Bacillus* spp. candidate identified by this study. For the latter, the adhesion coefficients to Caco-2 and to HT-29 MTX were 2.1 ± 0.4 and 32.3 ± 3.7, respectively. Our data are in agreement with similar in vitro studies conducted on other probiotic *Bacillus* spp. and emphasize the ability of our selected candidate to adhere in vitro, and the differences in characteristics and functions exhibited by the 2 cell lines. Results showed that feed supplementation with the selected *Bacilli* strain DSM 25841 had numeric or significant effect on daily gain (235 g/d vs. 218 g/d) and feed conversion (1.15 kg/kg vs. 1.21 kg/kg; $P < 0.05$) as well as improved fecal scoring ($P < 0.01$) compared to the control group.

Key Words: *Bacillus* probiotic, adhesion, pig production

269 Use of dietary carbohydrates as prebiotic in swine diets. R. T. Zijlstra[*1], J. M. Fouhse[1], E. Beltranena[2], A. M. H. Le[3], M. G. Gaenzle[3], *[1]Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, AB, Canada, [2]Alberta Agriculture and Forestry, Edmonton, AB, Canada, [3]University of Alberta, Edmonton, AB, Canada.*

Using dietary antibiotics as growth promotant will be reduced; thus, dietary alternatives are being investigated. Dietary carbohydrates include oligosaccharides, starch, and fiber (non-starch polysaccharides) and these may be part of a toolkit to manage gut health in pigs. Antibiotics are hypothesized to control gut health via manipulations of intestinal microbial profiles but may also reduce intestinal inflammation. Oligosaccharides may be rapidly fermented and thereby influence intestinal microbial profiles and metabolite production. Specific exopolysaccharides from *Lactobacillus reuteri* may serve as scavenger molecules for pathogenic bacteria, e.g., enterotoxigenic *E. coli* (ETEC), to bind to instead of adhering to the gut wall, thereby avoiding diarrhea initiation by ETEC. Starch is mostly digested and absorbed as glucose; however, resistant starch is not digested but fermented. Resistant starch acts as fiber but is unique, because it 1) specifically increases digesta content of bifidobacteria that have been associated with improved gut health and 2) is completely fermented within the gut. Sources of fiber differ in their 2 key characteristics: viscosity and fermentability. Increased viscosity has been associated with increased gut content of virulence factors that are linked with diarrhea. Increased kinetics of fiber fermentation is associated with changes in microbial profiles and increased metabolite production. Recently, microbial composition was hypothesized to be less important and the focus should be on their combined output of metabolites. Raw materials and prebiotic feed additives both influence kinetics of fermentation and have prebiotic activity. Their kinetics of fermentation should be quantified so that it can be included in feed formulation. In conclusion, dietary carbohydrates via their prebiotics activity are part of the solution to remove antibiotics as growth promotant from swine diets.

Key Words: carbohydrate, gut health, pig

270 Impact of different high fiber diets on intestinal cell proliferation and differentiation in finishing pigs. Z. Huang*, P. E. Urriola, G. C. Shurson, M. Saqui-Salces, *Department of Animal Science, University of Minnesota, St. Paul.*

Feeding diets high in fiber (DF) increases mucin secretion and alters intestinal morphology. This study aimed to investigate the impact of different sources of DF on intestinal epithelial proliferation and differentiation in finishing pigs. Forty-six finishing pigs (BW 84 ± 7 kg) were fed 1 of 4 diets: control (corn-soybean; CON; $n = 12$), wheat straw (23%; WS; $n =$

11), corn distillers dried grains with solubles (55%; DDGS; n = 11), and soybean hulls (30%; SBH; n = 12). The WS, SBH, or corn DDGS was the only DF containing ingredient in each diet, CON and DF diets were formulated to contain 8.5 and 17% NDF, respectively. Pigs were fed an amount equal to 2.5% of initial BW for 14-d in metabolism cages. Ileum samples were collected for histology and gene expression analysis after euthanasia. Data were analyzed using non-parametric tests in GraphPad Prism 6. Overall, DF diets were not different in proliferation (positive cells for Ki67/crypt) compared with CON. However, proliferation was greater ($P < 0.05$) for pigs fed DDGS (13.3 ± 0.8) than those fed SBH (10.0 ± 1.2). Presence of goblet cells (% area of mucosa) was greater ($P < 0.05$) in WS (11.5 ± 0.9) and DDGS (9.2 ± 0.5) diets compared with CON (8.2 ± 0.3) diet, WS diet was also greater ($P < 0.05$) than SBH (10.9 ± 0.6) diet. Furthermore, the expression of the mucin *Muc2* was greater ($P < 0.05$) in all DF diets compared with CON. The expansion of the progenitor cell pool was tested by *Olfm4* expression. Compared with CON, SBH decreased ($P < 0.05$) and DDGS increased *Olfm4* ($P < 0.05$); and SBH showed lower ($P < 0.05$) expression than WS and DDGS diets. This suggests that DDGS induced Notch signaling. Enterocyte differentiation was demonstrated by changes in functional marker *Fabp*, and differentiation driver *Hes1*. No differences were observed in *Fabp* expression, but SBH decreased ($P < 0.05$) and DDGS tended to increase ($P = 0.06$) *Hes1* compared with CON. These observations suggest that feeding SBH may reduce, and DDGS may promote swine intestinal enterocyte differentiation. Secretory cell expansion is indicated by cell markers *Muc2*, *ChgA*, and *Lyz,* and differentiation drivers *Atoh1*, *Dll4* and *Sox9*. Compared with CON, DDGS was a stronger inducer while SBH was a stronger repressor of secretory cells. These results indicate that sources of DF modulate different aspects of epithelial cell proliferation and differentiation.

Key Words: dietary fiber, cell proliferation, cell differentiation

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271 Effects of dietary supplementation of phytobiotics on growth performance and health status of growing-finishing pigs. I. Park*, W. Parnsen, S. W. Kim, *North Carolina State University, Raleigh.*

This study was to determine the effects of dietary supplementation of phytobiotics (By-o-reg, Advanced Ag Products, Hudson, SD) on growth efficiency and health status of growing-finishing pigs. Phytobiotics included encapsulated oregano essential oil. One hundred twenty pigs (60 barrows and 60 gilts at 27.9 ± 4.8 kg BW) were randomly allotted to 4 treatments (2 × 2 factorial arrangement) with 10 pens (3 pigs per pen) per treatment based on a randomized complete block design, and fed the experimental diets for 6 wk. Factors were antibiotic growth promoter (AGP: 0 or 0.5 g/kg) and phytobiotics (0 or 0.5 g/kg diet). All diets were formulated to meet or exceed the NRC nutrient requirements. Feed intake and body weight were measured weekly. At the end of 6 wk, blood samples to separate serum were obtained from 40 pigs representing a median BW of each pen. Serum samples were used to evaluate tumor necrosis factor-α (TNF-α) as an indicator of inflammatory status, immunoglobulin G (lgG) as an indicator of humoral immunity, and malnodialdehyde (MDA) and protein carbonyl (PC) as oxidative stress markers. Data were analyzed using the Mixed procedure in SAS with pen as the experimental unit with treatment and sex as fixed effects and initial BW as a random effect. There were AGP × phytobiotics interactions ($P < 0.05$) on BW, ADG, and ADFI. The G:F was increased ($P < 0.05$) by dietary AGP (0.464 to 0.478) and phytobiotics (0.465 to 0.477) in overall. The TNF-α was not affected by treatment factors. Dietary phytobiotics decreased ($P < 0.05$) concentration of IgG (10.40 to 8.76 mg/mL) and PC (5.33 to 4.07 nmol/mg protein). Collectively, both dietary AGP and phytobiotics enhanced feed efficiency only when they were used independently. Combinational use of AGP and phytobiotics had negative effects on growth performance. Dietary phytobiotics reduced systemic oxidative stress and humoral immune reaction whereas these were not affected by AGP.

Key Words: growth performance, oxidative stress, phytobiotics

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272 Alternatives to antibiotics: Biotechnological approach to deliver recombinant bioactive proteins. E. Huynh, C. F. M. de Lange, J. Li*, *University of Guelph, Guelph, ON, Canada.*

With the growing concern of the bacterial resistance to conventional antibiotics, time has come for us to search for alternative to antibiotics in animal production. In the past 6 yr, our laboratory has been working on establishing a platform for cost effective production of recombinant bioactive peptides, and evaluation of their efficiency both in vitro and in vivo. Candidate peptides may be derived from a variety of sources (e.g., milk, mammalian cell), and may be selected based on direct anti-microbial role such as Protegrin-1 (PG-1), or stimulation of gut health and development (e.g., epidermal growth factor; EGF); Using *Lactococcus lactis* and yeast as hosts, our laboratory has previously produced recombinant porcine EGF, animal trials demonstrated that it enhances the growth performance and intestine development of early weaned pig fed with antibiotic free diet. PG-1 is a porcine cathelicidin antimicrobial peptide that can exert its activity against a broad range of microorganisms, including bacteria that are resistant to conventional antibiotics. In addition, as the peptide is an integral part of the innate immune system, it may have other functions such as immuno- modulating effects, similar to its human cathelicidin counterpart. More recently, we have generated codon-optimized proform PG-1, mature PG-1 for expression in *Pichia pastoris*. We also investigated the potential inflammatory modulating and protective role of PG-1 in a *dextran sulfate sodium (DSS)*-induced *colitis* murine model. Protegrin treat-

ment prevented colitis-induced body weight loss and improved disease activity index (DIA) scoring ($P < 0.05$) compared to the untreated DSS-control mice. Histological analyses indicate reduced mucosal erosion and sub-mucosa inflammation in protegrin-treated groups. In addition, relative expression of inflammatory factors (*COX2* and *TNFa*) was significantly reduced in protegrin treatment groups compared to the colitis group ($P < 0.05$). Overall, oral administration of protegrin was demonstrated to be protective against colitis induction in the animal model. Resulting data establishes the potential application of protegrins to modulate intestinal health in vivo. These examples illustrate the potential for cost-effective production and application of recombinant bioactive proteins as alternatives to antibiotics in swine production.

Key Words: antimicrobial peptide, biotechnology, antibiotic resistance, immunoprotection, tissue repair

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273 Dietary kapok seed meal supplementation improved meat quality without adverse effects on growth performance in finishing pigs.

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Ninety-six crossbred [(Landrace × Yorkshire) × Duroc] finishing pigs with an average initial body weight (BW) of 67.02 ± 1.46 kg were used in this 10-wk feeding trial to evaluate effects of dietary kapok seed meal (KSM) supplementation in finishing pigs. Pigs were randomly allotted into 3 dietary treatments (8 replicates/treatment and 4 pigs/pen). The dietary treatments were: 1) CON, basal diet; 2) K1.5, CON + 1.5% KSM; 3), K3.0, CON + 3.0% KSM. Pigs were weighed at the beginning and at the end of week 5 and 10 of experimental period while feed consumption was recorded to calculate ADG, ADFI, and G:F. At the beginning of the experiment, 2 pigs were randomly selected from each pen, and blood samples were taken by jugular venipuncture. The same pigs were again bled at the week 5 and 10. At the end of the experiment, the same 2 pigs were transported to the abattoir for slaughter and meat sample was taken for late meat quality analysis. Data were analyzed using the GLM procedure of SAS (1996, SAS Inst., Inc., Cary, NC). Polynomial contrasts were used to determine linear effect of increasing kapok seed meal levels on all measurements. Overall, ADFI linearly decreased ($P < 0.05$) with the increase level of dietary KSM supplementation. KSM groups elevated concentration of LDL in blood at week 10 ($P < 0.05$). Moreover, meat color in sensory evaluation linearly increased ($P < 0.05$) as dietary KSM concentration increased. Myristic acid, palmitic acid, stearic acid, linolenic aid, saturated fatty acids (SFA) and saturated fatty acids/polyunsaturated fatty acids (SFA/PUFA) ratio linearly increased ($P < 0.05$) as dietary KSM concentration increased, however, palmitoleic acid and oleic acid linearly decreased ($P < 0.05$). Present study results indicated that finishing pig supplemented with 3% KSM could improve meat quality and enhance the content of fatty acids of carcass fats and muscle without any adverse effects on ADG or G:F ratio.

Key Words: finishing pigs, growth performance, kapok seed meal

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274 Dietary Levan-type fructan improved growth performance of lactating sows and their offspring and reduced fecal noxious gas emission.

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A total of 28 multiparous sows (n = 7/treatment) and their offspring were used to determine effects of levan-type fructan supplementation on growth performance, nutrient digestibility, blood profiles and fecal noxious gas emission. Treatments were CON (basal diet) and CON with 0.1% (FC1), 0.2% (FC2), and 0.3% (FC3) fructan, experimental diets were given to sows from 7 d before parturition until weaning. Body weight (BW) of sows was recorded 7 d before parturition, at 24 h after parturition, and at weaning. Individual piglet BW was assessed on Day 0, 7, 14, and 21 (weaning). During the lactation, feed intake of sow was recorded daily to determine the ADFI. The day before parturition and at weaning, back fat of sow was measured 6 cm off the midline at the 10th rib using a real-time ultrasound instrument. One week before farrowing and weaning, chromium oxide (0.20%) was added to experimental diet as indigestible marker to calculate digestibility. Before farrowing and at the end of lactation, fecal samples were taken from each sow to determine nutrient digestibility. Sows were bled via venipuncture before feeding on Day 110 of gestation and at weaning. In this experiment, the sow was considered the experimental unit. Data were analyzed using the ANOVA procedure of SAS (1996) suitable for a dose response, with linear and quadratic effects determined. No significant difference ($P > 0.05$) was observed on BW, ADFI, or back fat loss in lactating sows among treatments. Whereas, sows blood lymphocyte count were higher ($P < 0.05$) in levan inclusion treatments than in CON. Weaning BW and overall ADG of piglets in FC3 treatment was higher ($P < 0.05$) than piglets in CON. Blood lymphocyte counts and nutrient digestibility of sows, weaning BW and ADG of piglets increased linearly ($P < 0.05$) as concentration of levan in the diet increased. Diarrhea score of piglets and fecal gas emission of sows were decreased linearly ($P < 0.05$) as dietary levan increased. In conclusion, levan supplementation did not affect feed intake or decrease back fat loss of lactating sows, whereas, it improved nutrient digestibility and increased lymphocyte counts, decreased fecal noxious gas emission of lactating sows, moreover, it improved growth performance and reduced diarrhea of piglets.

Key Words: fructan, performance, sows

275 Effect of dietary enzyme complex on growth performance, nutrient digestibility, and fecal noxious gas emission in growing pigs. P. Y. Zhao*[1], H. L. Li[1], J. S. Jeong[1], J. H. Cho[2], I. H. Kim[1], *[1]Department of Animal Resource & Science, Dankook University, Cheonan, South Korea, [2]Department of Animal Science, Chungbuk National University, Cheongju, South Korea.*

A total of 180 growing pigs [(Yorkshire × Landrace) × Duroc] with an average BW of 26.40 ± 2.29 kg were used in this 6-wk study to evaluate the effect of dietary enzyme complex (cellulase, 12,000 units/g; amylase, 10,000 units/g, protease, 2000 units/g; xylanase, 1500 units/g; phytase, 1000 units/g; β-glucanase, 125 units/g; mannanase, 30 units/g; pectinase, 20 units/g; lipase, 5 units/g, and galactosidase, 3 units/g) on growth performance, nutrient digestibility, and fecal noxious gas emission in growing pigs. Pigs were allotted to pen given a basal diet with 0 (CON), 0.05% (EC1), and 0.10% (EC2) enzyme complex. Pig BW and feed consumption were recorded on d 42 to calculate ADG, ADFI, and G:F. Pigs were fed diets mixed with chromic oxide (0.2%) for the determination of apparent total tract digestibility (ATTD) for DM and N. On d 42, fecal samples were collected in each pen via rectal massage, and the urine was collected in a bucket via a funnel below the cage. Subsamples of slurry (150 g fresh feces and 150 g urine) were taken and stored in 2.6-L plastic boxes. The samples were permitted to ferment for 1 d at 25°C, after which the adhesive plasters were punctured, and a gas sampling pump was utilized for gas detection. After collection, the boxes were resealed with adhesive plaster to measure the fecal gas content at d 3, 5, and 7 as aforementioned. All data were analyzed as a randomized complete block design using the GLM procedures. Orthogonal contrasts were used to determine the effect of treatments: CON vs. EC1 + EC2 and EC1 vs. EC2, and $P < 0.05$ was considered statistically significant. Overall period (d 0 to 42), pigs fed with enzyme complex inclusion diets had a greater ($P < 0.05$) ATTD of DM and N than those fed with basal diet (CON). In conclusion, enzyme complex supplementation in corn-soybean based diets improved the ATTD of DM and N, but it neither improved growth performance nor decreased fecal noxious gas emissions in growing pigs.

Key Words: enzyme complex, growing pigs, nutrient digestibility

276 Essential oil and emulsifier in low energy density diets increase growth performance and meat quality of finishing pigs. P. Y. Zhao*[1], J. H. Cho[2], B. Balasubramanian[1], S. Kathannan[1], I. H. Kim[1], *[1]Department of Animal Resource & Science, Dankook University, Cheonan, South Korea, [2]Department of Animal Science, Chungbuk National University, Cheongju, South Korea.*

A total of 120 finishing pigs were fed 5 diets to determine effects of essential oil and emulsifier in a 10-wk trial. Diets including: 1) basal diet (BD); 2) low energy diet (LC); 3) LC + 0.05% emulsifier (LE); 4) LC + 0.05% essential oil (LO); and 5) LC + 0.05% emulsifier + 0.05% essential oil (LEO). Data were subjected to the GLM procedures of SAS (2001) as a randomized complete block design. Differences among dietary treatments were first separated by Tukey's multiple range test, then data in low energy treatments were analyzed as a 2 × 2 factorial design. Probability value less than 0.05 was considered significant. Pigs fed BD diet had greater ($P < 0.05$) G:F than those fed LC diet. The serum total cholesterol and high density lipoprotein cholesterol (HDL-C) concentrations in LE and LO treatments were decreased ($P < 0.05$) compared with BD treatment at the end of week 10. The low density lipoprotein cholesterol (LDL-C) concentration in LEO treatment was higher ($P < 0.05$) than that in BD, LE, and LO treatments at week 5. For sensory evaluation, LC had higher ($P < 0.05$) color score and marbling than BD. Firmness score was lower ($P < 0.05$) in LO than BD. The lightness and yellowness values in LEO were lower ($P < 0.05$) than BD. In low energy treatments, pigs fed the combination of essential oil and emulsifier diet had higher ($P < 0.05$) G:F during week 0 to 10. Serum LDL-C (week 5) and HDL-C (week 10) concentrations were increased ($P < 0.05$) by the combination of essential oil and emulsifier supplementation. Additionally, an interaction ($P < 0.05$) effect was detected on color, redness, and yellowness values between essential oil and emulsifier. The water holding capacity was decreased ($P < 0.05$) and loin muscle area was increased ($P < 0.05$) by the addition of essential oil. In conclusion, essential oil and emulsifier combination in low energy diet had beneficial effect on G:F and meat quality in finishing pigs.

Key Words: emulsifier, essential oil, finishing pig

277 Effect of protease and anti-inflammatory supplementation with low nutrient diets on growth performance, nutrient digestibility, blood profile and fecal noxious gas in growing-finishing pigs. D. H. Nguyen*, J. K. Kim, S. Shanmugam, I. H. Kim, *Department of Animal Resource & Science, Dankook University, Cheonan, South Korea.*

A total of 180 crossbred pigs [(Landrace × Yorkshire) × Duroc] with an average initial body weight (BW) of 22.61 ± 1.23 kg were used in 18 wk study. Pigs were randomly allotted to 1 of

4 dietary treatments (9 replicate pens per treatment, 5 pigs per pen). Dietary treatments included: 1) T1 (CON), 2) T2 (low protein diet), 3) T3 (low protein diet + 0.02% protease), and 4) T4 (low protein diet + 0.03% bromelain). All data were subjected to the GLM procedures of SAS and differences among treatments were separated by Tukey's multiple range test with a $P < 0.05$ indicating a significance. At the wk 18, pigs fed the T3, and T4 treatments had a greater ADG ($P < 0.05$) than pigs fed the T2 treatment. There was no differences ($P > 0.05$) in ADG, ADFI, G:F at the wk 6, wk 12 and in the overall experimental period. There was no significant difference observed in ADG, ADFI, G:F between T1, T3 and T4 treatments at the wk 6, wk 12, wk 18, and overall. The results showed that dry matter (DM), and nitrogen (N) increased ($P < 0.05$) at the wk 6 with pigs fed T4 treatment compared with T2 treatment. In addition, an increase ($P < 0.05$) of N and energy was observed with protease supplementation treatment compared with T2 treatment at the wk 6, wk 12, respectively. On blood profile, the levels of creatinine in the T2, T3, and T4 treatments was lower ($P < 0.05$) than the T1 treatment. The blood urine nitrogen in pigs fed the T4 treatment was lower ($P < 0.05$) than those fed the T3 treatment. At the wk sixth, a dramatic decrease ($P < 0.05$) in NH_3 and total mercaptans was observed in the T4 treatment compared with the T1 treatment. There was a decrease ($P < 0.05$) in NH_3 and H_2S in pigs fed with the T3 treatment compared with T1 treatment. No other significant differences were observed in NH_3, H_2S, and total mercaptans among T1, T2, T3 and T4 treatments ($P > 0.05$) in wk 12 and wk 18. In conclusion, results achieved in the present study indicated that supplementation of protease and bromelain with low protein enhanced growth performance, nutrient digestibility and decreased the amount of noxious gas emission in finishing pigs.

Key Words: Bromelain, protease, finishing pigs

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278 *Bacillus subtilis*, essential oil, chromium and glucose as sow pack are related to performance, immune and (or) stress of sows and piglets.

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This study was conducted to determine the effect of sow pack supplementation on growth performance, fecal score and blood profile in sows and piglets. A total of 26 (Landrace × Yorkshire) were used in 18 wk study, sows were randomly allotted to 2 experimental dietary treatments: 1) basal diet (CON); 2) CON plus 0.28% sow pack (SP) (including 0.3% *Bacillus subtilis* C-3102 spores, 0.5% chromium, 0.2% Fresta F Conc (essential oil). The day before farrowing, the backfat of sows was measured 6 cm off the midline at the 10th rib using a real-time ultrasound instrument (Piglot 105, SFK Technology, Herlev, Denmark). Sow feed intake was recorded daily to determine the average daily feed intake (ADFI) during lactation. During the overall study, sows fed with the SP. diet had significantly ($P < 0.05$) higher body weight in sows after farrowing as well as, weaning and average daily gain of piglets, but a substantial decrease ($P < 0.05$) in body weight loss in sows. Serum immunoglobulin-G (IgG), cortisol, insulin and glucose were analyzed using nephelometry (Dade Behring, Marburg, Germany). All data were subjected to the GLM procedures of SAS and differences among treatments were separated by Tukey's multiple range test with a $P < 0.05$ indicating a significance. During the overall study, sows fed with the SP. diet had significantly ($P < 0.05$) higher body weight in sows after farrowing (CO*N* = 201.8 kg, S*P* = 212.3 kg), sow backfat thickness (CO*N* = 19.8mm, S*P* = 21.1mm) on d 110 as well as, weaning (CO*N* = 184.8 kg, S*P* = 191.1kg) and average daily gain of piglets (CO*N* = 210 g, S*P* = 225 g), and a substantial decrease ($P < 0.05$) in body weight loss (CO*N* = 15.0 kg, S*P* = 11.2 kg) in sows. In blood profiles, the level of IgG (at 11 and 13 h) and insulin (at 9 and 10 h) on d 14 lactating as well as the level of IgG (at 9, 11, 12, and 13 h) and insulin (at 13 h) after weanling were significantly increased when sows were provided with sow pack diet. However, the level of cortisol dramatically decreased (at 7, 10, 11, and 13 h) on 14 d in lactating sows. The level of cortisol (at 11 and 13 h) after weanling was decreased. Our results indicated that supplementation of sow pack diet could improve the performance of sows and piglets. The sow pack diet had positive effects on IgG, cortisol, insulin and glucose in the blood profiles of sows.

Key Words: Probiotics, essential oil, sows and piglets

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279 Effects of xylanase on growth performance and digestibility of fiber and energy in growing pigs fed corn, corn DDGS and soybean meal based diet supplemented with phytase.

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A total of 28 pigs (initial BW 18.5 ± 3.0 kg) were used in a 42-d trial (d 1 to 21 and d 21 to 42 as phase 1 and 2, respectively) to evaluate effects of xylanase (X) on growth performance and nutrient digestibility. Pigs were fed a control diet without or with 2000 U of X/kg of feed. Each treatment had 7 pens with 2 (a female and a male) pigs per pen. The diets were based on corn, corn dried distillers grains with solubles and soybean meal with 500 FTU of phytase/kg of feed and celite as indigestible marker. Enzymes were provided by Danisco UK Ltd. Pigs had free access to feed and water throughout the trial. Fecal grab samples from each pen were collected during the last 3 d of each phase for apparent total tract digestibility

(ATTD) of gross energy (GE) and non-starch polysaccharides (NSP). The assayed xylanase levels in the feed were 2144 and 2675 U/kg of treated diets in phase 1 and 2, respectively. The dietary concentrations of the total NSP (11.4 vs. 13.1%) and arabinoxylans (4.7 vs. 5.9%) in phase 1 and 2, respectively, were comparable. However, phase 1 diets had higher ratio of soluble to insoluble NSP (19.5 vs. 14.7%) and arabinoxylans (6.7% vs. 4.7%) than phase 2 diets. Supplemental X enhanced ADG by 10.4% (805 vs. 729 g/d; $P = 0.01$) in phase 1 however, X had no effect ($P > 0.10$) on ADFI, FCR and ADG in phase 2 and during the overall period. In phase 1, X tended to improve ATTD of GE compared to the control (74.6 vs. 72.5%; $P = 0.10$).The improvements in GE could be explained by the tendency for an improvement in ATTD of total NSP (47.3% vs. 42.0%; $P = 0.08$), arabinose (49.9% vs.44.5%;$P = 0.05$), galactose (63.8 vs. 59.9%; $P = 0.06$) and glucose (51.8 vs.46.8%; $P = 0.10$) compared to the control mainly due to improvement ($P < 0.05$) of ATTD of the corresponding constituent sugars in the insoluble NSP fraction. In phase 2, X had no effect on ATTD of GE but increased ATTD of mannose (83.5 vs.79.6%; $P = 0.01$) and tended to improve ATTD of rhamnose (53.0 vs. 42%; $P = 0.08$) in the soluble NSP fraction. In conclusion, xylanase improved fiber utilization and hence energy digestibility and growth performance in growing pigs, however in this study the response was only evident in the first 21 d of feeding.

Key Words: digestibility, growth performance, phytase, pigs, xylanase

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280 Dietary effect of lactose on growth performance of nursery pigs on a liquid feeding system. X. Yang*, J. Kim, S. K. Baidoo, *Southern Research and Outreach Center, University of Minnesota, Waseca.*

A total of 216 weaned pigs (mean initial BW 6.4 ± 1.4 kg and average age 18 d) were used in a 42-d trial to evaluate effects of lactose on growth performance of nursery pigs. Piglets were grouped into 3 categories (mean initial BW 7.7, 6.1, and 4.8 kg for heavy, middle, and light groups, respectively) and fed isocaloric diets containing 0, 10, or 15% of lactose provided by whey powder from d 1 to 14 (phase 1) postweaning and then common diets without lactose from d 15 to 42 (phase 2). The 3 diets in phase 1 had same levels of standardized ileal digestible lysine, methionine + cysteine, threonine, and tryptophan. Spray dried porcine plasma was not used in the diets but fish meal was included in both phases. Each dietary treatment had 8 pens with 9 (5 gilts and 4 barrows) pigs per pen. Pigs were fed by a liquid feeding system (Big Dutchman, Vechta, Germany) without fermentation of feed. Water to feed ratio was 3:1 for all treatments during the whole experimental period. ADFI was presented on 88% dry matter basis. Pen was the experimental unit and treatment, BW category and their interaction were included in the statistical model for statistical analysis of growth performance data. No interaction between lactose level and BW category was noticed ($P > 0.10$). In phase 1, a linear increase ($P < 0.05$) in ADG and gain to feed ratio and a tendency of quadratic change in ADFI ($P < 0.10$) were observed with increasing levels of lactose. However, there were no differences ($P > 0.10$) in ADG, ADFI and feed efficiency in phase 2 and the overall period. Collectively, our data indicate that inclusion of lactose in phase 1 may enhance growth performance of phase 1 piglets fed by the liquid feeding system but this advantage is not maintained after phase 1.

Key Words: lactose, nursery piglets, liquid feeding

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281 The interactive effects of fenugreek seed extract supplementation and dietary metabolizable energy levels in growing pigs. M. Begum*[1], J. H. Cho[2], R. X. Lan[1], M. M. Hossain[1], I. H. Kim[1], *[1]Department of Animal Resource & Science, Dankook University, Cheonan, South Korea, [2]Department of Animal Science, Chungbuk National University, Cheongju, South Korea.*

Fenugreek seed extract (FSE) has been used for human health benefits, and is gaining attention for application in animal production. A total of 140 growing pigs (23.70 ± 2.80 kg) were used in a 6-wk trial to evaluate the effects of FSE supplementation in 2 different levels of energy, and density diets on the growth performance, nutrient digestibility, blood profile, and fecal microbiota in growing pigs. Pigs were randomly distributed into 1 of 4 treatments on the basis of body weight, and sex. There were 7 replicate pens per treatment with 5 pigs per pen (3 barrows, and 2 gilts). Treatments were (as-fed basis): 2 levels of FSE (FSE0, 0 or FSE0.2, 2 g/kg basal diet), and 2 levels of energy (LED, 3160 or HED, 3260 kcal/kg ME). All pigs were fed diets mixed with 2 g/kg of chromium oxide (Cr_2O_3) to calculate apparent total tract digestibility of nutrients. Non-heparinized tubes and vacuum tubes containing K_3EDTA were used to determine the blood profiles. Fecal sample (1 g) from each pen was diluted with 9 mL of 10 g/L peptone broth to evaluate fecal microbiota. Data were analyzed as a randomized complete block design using analysis for a 2 × 2 factorial arrangement of treatments, in the MIXED procedure of SAS. No interactions between density, and FSE supplementation were observed for any measurement in the whole study. Results show pigs in FSE0.2, and HED diets had higher ($P < 0.05$) final BW (FBW, 54.71 vs. 53.14 kg; 54.88 vs. 52.97 kg), average daily gain (ADG, 737 vs. 701 g; 742 vs. 696 g), and gain/feed ratio (G:F, 0.398 vs. 0.377; 0.399 vs. 0.376) compared with in FSE0, and LED diets, respectively ($P < 0.05$). Pigs fed the FSE0.2, and HED diets had higher energy (E) digestibility compared with that fed FSE0, and LED diets, respectively (78.44 vs. 75.92%, 78.11 vs. 76.23%; $P = 0.021$, and 0.046). Pigs fed the FSE0.2 diet increased serum immunoglobulin G (IgG), and reduced total cholesterol (TC) concentration than the FSE0 diet (499 vs. 469 mg/dL; 95.8 vs. 106.6 mg/dL; $P = 0.041$, and 0.045, respectively). No sig-

nificant differences were observed in fecal microbiota among treatments ($P > 0.10$). In conclusion, results indicated that dietary supplementation of FSE, and high energy diet improved performance in growing pigs.

Key Words: blood profile, gas emission, growth performance

282 Effects of δ-aminolevulinic acid, and lactulose supplements in weaning piglets. M. M. Hossain*, M. Begum, P. Y. Zhao, I. H. Kim, *Department of Animal Resource & Science, Dankook University, Cheonan, South Korea.*

δ-aminolevulinic acid (ALA) is a non-protein amino acid that plays a rate limiting role in the process of heme biosynthesis. Lactulose (LAC) is a kind of non-digestible oligosaccharides which has been shown to improve growth performance in weaning pigs through prebiotic actions. This study evaluated the efficacy of ALA, and LAC **o**n growth performance, nutrient digestibility, blood profile, and fecal microbiota in weaned piglets. The study was conducted with 175[(Yorkshire × Landrace) × Duroc] weaned piglets in a 33 d feeding trial, and 1 of 5 diets: 1) CON (basal diet, no antibiotic); 2) ALA05 (CON + 0.5 g ALA/kg of diet); 3) ALA10 (CON + 1 g ALA/kg of diet); 4) LAC05 (CON + 0.5 g LAC/kg of diet); 5) LAC10 (CON + 1 g LAC/kg of diet). All pigs were fed diets mixed with 2 g/kg of chromium oxide (Cr_2O_3) to calculate apparent total tract digestibility of nutrients. Non-heparinized tubes and vacuum tubes containing K_3EDTA were used to determine the blood profiles. Fecal sample (1 g) from each pen was diluted with 9 mL of 10 g/L peptone broth to evaluate fecal microbiota. All data were statistically analyzed using the PROC MIXED procedure of SAS. Orthogonal contrasts were used to the effects of treatments. Piglets fed diets with ALA, and LAC had higher feed efficiency (G:F; 0.662, 0.691 vs. 0.624, and 0.675, 0.691 vs. 0.645) compared with piglets fed CON diet during phase 2 (d 6–19), and overall (d 1–33), respectively ($P < 0.05$). Besides, LAC diets improved ADG (447 vs. 421 g; $P = 0.037$), and G:F (0.691 vs. 0.662; $P = 0.024$) compared with ALA diets during phase 2. Weaned piglets fed LAC increased dry matter (DM; 83.98 vs. 80.36%, 82.46 vs. 79.52%; d 19, and 33, respectively), and nitrogen (N; 81.70 vs. 77.06; d 33) digestibility compared with CON diet ($P < 0.05$). Piglets fed with ALA diet increased serum total iron-binding capacity (TIBC), and hemoglobin (Hb) compared with CON diet (714 vs.655 μg/dL, and 8.1 vs. 7.2 g/dL; $P < 0.05$) on d 33. Piglets fed with the LAC diet increased fecal *Lactobacillus* (7.58 vs. 7.38 $^{log}_{10}$ cfu/g), and reduced *E. coli* (6.41 vs. 6.51 $^{log}_{10}$ cfu/g) counts when compared with CON diet on d 33 ($P < 0.05$). In conclusion, results indicated that dietary supplementation of ALA, and/or LAC improved performance, and/or gut health in weaned piglets.

Key Words: average daily gain, *E. coli*, hemoglobin

283 Role of emulsifier as fat replacer in low density diet for growing and finishing pigs. S. D. Upadhaya*, J. H. Park, H. M. Yun, I. H. Kim, *Department of Animal Resource & Science, Dankook University, Cheonan, South Korea.*

Energy is a major cost component in diets for growing-finishing pigs. We hypothesized that the emulsifier may be used as fat replacer in low density diet because of its efficiency in increasing fat digestibility thus contributing in feed cost reduction. Two experiments were conducted to evaluate the efficacy of emulsifier, sodium stearoyl-2-lactylate in energy reduced diet on growth performance and meat quality of pigs. In Experiment 1, a total of 60 growing pigs [(Landrace × Yorkshire) × Duroc] (2 gilts and 2 barrows/pen, 5 pens/treatment) at 63 d of age with an average body weight (BW) of 25 kg were used for 5-wk trial. In Experiment 2, a total of 84 finishing pigs [(Landrace × Yorkshire) × Duroc] at 112 d of age with an average body weight (BW) of 60 kg (2 gilts and 2 barrows/pen; 7 pens/treatment) were used for 8-wk trial. Pigs were randomly allotted to 3 treatments according to their body weight and sex. The following 3 treatments were used: CON; basal diet, T1; basal diet minus 50 K cal ME diet and T2; T1 + 0.1% emulsifier. All data were subjected to the GLM procedures of SAS and differences among treatments were separated by Tukey's multiple range tests with a $P < 0.05$ indicating significance. In experiment 1, the addition of emulsifier in the energy reduced diet decreased ($P < 0.05$) average daily feed intake (1601 g vs. 1616 g)) during d 15–35 compared to energy reduced diet without the emulsifier supplement. Emulsifier had no effect ($P < 0.05$) on other growth performance parameters in growing pigs. In experiment 2, supplementation of emulsifier in energy reduced diet did not have any influence ($P < 0.05$) on growth performances parameters and meat quality attributes compared to energy reduced diet without emulsifier though numerical differences were observed. However, the values for ADG (844 g vs. 842.6g), ADFI (2653.4g vs. 2669.6 g) and G: F (0.318 vs. 0.314), were comparable with basal diet. In conclusion, supplementation of emulsifier at 0.1% in energy reduced diet decreased ADFI in 5-wk trial and appeared to have comparable result as that of basal diet on growth performance in 8-wk trial.

Key Words: emulsifier, energy reduced diet, growing-finishing pig

284 Effects of a xylanase and an emulsifier in diets with dried yeast on nursery pig performance. A. Hesse*, J. Less, T. R. Radke, V. G. Perez, *ADM Animal Nutrition, Decatur, IL.*

Two experiments evaluated the effect of using xylanase alone (XY) or with an emulsifier (XY+EM) in pigs fed increasing levels of dried yeast (DY). Both experiments were a RCBD; blocks were 3 BW categories × 2 nursery rooms. Each exper-

iment had 8 dietary treatments in a 4 (DY at 0, 2.5, 5, or 10%) × 2 (None vs. XY+EM in Exp. 1, or None vs. XY in Exp. 2) factorial arrangement. Each treatment had 6 block-replicates; experimental units were pens with 4 pigs (~21-d old; 5.8 ± 0.2 kg BW in Exp. 1, and 6.7 ± 0.4 kg BW in Exp. 2). Sexes were kept balanced among treatments, within block. Performance was measured and feed was changed at the end of each feeding phase (n = 4): d 7, 14, 28, and 42. Dietary treatments were fed for the full 42 d of the trial. Inclusion of DY (48% CP; 3699 kcal ME/kg) replaced fish meal and soy protein concentrate from d 0–14, and then soybean meal from d 14–42. Xylanase (25 g enzyme/t) was added without consideration of energy or nutritional value. The emulsifier (8527 kcal ME/kg) was added at 1% of diet replacing fat. Data were analyzed using the MIXED procedure of SAS; block was a random variable. Linear and quadratic polynomials were used to assess DY level. Dietary DY did not interact with XY+EM (Exp. 1) or XY (Exp. 2). In Exp. 1, inclusion of XY+EM improved (P < 0.05) G:F (802 vs. 856 g/kg; SEM = 17) on d 0–14, as well as the overall (d 0–42) ADG (411 vs. 432 g/d; SEM = 17) and ADFI (608 vs. 636 g/d; SEM = 29). In Exp. 2, no main effect of XY was detected. The inclusion of DY up to 10% of diet did not affect pig performance from d 0–14. In both experiments, increasing levels of DY reduced (linear, P < 0.05) the overall (d 0–42) ADG (Exp. 1: 441, 424, 409, 411 g/d; SEM = 18; and Exp. 2: 502, 491, 478, 464 g/d; SEM 13, for 0, 2.5, 5, and 10% DY, respectively). In conclusion, DY may be used up to 10% of the diet to replace fish meal and soy protein concentrate without affecting pig performance during the first 14 d postweaning. Inclusion of XY+EM improves nursery pig performance, whereas XY alone did not.

Key Words: Xylanase, Emulsifier, Grain Distillers Dried Yeast

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285 Spray dried plasma compared to alternative specialty proteins in weanling pig diets.

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Spray dried plasma (SDP) is a specialty protein source used in pig diets because of its beneficial effects on postweaning performance and survival. The objective was to evaluate effects of specialty proteins including enzyme treated soybean meal (ESM), activated plasma protein (APP), spray dried egg from hyper-immunized hens (Egg), or a combination of APP, ESM, and fish meal compared with bovine SDP in diets on weaned pig performance. Pigs (n = 300) were weaned in 2 groups at 21 ± 2 d of age (6.3 ± 0.5 kg initial BW) and allotted to pens within weaning group and balanced by weight, gender, and litter to provide 10 replications per treatment (4–6 pigs/pen). The nursery was not cleaned between groups creating a stress environment. Diets contained 20% SBM and 20.6% dried whey, were non-pelleted, non-medicated and formulated to contain 3.4 Mcal ME/kg and 1.45% SID lysine. Diets were fed for 14 d after weaning. Specialty proteins used in diets 2–6 replaced soy protein concentrate (SPC) on an equal lysine basis, as shown below. Analysis of variance included effect of diet, weaning group, and the covariance of initial BW. No pigs died during the experiment. Pigs fed diet 6 with SDP had greater (P < 0.05) final BW, ADG, ADFI and G:F compared with all other diets. Pigs fed diets with other specialty proteins (diets 2–5) did not differ (P > 0.10) in performance compared with SPC (diet 1). Conclusion: Under conditions of this experiment, none of the specialty proteins were an effective replacement for SDP.

Key Words: pigs, spray dried plasma, specialty proteins

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286 Effect of *Saccharomyces cerevisiae* fermentation product supplementation in late gestation and lactation on sow and litter performance, milk components, and fecal Clostridium perfringens.

T. C. Tsai*[1], H. J. Kim[1], X. Wang[1], B. E. Bass[2], J. W. Frank[2], C. V. Maxwell[1], *[1]Department of Animal Science, Division of Agriculture, University of Arkansas, Fayetteville, [2]Diamond V, Cedar Rapids, IA.*

A study was conducted to evaluate dietary addition of *Saccharomyces cerevisiae* fermentation product during late gestation through a 21-d lactation on sow and litter performance, milk components, and fecal *Clostridium perfringens*. On d 93 of gestation, sows (n = 41; PIC 29) were blocked by parity and BW and assigned to 1 of 2 dietary treatments: control (CON) or CON + 0.20% *Saccharomyces cerevisiae* fermentation product (XPC; Original XPC, Diamond V, Cedar Rapids, IA). Control gestation (3315 kcal/kg of ME; 0.60% SID Lys), and lactation (3.30 kcal/kg of ME; 1.04% SID Lys) experimental diets were formulated to be devoid of antibiotics and to meet or exceed NRC 2012 recommendations. Colostrum (within 6 h of partum) and milk (d 14) samples were collected from individual sows to determine IgG, IgA and lysozyme concentration. In addition, fresh grab fecal samples were obtained from sows and their litter on d 7 postpartum to quantify *Clostridium perfringens* using PCR. Sows fed XPC had heavier 110 d BW (270.8 vs. 266.4 kg; P = 0.05) and gained more weight (22.85 vs. 18.48 kg; P = 0.05) during late gestation than CON. Sows fed XPC tended to have higher ADFI during lactation week 1 (3.64 vs. 3.19 kg/d; P = 0.07) and overall (5.84 vs. 5.37 kg/d; P = 0.10). Moreover, XPC-fed sows had heavier piglet birth weights (1.40 vs. 1.28 kg; P = 0.05), reduced numbers of stillborn pigs (1.13 vs. 1.88; P = 0.04), and heavier average piglet BW on d 7 postpartum (2.86 vs. 2.60 kg; P = 0.04) than those fed CON diet. Colostrum IgA (14.34 vs. 15.06 mg/mL), IgG (80.93 vs. 86.80 mg/mL) and lysozyme (81.52 vs. 108.33 U/mL) were similar between XPC- and control-fed sows (P > 0.35). Similarly, milk IgA did not differ between treatments (P > 0.79). Milk lysozyme tended to be lower in sows fed XPC (23.6 vs. 31.6 U/mL; P = 0.09) when compared to CON-fed sows. Finally, XPC-fed sows had reduced levels of *Clostridium perfringens* in both sow (2.86 vs. 3.33 log CFU; P = 0.09) and piglet (5.09 vs.

5.39 log CFU; $P = 0.02$) feces compared to those fed CON diet. In conclusion, supplementing XPC to sows in late gestation and lactation improved sow and litter performance, modulated milk lysosome level, and reduced the level of fecal *Clostridium perfringens* in both the sow and piglets.

Key Words: Pigs, *Saccharomyces cerevisiae* fermentation product, *Clostridium perfringens*

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287 Effects of Herbiotic FS Supplementation in weanling pigs. S. Mohana Devi*, B. Balasubramanian, Y. M. Kim, I. H. Kim, *Department of Animal Resource & Science, Dankook University, Cheonan, South Korea.*

This study was conducted to investigate the effects of Herbiotic FS supplementation in weanling pigs. A total of 150 pigs (Landrace × Yorkshire × Duroc) with an average initial body weight of 8.02 ± 0.92 g were assigned to 5 treatments (5 replicate pens/treatment, 6 pigs/pen). The experiment lasted for 6 wk. The time period for each phase of the feeding trial was initial day, 1 wk, 3 wk and 6 wk of the experimental period. The dietary treatments were as follows: 1) NC (basal diet), 2) PC (NC + 150 ppm apramycin), 3) H1 (NC + 0.025% Herbiotic FS), 4) H2 (NC + 0.05% Herbiotic FS) and 5) H3 (NC + 0.025% Herbiotic FS + 75 ppm apramycin). The Herbiotic FS powder includes Buckwheat (15.00%), Thyme (7.50%), Turmeric (3.75%), Black pepper (1.25%) and Ginger (1.25%). All data were analyzed using a randomized complete block design following GLM procedures of SAS, with each pen being used as the experimental unit. The effects of increasing dietary concentration of supplemental herbiotics were evaluated by polynomial contrasts. The means of the treatments were compared by Tukey's range test. Orthogonal contrasts were used for the effect of treatments: NC vs. PC. During phase 1, pigs fed PC (basal diet + 150 ppm apramycin), H2 (basal diet + 0.05% Herbiotic FS) and H3 (basal diet + 0.025% Herbiotic FS + 75 ppm apramycin) diets improved ADG [PC = 210; H2 = 212; H3 = 219] and G:F ratio [PC = 0.793; H2 = 0.803; H3 = 0.842] ($P < 0.05$) compared with those fed NC (basal diet) and H1(basal diet + 0.025% Herbiotic FS) diets. During phase 2, ADFI increased [PC = 775 and H3 = 772] ($P < 0.05$) when compared to NC pigs. During phase 3 and overall, pigs fed PC, H2 and H3 diets showed higher ADG [PC = 632, H2 = 629, H3 = 638]. Pigs fed PC and H3 diets increased N digestibility ($P < 0.05$) compared with those fed NC and H1 diets. On d 7, red blood cell concentration in PC, H2 and H3 treatments was higher ($P < 0.05$) than that in NC treatment. Pigs fed Herbiotic FS diets increased lymphocyte (d 42) and IgG (d 21) ($P < 0.05$) compared with those fed NC and PC diets. No effect ($P > 0.10$) was observed among treatments in diarrhea score. The herbiotic FS could be considered as antibiotic alternative in weanling pigs because of its feed intake promotion effect.

Key Words: Herbiotic, Weaning pigs, Growth performance

Table 287.

Diet[1]	1	2	3	4	5	6	SEM[2]
SPC, %	8.04	7.49	0.00	0.00	7.71	0.00	
APP, %	0.00	0.40	0.00	0.40	0.00	0.00	
ESM, %	0.00	0.00	10.66	6.36	0.00	0.00	
Fish meal, %	0.00	0.00	0.00	2.50	0.00	0.00	
Egg, %	0.00	0.00	0.00	0.00	0.44	0.00	
SDP, %	0.00	0.00	0.00	0.00	0.00	5.00	
Final BW, kg	8.17^{b}	7.83^{b}	8.07^{b}	7.90^{b}	8.19^{b}	9.01^{a}	0.19
ADG, g/d	133^{b}	109^{b}	127^{b}	114^{b}	135^{b}	193^{a}	13.3
ADFI, g/d	205^{b}	186^{b}	186^{b}	182^{b}	207^{b}	245^{a}	11.9
Gain:feed	0.65^{b}	0.58^{b}	0.68^{b}	0.63^{b}	0.65^{b}	0.79^{a}	0.04

[1]Means within a row with uncommon superscripts differ ($P < 0.05$).
[2]Pooled standard error of the variable mean.

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288 Evaluation of the Effects of a Formaldehyde-based Feed Additive on Free Lysine. C. Rude*, D. Mellick, A. Lamptey, M. Bienhoff, *Kemin Industries, Des Moines, IA.*

Feed has been identified as a potential biosecurity risk factor, and commercial swine operations are looking at steps to reduce their risk. Formaldehyde based feed additives (Sal CURB® ASF Liquid Antimicrobial, Kemin Industries, Des Moines, IA) have been identified as a potential step to mitigate risk. One of the potential drawbacks to formaldehyde is the denaturation and cross-linking of protein as this could limit the availability of protein to swine. An experiment was conducted to identify if free lysine is susceptible to damage from formaldehyde levels added to feed. The experiment was a 4 × 2 × 2 factorial design, and was analyzed as an ANOVA. Corn was mixed with 4 different levels of L-lysine HCl (0.00, 0.30, 0.45, and 0.60%) and was either not-treated or treated with Sal CURB (SC) with 3 replicate batches mixed per L-lysine HCl level. To simulate possible storage conditions, the corn and crystalline lysine mixture was stored for up to 20 d at room temperature and was analyzed for free lysine at 0, 10, and 20 d post-mix. At 0 d post-mix, SC negative treatments were analyzed for total lysine and crude protein to verify the correct amount of L-lysine HCl added. For this trial SC was applied at exaggerated levels between 3.72 to 3.85 kg/ton to increase the level of the formaldehyde challenge, and the application levels exceeded the regulated label requirements (3.0 kg/ton). Therefore, these study conditions reflect an experimental scenario. This resulted in a higher challenge to the free lysine in the mixture than a typical field application system. Average recovered free lysine level for the 0.00, 0.30, 0.45 and 0.60% L-lysine HCl treatments without SC were 0.00, 0.25, 0.38 and 0.50% respectively, and did not significantly change when SC was included ($P = 0.5009$). There was no effect of d post-mix ($P = 0.1253$) and no interaction between SC inclusion and L-lysine HCl level ($P = 0.6880$). Even with Sal CURB levels being higher than the label requirements there were no effects of Sal CURB

inclusion on free lysine.

Key Words: Formaldehyde, Biosecurity, Antimicrobial

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289 The effects of egg yolk on nursery pig growth performance. K. C. Moore*, S. M. Barnett, Y. Li, M. D. Trenhaile, T. E. Burkey, P. S. Miller, S. C. Fernando, *University of Nebraska, Lincoln.*

An experiment was conducted to determine the effects of egg yolk compared to spray-dried plasma on growth performance and circulating immunoglobulins in nursery pigs. Crossbred pigs (n = 72) were weaned at 24 d (7 ± 0.54 kg) and divided into 3 dietary treatments in a completely randomized design (CRD), resulting in 6 pens per treatment with 4 pigs per pen (2 barrows, 2 gilts). The 3 dietary treatments were standard nursery diets supplemented with spray-dried plasma (2.36%), egg yolk (6%), and a control, which were fed in 2 phases (Phase 1: d 0 to 7; Phase 2: d 7 to 21). In the third phase (Phase 3: d 21 to 28), all pigs were fed the same diet. Pigs and feeders were weighed and blood samples were collected on d 0, 7, 14, 21, and 28. Growth performance (ADG, ADFI, G:F) was analyzed using PROC GLIMMIX of SAS. Circulating immunoglobulins (IgA and IgG) were analyzed using repeated measures by time. For Phase I and II, growth performance was not affected by dietary treatment. The overall means for growth performance parameters were: Phase I (ADG = 90.2 g, ADFI = 149.5 g, G:F = 553.7 g/kg); Phase II (ADG = 436.7 g, ADFI = 644.6 g, G:F = 677.9 g/kg). During Phase III, ADG was affected by treatment ($P < 0.10$). Pigs consuming the egg yolk diet had greater ($P < 0.05$) ADG vs. the plasma group (647.5 g vs. 538.7 g; respectively) for Phase III. Circulating immunoglobulins were not affected by dietary treatment. The concentration of IgA increased from d 0 (0.17 ng/mL) to 28 (0.3 ng/mL; time; $P < 0.0001$). The concentration of IgG did not respond ($P > 0.10$) over the course of the 28-d trial. These results indicate that performance and circulating immunoglobulins are similar in pigs receiving nursery diets containing egg yolk or spray dried plasma.

Key Words: egg yolk, growth performance, nursery pigs

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290 Effect of feeding grower-finisher pig diets containing 20% soybean hulls with or without enzyme supplementation. L. J. Schertz[1], G. A. Apgar[2], L. A. Lekatz[1], P. J. Lammers*[3], *[1]Illinois State University, Normal, [2]Southern Illinois University, Carbondale, [3]Univeristy of Wisconsin-Platteville, Platteville.*

The high concentration of nonstarch polysaccharides in soybean hulls limit the pig's ability to digest this feedstuff. Exogenous enzymes with protease and carbohydrase activity are commercially available and may improve utilization of soybean hulls by pigs. Three feeding trials were performed with the objective to examine the individual and combined effects of feeding soybean hulls and exogenous enzymes to grower-finisher pigs. In each trial, pigs (initial body weight 73 ± 3 kg) were allotted to pens of 10 or 12 pigs. Pens were randomly assigned to 1 of 4 dietary treatments in a 2 × 2 factorial design with 2 levels of soybean hull (0 or 20%) combined with 2 levels of exogenous carbohydrase and protease enzyme supplementation (0 or 1000 ppm). Pigs were fed ad libitum in 2 phases (grower 70–90 kg and finisher 90–115 kg) until 75% of the pigs reached 115 kg. Every 14 d, pigs, feed, and feeders were weighed to determine ADG, ADFI, and G:F. Least square means were compared using JMP 12.1 (SAS Institute Inc.) The statistical model included soybean hull inclusion rate (0 or 20%), exogenous enzyme inclusion rate (0 or 1000 ppm), and their interaction terms. The experimental unit for all analyses was pen. Differences were considered trends if $P \leq 0.10$ and significant if $P \leq 0.05$. There were no significant interactions between soybean hull inclusion rate and enzyme supplementation and so only main effects are presented. Grower pigs supplemented with 1000 ppm enzyme grew more efficiently than unsupplemented grower pigs (G:F = 0.44 vs. 0.38 g/g; P = 0.02). There was a trend (P = 0.06) for enzyme supplemented grower pigs to grow more rapidly than unsupplemented pigs (ADG = 1.00 vs. 0.86 kg/d). There was also a trend (P = 0.06) for grower pigs fed 20% soybean hulls to grow less quickly that pigs fed 0% soybean hulls (ADG = 0.86 vs. 0.99 kg/d). For finishing pigs, ADG, ADFI, and G:F were not impacted ($P \geq 0.10$) by diet type or enzyme supplementation. Balanced diets containing 20% soybean hulls will support growth and performance in finishing pigs. Grower pigs may benefit from exogenous carbohydrase and protease enzyme supplementation when fed diets containing 20% soybean hulls.

Key Words: Carbohydrase, Non-starch polysaccharides, Protease, Soybean hulls

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291 Sow performance in response to natural betaine fed during lactation and weaning-to-35 d post-insemination during non-summer months. S. M. Mendoza*[1], G. Martinez[1], M. Knauer[1], E. van Heugten[1], P. Wilcock[2], D. S. Rosero[3], R. D. Boyd[1,3], *[1]Department of Animal Science, North Carolina State University, Raleigh, [2]AB Vista Feed Ingredients, Marlborough, United Kingdom, [3]Hanor Company, Inc., Franklin, KY.*

This study was conducted to evaluate the effect of feeding natural betaine during lactation and weaning-to-35 d post-insemination on subsequent sow reproduction during non-summer months. This study is a counterpart to the experiment conducted during the summer, in which feeding 0.20% betaine during lactation decreased wean-to-estrus interval and increased subsequent litter size. A total of 627 sows were allocated by parity (300 parity 1 and 2 sows (young) and 327 parity 3 to 6 sows (mature)) to a 2 × 2 factorial arrangement

of treatments. Factors included betaine supplementation: 1) in lactation (0 or 0.2%) and 2) from weaning through early gestation (0 or 0.2%). Lactation diets were corn-soybean meal based with 10% rice bran, 6.0% wheat middlings, and contained 651 ppm of choline, 3.31 g SID Lys/Mcal ME and a SID Met+Cys:Lys ratio of 0.56. Gestation diets were corn-soybean meal based with 30% wheat middlings, 15% rice bran, and contained 651 ppm choline, 1.82 g SID Lys/Mcal ME and a SID Met+Cys:Lys ratio of 0.69. Data were analyzed using the MIXED procedure of SAS and GLM was used for dichotomous variables. Average temperature was 22.9 ± 1°C during lactation and 23.7 ± 0.6°C during the weaning-to-35 d post-insemination period. Betaine fed in lactation did not affect ADFI (P = 0.155; 4.85 vs. 4.96 kg/d), sow ADG (P = 0.939; −0.102 vs. −0.098, kg/d), litter gain (P = 0.687; 47.19 vs. 47.74, kg), and number of pigs weaned (P = 0.622; 10.74 vs. 1078) compared to the control. Supplementation of betaine during lactation to young, but not mature, sows reduced the percentage of no-value (< 3.62 kg BW) pigs (interaction, P = 0.036; 10% vs. 25%). Feeding betaine after weaning to young sows reduced the percentage of sows returning to estrus (P = 0.002; 91.94 vs. 98.00%), but did not affect mature sows (P = 0.51; 98.15 vs. 99.40%). Post hoc analysis showed that wean-to-estrus interval was reduced (P = 0.022) for parity 2 and 3 sows fed betaine after weaning (6.15 vs. 8.41 d). Supplementation of betaine during lactation reduced farrowing rate in mature sows (P = 0.001; 78.06 vs. 91.43) but not young sows (P = 0.60; 82.69 vs. 80.63%). The reduction in farrowing rate was driven by a greater cull percentage for reproductive reasons (P = 0.005; 14.03 vs. 4.3%). Feeding betaine postweaning reduced total pigs born (P = 0.017; 12.79 vs. 13.54). Results suggest that the use of 0.2% betaine during lactation and postweaning did not benefit sow performance and subsequent litter size, as was the case for summer-bred sows in the previous study.

Key Words: betaine, sows, lactation.

292 Responses of growing-finishing pigs to two levels of a multi-enzyme blend (Natuzyme) as compared to pigs fed a lower energy-higher fiber, or a higher energy-lower fiber diet. F. B. Sandberg*, S. J. England, M. R. Bible, *Furst McNess Company, Freeport, IL.*

The objective of this study was to evaluate whether the performance of pigs could be maintained when pigs were fed a lower energy diet (ME = 3423 kcal/kg) with higher fiber from 50% DDGS (NC), compared to a positive control (PC) diet with lower fiber and a maximum of 30% DDGS with an increased energy content from additional added fat (ME = 3476 kcal/kg), when either 193 (NZ1X) or 386 (NZ2X) mg/kg of Natuzyme (a source of xylanase, phytase, cellulase, β-glucanase, α-amylase and protease) was added to the NC diet. A FANCOM feed weighing system measured feed delivered to the individual pens, and weight of pigs (1024 pigs, initial body weight of 50.1 kg) and feed was determined on d 0, 14, 28, 42, 56, 70, and 83. Blood glucose was measured at d 42 on trial. Data were analyzed as a completely randomized design using GLM in Minitab. On d 83 of the trial, NC (107.4 kg) and NZ2X (108.4 kg) weighed less (P = 0.050) than PC (112.4 kg) and NZ1X was intermediate (109.5 kg). In Table 292 is a summary of performance. PC tended to have a 9.4% higher ADFI (P = 0.088) than NC, with NZ1X 5.2% and NZ2X 4.3% intermediate. This difference in ADFI resulted in PC consuming 11.1% more energy per day (9166 vs. 8249 kcal ME/d) than NC. The PC tended to have a 7.8% greater ADG than NC (P = 0.062), with NZ1X and NZ2X intermediate. NZ1X and NZ2X tended to have lower mortality (including pulled pigs) than NC, with PC intermediate. No differences were observed in blood glucose (P = 0.294), but NC had a 7.7% lower blood glucose (72.8 umol/L) as compared to PC (78.8 umol/L), NZ1X (78.8 umol/L) and NZ2X (79.4 umol/L). In conclusion, PC grew faster than NC and Natuzyme partially recovered the performance difference between NC and PC, and tended to improve survivability of pigs on a lower energy, high DDGS diet (NC).

Key Words: Pigs, Enzymes, DDGS

Table 292. Summary of performance of Day 0 to 83

	NC	PC	NZ1X	NZ2X	SE	P-value
ADG, g	821[c]	885[d]	848[c,d]	835[c,d]	41	0.062
ADFI, g	2410[c]	2637[d]	2537[c,d]	2515[c,d]	147	0.088
FCRg/g	2.93	2.98	3.00	3.00	0.08	0.409
Morbidity/ Mortality, %	4.52[c]	1.38[c,d]	0.81[d]	0.98[d]	2.41	0.051

293 Impact of lipid peroxidation and antioxidants on nursery pig performance and health. P. L. Chang*, E. van Heugten, *Department of Animal Science, North Carolina State University, Raleigh.*

The purpose of the current study was to determine the impact of oxidized corn oil with or without addition of a synthetic antioxidant on growth performance, oxidative status and response to vaccination in nursery pigs. A total of 176 nursery pigs (1 wk postweaning; initial BW = 9.11 ± 0.1 kg) were housed in pens with 4 pigs/pen in a RCBD and assigned to 4 dietary treatments. Treatments consisted of a corn-soybean meal basal mix that was supplemented with 6% of either control corn oil (IV = 123.2, FFA = 0.09%, anisidine value = 2.2, peroxide value = 0.4 meq/kg oil) or oxidized corn oil (IV = 116.9, FFA = 0.11%, anisidine value = 164.4, peroxide value = 146 meq/kg oil) with or without addition of an antioxidant blend containing ethoxyquin (min 3%), BHT and BHA (Endox Dry, Kemin Industries, Inc). Nursery diets consisted of 2 phases; Phase 1 fed for 14 d and Phase 2 fed for 16 d. Pigs were vaccinated with porcine circovirus type 2 (PCV2) and *Mycoplasma hyopneumoniae* (Mhyo) killed vaccine (Circumvent PCV M, Intervet Inc.) at d 2 and d 16 of the study. Blood samples were collected from 2 pigs per pen before vaccination at d 2, d 16 and at the end of the trial (d 30) to determine

antibody titers to vaccinations, oxidative status, and vitamin E concentrations. There were no differences in performance among treatments. Serum malondialdehyde concentration, a marker for oxidative stress, did not differ ($P = 0.7$; mean = 3.55 ± 0.2 mmol/L) among treatments. Antibody titers to Mhyo and PCV2 increased following the second vaccination, but not the first vaccination ($P < 0.001$; 0, 0.06, and 1.66 for d 2, d 16, and d 30 for Mhyo; 0, 0.06, and 0.89 for d 2, d 16, and d 30 for PCV2), yet there were no differences due to dietary treatment. Serum vitamin E decreased in pigs fed oxidized oil by 29% on d 16 (0.79 vs. 1.11 mg/kg for oxidized oil and control, resp.) and 36% (1.06 vs. 1.64 mg/kg) on d 30 (interaction, $P < 0.001$). Supplementation of antioxidant increased serum vitamin E concentration ($P < 0.001$; 1.28 vs. 1.01 mg/kg) and this effect tended to be greater in pigs fed control oil. Results indicate that pig performance and response to vaccine was not affected by peroxidized corn oil or supplementation of antioxidant. However, serum vitamin E status was reduced by consumption of peroxidized oils, which could be counteracted by the use of antioxidants in the diet.

Key Words: lipid, peroxidation, antioxidant

294 Alteration of fecal bacterial communities in weanling pigs fed diets supplemented with chicory, mannan oligosaccharides, or chitosan.

Y. S. Li*, S. C. Fernando, P. S. Miller, T. E. Burkey, *University of Nebraska, Lincoln.*

Our previous study demonstrated that dietary prebiotics did not affect growth performance and serum IgA of weanling pigs, except that feeding mannan oligosaccharides (MOS) decreased G:F compared to the other treatments. To determine changes in fecal bacterial communities, 64 weanling pigs were allotted to 16 pens with 4 dietary treatments. The control diet was a complex nursery diet and the additional 3 diets contained 0.1% chicory, 0.1% MOS, and 0.02% chitosan, respectively. Fecal samples from 2 pigs/pen were collected on d 0, 14, and 28 postweaning to evaluate bacterial community composition using 16S rRNA tag sequencing. Database independent operational taxonomic unit (OTU) approach was used for bacterial community analysis. The α–diversity estimate (Chao 1) was different ($P < 0.05$) over time, but was not affected ($P > 0.10$) by treatment. Additionally, β-diversity changed over time ($P < 0.05$). On d 14, β-diversity of the bacterial community in control pigs were different ($P < 0.05$) from chicory and chitosan, but were not different ($P > 0.10$) from MOS. Linear discriminate analysis (LDA) by LEfSe was used for pair-wise comparisons of OTU abundances in the bacterial communities (|LDA score| > 2 was considered significant). On d 14, control and MOS had 26 and 12 OTUs, respectively more abundant in the 3 comparisons with other treatments, in which the majority of these OTUs belonged to family *Lactobacillaceae*. Additionally, 25 and 17 OTUs, respectively that predominantly belonged to family *Ruminococcaceae* and *Christensenellaceae* were associated with chicory and chitosan. Using multivariate association with linear models (MaAsLin; $P < 0.05$, $q < 0.05$), 3 OTUs belonging to *Lactobacillaceae* family were positively correlated to MOS (coeff. > 0.012). *Mocosae spp.* was associated (coeff. = 0.092) with IgA. One OTU belonging to family *Christensenellaceae* was negatively correlated (coeff. = −0.01) to BW. Family level classification of OTUs was analyzed using ANOVA1 of MATLAB. On d 14, *Lactobacillaceae* decreased ($P < 0.05$) in chicory (18.4%) compared to control (46.5%) and MOS (41.7%); whereas, *Ruminoccocaceae* increased ($P < 0.05$) in chicory (15.4%) and chitosan (15.0%) compared to control (10.6%) and MOS (10.3%). Chicory had greater ($P < 0.05$) *Christensenellaceae* (5.6%) compared to the other 3 treatments (< 1.8%). On d 28, *Streptococcaceae* increased ($P < 0.05$) in control (27.2%) compared to chicory (8.7%) and chitosan (9.5%). In conclusion, pigs fed MOS shared a similar bacterial community with control; however, bacterial communities in chicory and chitosan were similar.

Key Words: fecal bacteria, prebiotics, weanling pigs

295 Effects of tribasic copper chloride (TBCC), *Saccharomyces cerevisiae* fermentation product (YFP), and narasin (NAR) supplementation on growth performance of 12 to 25 kg pigs.

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A total of 929 pigs were used in a 28-d experiment to determine the effects of TBCC (Intellibond C, Micronutrients), YFP and NAR (Skycis, Elanco Animal Health) alone and in combination on growth performance of 12 to 25 kg pigs. Twenty-one days postweaning, pens of pigs were allotted to one of 6 dietary treatments (TRT) in a randomized complete block design based on previous TRT and BW with 24 to 26 pigs per pen and 6 replicates per TRT. Data were analyzed us-

Table 295.

	Initial BW, kg	ADG, g	ADFI, g	G:F	Final BW, kg
d 0–28[1]					
TRT 1	12.22	603[c]	901[bc]	0.669[c]	29.11[c]
TRT 2	12.12	653[b]	939[ab]	0.696[ab]	30.40[b]
TRT 3	12.14	588[c]	880[c]	0.669[c]	28.61[c]
TRT 4	12.15	655[b]	948[ab]	0.691[b]	30.48[b]
TRT 5	12.13	655[b]	932[ab]	0.703[ab]	30.46[b]
TRT 6	12.14	684[a]	965[a]	0.709[a]	31.29[a]
SEM	0.08	10.19	16.68	0.005	0.32
P =	0.96	< 0.01	0.01	< 0.01	< 0.01

[1][abc] Within a column, means without common superscript differ ($P < 0.05$).

ing GLM procedure of SAS. All diets were Corn-SBM- 10% DDGS based, fed in pellet form (3.17 mm), and formulated to contain 1.25% SID LYS. The dietary TRT were; 1) Control (C), 10 ppm Cu sulfate; 2) C + 142.5 ppm TBCC; 3) C + 0.05% YFP; 4) C +142.5 ppm TBCC + 0.05% YFP; 5) C + 19.91 ppm NAR; 6) C + 142.5 ppm TBCC + 0.05% YFP + 19.91 ppm NAR. Overall (Table 295), pigs fed TRT 6 had the greatest ADG, followed by TRT 2, 4, and 5, with TRT 1 and 3 being the poorest. Pigs fed TRT 6 had the highest ADFI ($P <$ 0.05) compared with pigs fed TRT 3, with all other TRT being intermediary. Feed efficiency was greatest ($P < 0.05$) for pigs fed TRT 6 and poorest for pigs fed TRT 1 and 3. Pigs fed TRT 2 and 5 had similar ($P < 0.05$) GF to TRT 6 and 4, but TRT 4 was not similar ($P > 0.05$) to TRT 6. In summary, feeding TBCC or NAR alone can increase growth performance compared with pigs fed the C and YFP, while the combination of TBCC, NAR, and YFP were additive and resulted in the greatest improvement in ADG, ADFI, and GF.

Key Words: pig, copper, narasin

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296 Evaluation of interactive effects of vitamin E and linseed oil as a source of omega-3 fatty acids on growth performance, blood characteristics and meat quality of finishing pigs. S. D. Upadhaya*, T. S. Li, Y. M. Kim, I. H. Kim, *Department of Animal Resource & Science, Dankook University, Cheonan, South Korea.*

Omega-3 and vitamin E are the essential nutrients which possess anti-inflammatory properties and have many health benefits for both human and animals. This study was conducted to evaluate the effects of supplementation of vitamin E and omega-3 fatty acid to corn soybean meal based diet on the growth performance, nutrient digestibility, blood profiles and meat quality of finishing pigs for a period of 12 wk. A total of 140 finishing pigs [(Yorkshire × Landrace) × Duroc] with an average initial BW of 46.5 kg were blocked and stratified based on sex and body weight to a 2 × 2 factorial design with the respective factors being 1) with and without 300 IU vitamin E (Vit E), and 2) with and without 0.75% of linseed oil as a source of omega-3 fatty acid (*n*-3 FA). Each treatment consisted of 7 replicate pens with 5 pigs (3 barrows and 2 gilts) per pen. The supplementation of Vit E improved ($P < 0.05$) overall ADG (828 g) compared with non supplemented group (800 g). The digestibility of nitrogen (N) tended to improve ($P = 0.07$) with the addition of Vit E in the diet. At wk 12, the concentration of IgG increased ($P < 0.01$) with the addition of Vit E (704 mg/dL vs. 660 mg/dL) in the diet whereas the concentration of cortisol was reduced ($P < 0.05$) with the addition of Vit E (1.1 µg/dL vs. 1.4 µg/dL) or *n*-3 FA (1.2 µg/dL vs. 1.4 µg/dL). Moreover there was an additive effect ($P = 0.03$) of the combined supplementation of Vit E and *n*-3 FA on cortisol concentration. Surface LM color (a*) scored higher (($P < 0.05$) with the supplementation of Vit E (17.1 vs. 16.6) However, the score of color based on sensory evaluation was lower ($P < 0.05$) in Vit E supplemented group (3.4 vs. 3.7) and drip loss was lower ($P < 0.05$) in Vit E supplemented groups (16.5% vs. 19.2%) on Day 5. In conclusion, vitamin E independently influenced overall daily gain, IgG and meat quality. However, additive effects of Vitamin E and omega-3 fatty acids were observed for cortisol concentration.

Key Words: finishing pig, omega-3 fatty acid, vitamin E

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297 Effects of dietary zinc source and level on nursery pig performance. K. E. Jordan[1], K. M. Gourley*[1], M. D. Tokach[1], R. D. Goodband[1], S. S. Dritz[1], J. M. DeRouchey[1], J. C. Woodworth[1], J. L. Usry[2], *[1]Kansas State University, Manhattan, [2]Micronutrients, Indianapolis, IN.*

A total of 360 pigs (initially 5.9 ± 0.14 kg BW) were used in a 28-d study to evaluate the effects of dietary Zn source and level on weanling pig growth performance. Pigs were randomly allotted to pen at weaning by initial BW. The pen was assigned in a completely randomized design to 1 of 9 dietary treatments arranged in a 2 × 4 + 1 factorial. There were 8 pens per treatment and 5 pigs per pen. The corn-soybean meal based diets consisted of a control diet containing 110 ppm Zn from $ZnSO_4$ from the trace mineral premix or the control diet with 390, 890, 1890, or 2890 ppm added Zn from either tetrabasic Zn chloride (TBZC; Intellibond Z; Micronutrients, Indianapolis, IN) or ZnO. This provided diets with a total of 500, 1000, 2000, or 3000 ppm added Zn. A 3 phase diet series was used with treatment diets fed during Phase 1 (d 0 to 7), Phase 2 (d 7 to 21) and Phase 3 (d 21 to 28). There were no Zn source × level interactions or Zn source differences observed for growth performance. From d 0 to 21, increasing Zn increased (linear; $P \leq 0.05$) ADG and ADFI with no difference in G:F. From d 21 to 28, pigs fed increasing Zn had increased (linear; $P = 0.018$) ADFI resulting in decreased G:F (quadratic; $P = 0.041$). Overall, from d 0 to 28, increasing Zn increased (linear; $P \leq 0.05$) ADG and ADFI without influencing G:F. On d 28, fecal samples were collected from 3 pigs in each pen and analyzed for DM content. There was a tendency ($P = 0.081$) for a Zn source × level interaction as increasing Zn from TBZC decreased fecal DM, whereas no difference in fecal DM was observed for increasing Zn from ZnO. In conclusion, increasing dietary Zn up to 3000 ppm increased ADG and ADFI but no differences

Table 297.

	Total added dietary Zn, ppm								
	Control	IBZ				ZnO			
Item	110	500	1,000	2,000	3,000	500	1,000	2,000	3,000
D 0 to 28									
ADG, g	285	288	289	300	323	294	273	318	307
G:F, g	0.728	0.712	0.716	0.731	0.729	0.706	0.717	0.733	0.707

SEM = 13.4 for ADG and 0.0144 for G:F

existed between sources evaluated.

Key Words: growth performance, nursery pig, zinc

298 Could zinc citrate supplementation during lactation increase the serum Zn levels at weaning?

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Zinc is essential for normal growth and development in all animals. In our previous studies it was observed that weaning causes a decrease in the serum Zn, and that piglets with low BW (5.5 kg) at weaning had lower Zn levels (0.79 mg/L) than piglets with a higher BW (8.63kg; 0.98 mg of Zn/L). It was hypothesized that supplementing with 6 mg/d of Zn (19.35mg of Zn Citrate) during the last 10 d of lactation may improve the Zn status at weaning (d 28), especially in light piglets. A total of 48 piglets were selected from 12 litters (2 piglets/litter categorized as heavy 5.7 ± 0.2 kg BW, and 2 piglets as light 3.9 ± 0.3 kg BW) on Day 18 of lactation. Experimental treatments consisted on the daily administration of a capsule containing either 0 or 6 mg/d of Zn as Zn Citrate for each piglet and BW category in each sow from d 18 to 28 (12 replicates per treatment and BW category). The 6 mg Zn/d was chosen to be similar to the Zn provided in one kg of sow milk. Body weight was individually recorded on d 18 and 28 of lactation and on d 2, 7, and 14 postweaning (d 28). Blood samples were obtained on Day 18 and 28 of lactation. BW and serum Zn levels were analyzed with ANOVA by using the proc mixed procedure of SAS. All piglets had a drop on the serum levels of Zn, from 0.93 mg/L on Day 18 to a 0.74 mg/L on Day 28, which may reflect that suckling was likely limiting Zn intake. No different average serum Zn levels were observed according to the BW category for the entire period (0.85 and 0.82 mg/L for heavy and light piglets, respectively; $P = 0.26$), and neither between animals supplemented and non-supplemented at weaning (d 28) (0.76 vs. 0.71 mg/L Zn, respectively; $P = 0.40$). However, supplemented piglets had quantitatively higher Zn levels. No different performance was observed due to Zn supplementation for the whole period. In conclusion, supplementing 6 mg/d Zn as Zn citrate for the last 10 d of lactation is not sufficient to prevent the decrease in serum Zn during lactation.

Key Words: Piglets, Zinc Citrate, Zinc Status

299 Effect of diet type and added copper on growth performance, carcass characteristics, total tract digestibility, gut morphology, and mucosal mRNA expression of finishing pigs.

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A total of 757 pigs (PIC 337 × 1050; initially 27.6 kg BW) were used in a 117-d experiment to determine the effects of added Cu (TBCC; tribasic copper chloride, IntelliBond C; Micronutrients, Inc., Indianapolis, IN) and diet type on growth performance, carcass characteristics, energy digestibility, gut morphology, and mucosal mRNA expression of finishing pigs. Pens of pigs were allotted to 1 of 4 dietary treatments, balanced on average pen weight in a randomized complete-block design with 26 to 28 pigs/pen and 7 replications/treatment. Treatments were arranged in a 2 × 2 factorial arrangement with main effects of diet type, a corn-soybean meal-based diet (corn-soy) or a high byproduct diet (byproduct) with 30% distillers dried grains with solubles (DDGS) and 15% bakery meal, and added Cu (0 (10 mg/kg basal) or 150 mg/kg added Cu). There were no Cu×diet type interactions for growth performance. Neither added Cu nor diet type significantly influenced overall growth performance, although adding Cu during the early finishing period tended to increase ($P = 0.076$) ADG compared to pigs fed none (0.85 vs. 0.83). However, NE caloric efficiency was improved ($P = 0.001$) for pigs fed the corn-soy diet compared to the byproduct diet (6.76 vs. 7.15 Mcal intake/kg BW gain). Pigs fed the corn-soy diet had improved carcass yield ($P = 0.007$; 74.33 vs. 73.19%) and HCW G:F ($P = 0.011$; 0.274 vs. 0.266), and tended to have increased HCW ($P = 0.067$; 94.60 vs. 92.65 kg) and HCW ADG ($P = 0.056$; 0.635 vs. 0.615 kg/d) compared to pigs fed the byproduct diet. A Cu×diet type interaction ($P < 0.05$) existed for DM and GE digestibility in phase 2 as added Cu improved digestibility of DM and GE in the corn-soy diet, but not in the byproduct diet. In phase 4, added Cu tended to increase DM and GE digestibility ($P = 0.060$) while pigs fed the byproduct diet had decreased DM and GE digestibility ($P = 0.001$) compared to the corn-soy diet. For gut morphology, pigs fed added Cu had decreased distal small intestine crypt depth ($P = 0.017$; 207 vs. 225 um) compared to those fed no added Cu. Furthermore, pigs fed added Cu had decreased ($P = 0.032$; 0.618 vs. 0.935) relative mRNA expression of intestinal fatty acid binding protein (iFABP) compared to those fed no added Cu. In summary, 150 mg/kg added TBCC did not significantly affect overall growth but did influence diet digestibility and some gut morphology or mRNA expression measurements. Feeding a high byproduct diet decreased yield, caloric efficiency, and diet digestibility.

Key Words: finishing pigs, copper, fiber

Table 300.

Item	Treat			Pooled SEM	*P*-Value
	LCa	MCa	HCa		
BW d7, Kg	8.43[a]	8.33[ab]	8.21[b]	0.06	0.041
BW d14, kg	10.72[a]	10.6[a]	10.16[b]	0.08	0.0001
ADG 0–7d, g/d	106.94[a]	91.25[ab]	74.62[b]	8.37	0.044
ADFI 0–7d, g/d	162.51	148.45	149.69	8.05	0.411
G:F 0–7d	0.654[a]	0.616[a]	0.481[b]	0.04	0.014
ADG 0–14d, g/d	219.19[a]	207.25[a]	176.76[b]	5.72	0.0002
ADFI 0–14d, g/d	342.35	323.01	314.64	9.04	0.113
G:F 0–14d	0.640[a]	0.645[a]	0.561[b]	0.01	0.0003

300 Low calcium levels improve growth in piglets after weaning.
L. Blavi*, D. Solà-Oriol, J. F. Pèrez, *Animal Nutrition and Welfare Service, Department of Animal and Food Sciences, Universitat AutÚnoma de Barcelona, Bellaterra (08193), Spain.*

Piglets have a low acidification capacity that may promote digestive disorders and diarrhea. The inclusion of $CaCO_3$ and ZnO with high acid-binding capacity in weanling diets diets can aggravate the problem. It was hypothesized that reducing the levels of Ca from 0.95% to 0.35% (no addition of $CaCO_3$) may improve the growth of piglets after weaning. A total of 240 piglets were distributed into 3 treatments during the pre-starter phase (0 to 14 d postweaning; 8 replicates per treatment). Treatments were based on 3 different Calcium levels: High (HCa) with 0.95% of Ca (1.55% $CaCO_3$), Medium (MCa) with 0.65% of Ca (0.78% $CaCO_3$) and Low (LCa) with 0.35% of Ca (0% $CaCO_3$). The diets contained 2520 Kcal NE/kg, 19.7% CP, and 1.39 Lys. Feed Intake and individual BW were registered on d 0, 7, and 14. The initial BW was 7.69 ± 0.01 kg for each treatment. Piglets fed HCa showed lower BW, ADG and G:F ratio than piglets with LCa and MCa (Table 300). These results show that feeding piglets low inclusion or no $CaCO_3$ increased growth, suggesting that the reduction of $CaCO_3$allow a better digestion of feed during the pre-starter phase.

Key Words: calcium, pigs, weaning

301 Effects of increasing zinc from zinc sulfate or zinc hydroxychloride on finishing pig growth performance and carcass characteristics.
C. B. Carpenter*[1], K. Coble[1], J. C. Woodworth[1], J. M. DeRouchey[1], M. D. Tokach[1], R. D. Goodband[1], S. S. Dritz[1], J. L. Usry[2], *[1]Kansas State University, Manhattan, [2]Micronutrients, Indianapolis, IN.*

A variety of zinc sources are available for use in swine trace mineral premixes. However, more research is needed to compare zinc sources and dietary levels in growing and finishing pigs in a commercial environment. A total of 1008 pigs [TR4 × (Fast Large White × L02 PIC); initially 32.1 kg BW)] were used in a 103-d growth study to determine the effects of Zn source and level on finishing pig growth performance and carcass characteristics. The 6 dietary treatments were arranged as a 2 × 3 factorial with main effects of Zn source ($ZnSO_4$ Agrium Advance Technology, Loveland, CO or Zn Hydroxychloride; IntelliBond Z®; Micronutrients, Indianapolis, IN) or level (50, 100, or 150 ppm added Zn). There was no additional Zn provided from the trace mineral premix. There were 21 pigs per pen and 8 pens per treatment. Overall, there were no Zn source × level interactions observed for ADG or ADFI, however G:F tended (linear, $P = 0.069$) to be poorer when pigs were fed increasing levels of Zn from $ZnSO_4$. Overall, there were no Zn source effects for growth performance observed. For Zn level main effects, ADG was maximized (quadratic, $P = 0.007$) and ending BW was heaviest (quadratic, $P = 0.011$) when diets contained 100 ppm of Zn. Feed efficiency was poorer (linear, $P = 0.006$) when pigs were fed increasing levels of Zn. For carcass characteristics, pigs fed diets with Zn Hydroxychloride had heavier ($P = 0.041$) HCW than those fed $ZnSO_4$. Also carcass yield increased (linear, $P = 0.027$) when pigs were fed increasing levels of Zn and HCW was maximized (quadratic, $P = 0.006$) when diets contained 100 ppm of Zn. These results suggest that a total of 100 ppm added Zn is enough to maximize ending BW, ADG and HCW, but G:F worsened as Zn level increased. Zn source did not impact growth performance; however, pigs fed Zn Hydroxychloride had increased HCW compared to those fed $ZnSO_4$.

Key Words: finishing pig, zinc sulfate, zinc hydroxychloride

Table 301.

Item[1]	$ZnSO_4$, ppm			Zn Hydroxychloride, ppm			Zn source	***P* <** Level	
	50	100	150	50	100	150		Linear	Quadratic
ADG, kg	0.94	0.96	0.94	0.95	0.97	0.94	0.555	0.951	0.007
ADFI, kg	2.46	2.50	2.49	2.47	2.56	2.53	0.163	0.168	0.126
G/F[2]	0.382	0.385	0.380	0.386	0.381	0.374	0.318	0.006	0.270
Yield, %	73.63	74.08	74.53	74.03	74.68	74.36	0.240	0.027	0.329
HCW, kg	92.65	95.04	93.66	94.35	96.90	94.51	0.041	0.494	0.006

[1]SEM: ADG = 0.009, ADFI = 0.032, G:F = 0.0026, Yield = 0.003, HCW = 0.883
[2]Zn source × level interaction (linear; $P = 0.069$)

302 Lysozyme as an alternative to antibiotics in swine feed. W. T. Oliver*, J. E. Wells, *USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE.*

Antibiotics have been fed at subtherapeutic levels to swine as growth promoters for more than 60 yr, and the majority of swine produced in the U.S. receive antibiotics in their feed at some point in their production cycle. These compounds benefit the producers by minimizing production losses by increasing feed efficiency and decreasing susceptibility to bacterial infection and disease. However, many countries, including all of the European Union, have banned the use of antibiotics as growth promotants in animal agriculture. Due to the perceived risk of bacterial resistance to antibiotics important in human medicine, swine producers are currently under tremendous pressure to eliminate subtherapeutic antibiotic use. Recent Federal Drug Administration guidance (No. 209 and 213) are designed to limit the use of medically important antibiotics in animal agriculture in the U.S. Lysozyme, also known as muramidase, is a naturally occurring enzyme found in bodily secretions such as tears, saliva, and milk and is a good replacement for traditional antibiotics. It functions as an antimicrobial agent by cleaving the peptidoglycan component of bacterial cell walls, which leads to cell death. While the mechanism by which antibiotics or lysozyme improve performance is not clearly understood, they improve gastrointestinal health, improve the metabolic profile, and alter the gastrointestinal bacteria ecology of swine.

Key Words: Lysozyme, antibiotics, swine, gastrointestinal, microbiota

ODOR AND NUTRIENT MANAGEMENT

303 Effect of feeding grower-finisher pig diets containing 20% soybean hulls with or without enzyme supplementation. L. J. Schertz[1], G. A. Apgar[2], L. A. Lekatz[1], P. J. Lammers*[3], *[1]Illinois State University, Normal, [2]Southern Illinois University, Carbondale, [3]Univeristy of Wisconsin-Platteville, Platteville.*

The high concentration of nonstarch polysaccharides in soybean hulls limit the pig's ability to digest this feedstuff and thus decreases its value to pork producers. Current feeding recommendations suggest limiting inclusion of soybean hulls in finishing pig diets to 10%. Exogenous enzymes with protease and carbohydrase activity are commercially available and the addition of these enzymes to pig diets containing soybean hulls may enable utilization of nonstarch polysaccharides. Three feeding trials were performed with the objective to examine the individual and combined effects of feeding soybean hulls and exogenous enzymes to grower-finisher pigs. In each trial, grower pigs (initial body weight 73 ± 3 kg) were allotted to pens of 10 or 12 pigs. Pens of pigs were randomly assigned to 1 of 4 dietary treatments in a 2 × 2 factorial design with 2 levels of soybean hulls (0 or 20%) combined with 2 levels of exogenous carbohydrase and protease enzyme supplementation (0 or 1000 ppm). Pigs were fed ad libitum until 75% exceeded a market weight of 115 kg at which time the trial was complete. Every 14 d, pigs, feed, and feeders were weighed to determine ADG, ADFI, and G:F. Grower pigs (70–90 kg) fed 20% soybean hulls grew 12% slower ($P = 0.05$) than pigs fed control diets. Grower pigs supplemented with 1000 ppm REAP enzyme diets gained weight 17% faster ($P = 0.03$) and required 18% less feed per unit of gain as compared to pigs fed diets not containing enzyme (P-value = 0.01). For finishing pigs (90–120 kg), growth rate, average daily feed intake and feed efficiency were not different ($P \geq 0.10$) based on diet type or enzyme supplementation. There was no soybean hull × enzyme interaction during the grower or finisher phases. Overall, grower-finisher pigs grew 7% slower ($P = 0.01$) and were 5% less efficient ($P = 0.04$) when fed diets containing 20% soybean hulls. Pigs supplemented with enzyme grew 7% faster ($P = 0.03$) than those that were not given exogenous enzymes but there was no soybean hull × enzyme interaction. Results indicate that 20% soybean hulls can be fed to finisher pigs weighing more than 90 kg without negatively impacting growth or performance.

Key Words: Carbohydrases, Non-starch polysaccharides, Protease, Soybean hulls

304 A comparison of antibiotic-free and conventional management on nutrient excretion in swine. C. E. Vonderohe[1], K. M. Mills*[1], A. M. Jones[2], M. D. Asmus[1], E. R. Otto-Tice[1], J. Ni[1], B. T. Richert[1], J. S. Radcliffe[1], *[1]Purdue University, West Lafayette, IN, [2]Kansas State University, Manhattan.*

Seven hundred twenty-four, mixed-sex pigs were used in a wean-finish experiment to determine the effects of antibiotic free rearing on nutrient excretion compared to conventional rearing. At weaning, pigs were blocked by BW and sex and randomly assigned within block to rooms and pens in the Swine Environmental Research Building. Each room contained 6 pens of 10–11 mixed sex pigs with 3 pens over each manure pit. There were 5 control and 6 antibiotic-free rooms (10 and 12 manure pits, respectively). All pigs were fed a 9-phase wean-finish diet program. Control pigs consumed diets containing antibiotics and were treated with injectable antibiotics when deemed necessary. Antibiotic-free animals consumed diets with alternatives to antibiotics and received no injectable antibiotics. At the conclusion of the finisher phase, pits were individually emptied into a Slurrystore, mixed and subsampled. Data were analyzed using the GLM procedure in SAS. Previously reported, there was no difference ($P > 0.10$) in overall growth rate between control and antibiotic free pigs, however

there was a greater pig removal rate from the antibiotic free treatment (8.6% vs. 5.7%). No differences were observed between control and antibiotic-free management on the excretion of DM, P, N, and ammonium N ($P > 0.10$) per kg of carcass weight. Dry matter excretion was 456 and 445 g/kg of carcass weight for antibiotic free and control animals, respectively. Phosphorus (0.59 versus 0.45 g/kg carcass), N (43.48 versus 42.56 g/kg carcass) and Ammonium N (35.07 versus 33.01 g/kg carcass) excretion were all approximately 6% lower for control animals compared to those reared without antibiotics. However, these findings were not significant. Therefore, future research with a higher number of observations is needed to confirm the lack of differences in nutrient excretion observed between pigs reared with and without antibiotics.

Key Words: swine, antibiotics, manure, excretion, environment

PHYSIOLOGY

305 Does heat stress alter the pig's response to dietary fat source, as it relates to apparent or true total tract digestibility of dietary lipids? T. Kellner*, L. H. Baumgard, J. F. Patience, *Iowa State University, Ames.*

The objective was to investigate the effect of heat stress on the pig's response to dietary fat in terms of growth performance and digestibility of apparent (ATTD) and true total tract digestibility (TTTD) of acid hydrolyzed ether extract (AEE) over a 35 d finishing period. A total of 96 barrows (PIC 337 × C22/29) with an initial BW of 100.4 ± 1.2 kg were randomly allotted to 1 of 9 treatments arranged as a 3 × 3 factorial: [TN (thermonetural: constant 24°C; ad libitum access to feed), PFTN (pair-fed thermoneutral: constant 24°C; limit-fed based on previous HS daily feed intake), or HS (heat stress: cyclical 28°C nighttime, 33–35°C daytime; ab libitum access to feed)] and diet [a corn-soybean meal based diet with 0% added fat (CNTR), 3% added tallow (3%TAL; iodine value = 41.8), or 3% added corn oil (3%CO; iodine value = 123.0)]. Pigs were individually housed (1.25 m^2/pig). Titanium dioxide was included as an indigestible marker at 0.4%. Fecal samples were collected on d 17 (~ 114 kg BW). TTTD (%) of AEE was calculated via correcting ATTD of AEE for endogenous fat losses at 20 g of AEE/kg of dry matter intake. Data were analyzed using PROC MIXED with environment and dietary treatment as fixed effects, and replicate (2 replicates of 48 barrows) as a random effect. Rectal temperature increased due to HS (HS = 39.0, T*N* = 38.1, PFT*N* = 38.2°C; $P < 0.001$). HS decreased ADFI (27.8%; $P < 0.001$), ADG (HS = 0.72, T*N* = 1.03, PFT*N* = 0.78 kg/d; $P < 0.001$), and G:F (HS = 0.290, T*N* = 0.301, PFT*N* = 0.319; $P = 0.006$). G:F but not ADG or ADFI tended to be influenced by dietary treatment (CNTR = 0.292, 3%TAL = 0.303, 3%CO = 0.314 g/100 g; $P \leq 0.073$). HS tended to result in the lowest ATTD of AEE (HS = 59.0, T*N* = 60.2, PFT*N* = 61.4%, $P = 0.055$). Inclusion of dietary fat, and a source that was unsaturated increased ATTD of AEE (CNTR = 41.6, 3%TAL = 67.9, 3%CO = 71.2%, $P < 0.001$). TTTD of AEE of 3%CO-based diets (99.3%) was higher than that of CNTR (97.3%) and 3%TAL-based diets (96.3%; $P = 0.012$). Environment had no impact on TTTD of AEE ($P = 0.118$). In summary, ATTD, but not TTTD of AEE was decreased by HS exposure.

Key Words: heat stress, fat digestibility, and energy intake

306 Effects of dietary chromium propionate during heat stress on finishing pigs. E. J. Mayorga*[1], S. K. Stoakes[1], J. T. Seibert[1], E. A. Horst[1], M. Abuajamieh[1], S. Lei[1], L. Ochoa[2], B. Kremer[2], L. H. Baumgard[1], *[1]Iowa State University, Ames, [2]Kemin Industries, Inc., Des Moines, IA.*

Study objectives were to determine the effects of chromium (Cr) propionate (Kemin Industries, Des Moines, IA) on growth performance and biomarkers of metabolism and health in heat stress (HS) and nutrient-restricted pigs. Crossbred barrows ($n = 96$; 122 ± 1 kg BW) were enlisted in a 2 × 3 factorial experiment with 2 replicates, blocked by initial BW and randomly assigned to 1 of 6 dietary-environmental treatments: 1) thermoneutral (TN) conditions and fed ad-libitum a control diet (TNCtl), 2) TN conditions and fed ad-libitum a Cr diet (TNCr), 3) TN and pair-fed a control diet (PFCtl), 4) TN and pair-fed a Cr diet (PFCr), 5) HS and ad-libitum fed a control diet (HSCtl), and 6) HS and ad-libitum fed Cr a diet (HSCr). Pair-fed animals were fed to match intake of their HS counterparts to eliminate the confounding effect of dissimilar feed intake. The Cr diet contained 0.5g/kg of feed to deliver 200 ppb Cr/d. The study consisted of 3 experimental periods (P). During P0 (5 d), all pigs were exposed to TN conditions (21.3 ± 0.1°C, 56.8 ± 0.3% RH) and fed the control diet ad libitum. During P1 (5 d), pigs were fed their respective dietary treatments ad-libitum and kept in TN conditions. During P3 (35 d), HSCtl and HSCr pigs were fed ad-libitum and exposed to progressive cyclical HS conditions (27 to 31°C, 50 ± 0.3% RH) while TNCtl, TNCr, PFCtl and PFCr pigs remained in TN conditions and were fed ad-libitum or pair-fed to their HSCtl and HSCr counterparts. Overall, pigs exposed to HS had increased ($P < 0.01$) rectal temperature, skin temperature and respiration rate (0.40°C, 3.8°C, 32 bpm, respectively). HS decreased ($P < 0.01$) ADFI (20%), and ADG (21%) compared to TN controls. Final BW was increased in HSCr (2.00 kg, $P = 0.03$) compared to HSCtl pigs, and ADFI tended to be increased in HSCr during P2 relative to HSCtl treatment (0.78 vs. 0.72 kg/d; $P = 0.08$). During TN conditions there were no effects of Cr on most production parameters, but ADFI tended to be increased in Cr relative to Ctl-fed pigs (3.29 vs.

3.09 kg/d; $P = 0.08$). No effects of Cr supplementation were detected on circulating blood glucose, insulin, NEFA, cholesterol, triglycerides and LPS binding protein. However, blood neutrophils were increased in HSCr (38%; $P = 0.02$) relative to HSCtl pigs. In summary, these findings suggest chromium supplementation may be beneficial to growth performance and health during HS.

Key Words: Growth performance, biomarkers of metabolism, pair-fed animals

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307 Supplementation of a *Lactobacillus acidophilus* fermentation product can attenuate the acute phase response following a lipopolysaccharide challenge in pigs. P. R. Broadway*[1], J. A. Carroll[1], N. C. Burdick Sanchez[1], B. E. Bass[2], J. W. Frank[2], *[1]USDA-ARS, Livestock Issues Research Unit, Lubbock, TX, [2]Diamond V, Cedar Rapids, IA.*

This study was designed to determine if feeding a *Lactobacillus acidophilus* fermentation product to weaned pigs would reduce stress and acute phase responses (APR) following a lipopolysaccharide (LPS) challenge. Pigs ($n = 30$; 6.4 ± 0.1 kg BW) were housed individually in pens with ad libitum access to feed and water. Pigs were weighed on arrival, assigned to 1 of 3 groups ($n = 10$/treatment), and fed for 18 d: 1) Control, fed a non-medicated starter diet; 2) Control + *Lactobacillus acidophilus* fermentation product at 1 kg/MT (SGX1; Diamond V SynGenX, Cedar Rapids, IA), and 3) Control + *Lactobacillus acidophilus* fermentation product at 2 kg/MT (SGX2). Pigs were anesthetized on d 7 and 14 for insertion of an i.p. temperature device and jugular catheter, respectively. On d 15, pigs were challenged i.v. with LPS (25 μg/kg BW). Blood samples were collected at 0.5 h (serum) and 1 h (complete blood cell counts) intervals from −2 to 8 h and at 24 h relative to LPS administration at 0 h. Pigs were weighed on d 7, 14, and 18, while feeders were weighed on d 7, 11, 14, 17, and 18. There was a treatment by time interaction ($P < 0.01$) for pig BW and ADG. The SGX1 pigs had the greatest body weight at 7, 14, and 18 d. Pig ADG was greater in SGX1 and SGX2 on d14, yet was less on d18 compared to Control. In response to LPS, there was a greater change in i.p. temperature in Control pigs compared to SGX1 and SGX2 pigs ($P < 0.01$). There was a treatment by time interaction ($P = 0.006$) for cortisol; SGX2 pigs had decreased cortisol from 2.5 to 4.5 h and at 5.5 and 6.5 h compared to SGX1 and/or Control pigs. White blood cells, neutrophils and lymphocytes were decreased in SGX1 and SGX2 compared to Control pigs ($P < 0.001$). There were treatment by time interactions for TNF-α, IFN-γ and IL-6 ($P \leq 0.04$). Specifically, SGX1 pigs had a decreased ($P \leq 0.04$) TNF-α response while SGX2 pigs had a greater ($P \leq 0.01$) response. The IFN-γ response was delayed and decreased in SGX2 pigs compared to Control and SGX1 pigs ($P \leq 0.02$). The IL-6 response was decreased in both SGX1 and SGX2 compared to Control pigs ($P \leq 0.01$). These data demonstrate that feeding a *Lactobacillus acidophilus* fermentation product to weaned pigs can attenuate the APR to an LPS challenge.

Key Words: acute phase response, *Lactobacillus acidophilus* fermentation product, lipopolysaccharide

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308 Intestinal microbiota and expression of genes involved in immunity are modulated in nursing piglets by growth performance in the first week of life. M. Lessard*[1], K. Deschíne[2], B. Morissette[2,3], M. Blais[2], F. Beaudoin[2], K. Lauzon[2], G. Talbot[2], *[1]Agriculture and Agri-Food Canada, Sherbrooke, QC, Canada, [2]Agriculture and Agri-Food Canada, Dairy and Swine Research and Development Centre, Sherbrooke, QC, Canada, [3]Université de Sherbrooke, Sherbrooke, QC, Canada.*

Growth performance of newborn piglets within a litter can be quite variable during the first wk of life. This study was performed to determine the impact of piglet growth on development of intestinal microbiota and immunity. Eight litters were used to select, within each litter, the piglets showing the lowest weight gain (LWG) and the highest weight gain (HWG) in their first week of lactation. At 16 d of age, the intestinal microbiota of LWG and HWG piglets were compared by amplicon length heterogeneity PCR. The data were analyzed by nonmetric multidimensional scaling (NMS) and multi-response permutation procedure (MRPP) to determine differences in microbial composition between treatments. Ileal mucosa samples were also taken to extract RNA for microarray analysis and gene expression by quantitative PCR. NMS analyses showed that LWG piglets harbored a distinct microbiota compared to HWG in the ileum and colon contents. In the ileum, the mucosa associated microbiota tended to be different in LWG piglets compared to HWG piglets (MRPP at $P < 0.1$) whereas in the colon, the luminal microbiota differed significantly ($P < 0.05$). Expression of several genes involved in innate immunity against microbial pathogens such as *MYD88, TLR4, TLR9, NOD2, NOS2, SOD1* and *CD74* was significantly ($P < 0.05$) downregulated in the ileum of LWG piglets compared to HWG piglets. These results indicate that growth performance in the first week of life affected the establishment of intestinal microbial populations and influenced the gene expression involved in innate immunity against microbial pathogens. As growth performance in the first week of life is closely related to colostrum and milk intake, these results suggest that bioactive factors in colostrum and milk can affect colonization of bacterial populations in the gut and the intestinal immune response early in life.

Key Words: immune response, microbiota, intestine, growth, piglets

309 Evaluation of a QTL for porcine circovirus type 2b (PCV2) viral load on growth performance in inoculated and vaccinated pigs for PCV2.

D. M. van Sambeek*, E. R. Tosky, P. S. Miller, D. C. Ciobanu, T. E. Burkey, *University of Nebraska, Lincoln.*

Data from a previous PCV2b experimental challenge revealed the presence of a QTL associated with viral load, a measure of susceptibility. A study was conducted to evaluate the effects of this QTL on growth in PCV2b-experimentally infected and vaccinated pigs. Before challenge the pigs were genotyped for the QTL (*CC*, resistant; *TT*, susceptible; and *CT*) and profiled for PCV2-specific maternal antibodies. Experimental pigs were either vaccinated (VAC) at 3 wk of age, or inoculated (NOV) with PCV2b at 5 wk of age. Pigs (n = 111) were allocated to 5 groups; VAC included pigs with *CT* and *TT* genotypes while NOV included pigs with all genotypes. Pigs were allocated to pens by genotype-PCV2b treatment, and were ad libitum fed an antibiotic free, corn-soybean meal based nursery diet that met or exceeded NRC (2012) requirements. Titanium dioxide was added to the diet as an indigestible marker. Feed disappearance and individual BW were obtained weekly for determination of ADG and feed disappearance. Blood (for viremia analysis) and fecal samples (for microbiome analysis; data not shown) were collected weekly. Pen fecal samples were collected at wk 2, 4, and 6 for digestibility analyses (data not available). Overall, ADG, feed disappearance, and BW were not different between treatment, genotype, or treatment × genotype ($P > 0.10$). In the NOV group, the *CC* genotype had numerically greater BW than *CT* and *TT* genotypes throughout the 6 wk trial (33.9, 30.9, and 29.5 kg at wk 6, respectively). This trend, with the *C* allele being considered favorable, was consistent in the VAC pigs (*CT* = 32.8 kg; *TT* = 30.4 kg). Although d 7–28 viremia data showed an increased viral titer in NOV pigs as expected, the *CC* genotype had a reduced titer compared with the *CT* and *TT* genotypes ($P < 0.05$). These preliminary data suggest that selection for the *CC* genotype may reduce the need for PCV2 vaccination by providing greater resistance to PCV2 challenge compared to the other genotypes. However, additional research is needed to delineate the long term and cellular effects of this QTL.

Key Words: pig, porcine circovirus type 2b, vaccine

310 Piglet growth before weaning has long-term effects on intestinal barrier function.

A. Mereu[*1], J. J. Pastor[1], D. Chin[2], G. Rimbach[2], I. R. Ipharraguerre[1,2], [1]*Lucta S.A., Barcelona, Spain,* [2]*Institute of Human Nutrition and Food Science, University of Kiel, Kiel, Germany.*

In mice, weaning stress increases intestinal permeability partly through a mechanism that involves TNF-α, intestinally-produced glucocorticoids, and myosin like chain kinase (MLCK). Recent evidence suggests that this interplay takes place predominantly in the colonic mucosa and has long-lasting effects on intestinal development and function. Interestingly, the impact of weaning-induced intestinal dysfunction is inversely correlated to age at weaning. However, little is known about the impact that pre-weaning growth has on postweaning gut permeability and animal performance. The aim of this experiment was to investigate the effect of pre-weaning growth on intestinal permeability and underlying regulatory pathways. To this end, 18 piglets ((LW × LD) × Pietrain) were weighed and identified at birth. At weaning (21 d of age) piglets were divided into 2 groups (n = 9): fast growers (FG) or slow growers (SG) according to their growth rate from birth to weaning. Thereafter, piglets were housed individually and fed ad libitum non-medicated pre-starter (21–35 d) and starter (35–56 d) feeds. Individual BW and feed intake were registered weekly. On Day 56, plasma for cortisol determination and recovery of permeability markers (Co-EDTA and mannitol) was obtained 1 h after marker intragastric infusion. Immediately after, ascendant colon samples were harvested for measurement of cortisol, TNF-α and MLCK mRNA in colonic mucosa. Performance data were analyzed with a mixed-effect model with repeated measures in which pig was treated as random and treatment, week and its interaction were considered fixed effects. Pigs in the SG group had a lower pre-weaning growth rate (181 vs. 208 ± 13.1 g/d; $P < 0.04$) and BW at d 21 (6.0 vs. 6.3 ± 0.005 kg; $P < 0.05$) than FG counterparts. At d 56, plasma cortisol was not different between groups. However, the ratio Co/mannitol in plasma was higher in SG than FG (28.7 vs. 11.9 ± 13.0; $P < 0.001$). In addition, SG pigs had a higher concentration of cortisol (20.0 vs. 2.5 ± 2.7 ng/mg of protein; $P < 0.001$) and TNF-*a* (0.15 *vs.* 0.09 ± 0.01 ng/mg of protein; $P < 0.001$) in the colonic mucosa. Interestingly, abundance of MLCK mRNA in colon mucosa was 35% lower ($P < 0.05$) in FG compared with SG. In conclusion, pre-weaning growth rate has a long-lasting impact on gut permeability and the mechanism underlying this phenomenon appears to be regulated locally at the colon epithelium.

Key Words: permeability, stress, cortisol

311 Dietary D-xylose effects on growth performance and portal-drained viscera nutrient fluxes, insulin production, and oxygen consumption in growing pigs. A. K. Agyekum[*1], M. C. Walsh[2], E. Kiarie[1,3,4], J. S. Sands[1,5], C. M. Nyachoti[1], *[1]University of Manitoba, Winnipeg, MB, Canada, [2]Danisco Animal Nutrition, DuPont Industrial Biosciences, Marlborough, UK, United Kingdom, [3]DuPont Industrial Biosciences- Danisco Animal Nutrition, Marlborough, United Kingdom, [4]University of Guelph, Guelph, ON, Canada, [5]BioQuest UK Ltd, Marlborough, United Kingdom.*

Addition of xylanase to pig diets rich in insoluble fiber can promote nutrient digestibility and pig performance. However, high doses of xylanase could result in high xylose release, particularly in diets with high cereal co-products, which are rich in xylose. It is well documented that free dietary xylose has negative effects in non-ruminants. However, the amount of xylose that could elicit such adverse effects is not known in pigs. Thus, 2 experiments were conducted to investigate the effects of dietary D-xylose on growth performance and portal-drained viscera (PDV) fluxes of glucose (GLU), essential AA (EAA), urea-N (BUN), insulin production, and O_2 consumption in growing pigs. In Exp. 1, 32 pigs (21.4 ± 0.1 kg BW; 8 pigs per diet) were used to determine the effects of replacing 25% cornstarch (CS) with D-xylose (w/w basis; 0, 5, 15, and 25%) in corn-soybean meal-based diet on pig performance in a 28-d trial. The results indicated that up to 15% dietary D-xylose did not reduce ($P > 0.10$) pig performance, whereas replacing 25% of CS with 25% D-xylose resulted in a 10%-unit decline ($P < 0.05$) in body weight and feed efficiency. In Exp. 2, six portal-vein catheterized gilts (22.8 ± 1.6 kg BW) were fed the 0 and 15% D-xylose diets at 4% of their BW once daily at 0900 h for 7 d in a crossover design (6 pigs per diet). On d 7, para-amino hippuric acid was infused into the ileal vein to measure blood flow rate (BFR), whereas blood was sampled from the portal vein and carotid artery for 6 h, postprandially, to assay GLU, O_2, BUN, insulin, and EAA concentrations. Diet had no effect ($P > 0.10$) on postprandial BFR, insulin production, and portal BUN and AA fluxes. In addition, diet had no effect ($P > 0.10$) on postprandial portal AA concentrations. Pigs fed 0% D-xylose had greater portal and carotid GLU ($P < 0.05$) and BUN ($P < 0.10$) concentrations, and portal GLU fluxes ($P < 0.05$) than pigs fed 15% D-xylose diet. Further, postprandial PDV O_2 consumption was greater ($P < 0.05$) in pigs fed 0% D-xylose diet than those fed 15% D-xylose. In conclusion, 15% D-xylose did not reduce pig performance, postprandial AA fluxes or increase PDV energetic demand, but reduced glucose fluxes linked to low dietary glucose. However, 25% xylose reduced growth performance in growing pigs.

Key Words: D-xylose diet, performance, net portal flux, nutrients, pig

312 Use of AliveCor heart monitor for heart rate and rhythm evaluation in domestic water buffalo calves. J. Smith[*1], J. Ward[1], T. Urbano[2], M. Mueller[3], *[1]Iowa State University College of Veterinary Medicine, Ames, [2]School of Veterinary Medicine, University of California Davis, Davis, [3]Blue Pearl Veterinary Partners, Seattle, WA.*

Objectives of this study were to evaluate the use of a smartphone-based electrocardiogram (ECG) device (AliveCor EC-G™) in dairy water buffalo calves for the determination of heart rate and rhythm as part of an adjunct to physical examination. Additionally, the quality of ECG from the AliveCor device was compared to a standard 6-lead ECG. We hypothesized that the AliveCor device could be used to obtain an accurate heart rate and rhythm in water buffalo calves in a field setting. Six healthy neonatal water buffalo calves had simultaneous AliveCor and standard 6-lead ECGs performed. The AliveCor ECG was recorded with the device placed over the left cardiac apex. Paper speed was 25 mm/sec and amplitude was 10 mm/mV. All ECGs were evaluated unpaired and independently by a data-blinded veterinary cardiologist. The average heart rate was determined based on 6 s of ECG recording, rhythm diagnosis was recorded for each tracing, and each ECG was assigned a quality score from 0 (high quality) to 3 (low quality). The findings were then reviewed to determine if the AliveCor device was comparable to the 6 lead ECG for rate and rhythm diagnosis. A paired *t* tests was used to assess for significant differences between each calf's average heart rate determined by the AliveCor device and the 6-lead ECG, and a Mann–Whitney test was used to assess the quality scores between the 2 readings for each calf. There was no significant difference between average heart rate obtained between AliveCor recordings when compared to those from the 6 lead ECG ($P = 0.174$). Average group quality scores were 1.167 (± 0.753) for the standard ECG and 0.833 (± 0.753) for the AliveCor. No significant difference was observed between standard and AliveCor quality scores ($P = 0.6250$). A normal sinus rhythm was diagnosed for all 12 recordings. We conclude that the AliveCor device allows for accurate heart rate determination and diagnosis of a normal sinus rhythm in neonatal diary water buffalo calves in a field setting. Thus, the AliveCor could serve as an adjunct for data collection from water buffalo calves in both research and clinical settings.

Key Words: AliveCor, Cardiology, Bubaline, Smartphone

313 Plasma analytes concentrations of beef heifers diverging in frame size and known feed efficiency group. A. B. P. Fontoura*, F. E. Doscher, C. R. Dahlen, K. Ringwall, K. A. Vonnahme, L. L. L. H. Hanna, K. C. Swanson, *North Dakota State University, Fargo.*

Blood plasma analytes might reflect important variation in metabolism and be associated with efficiency of feed utilization and also animal size. Thus, objectives were to evaluate the concentrations of glucose and plasma urea-N in beef heifers from 2 frame size groups and also divided into 2 residual feed intake (RFI) groups using 2 prediction models as measures of feed efficiency. A group of 89 crossbred heifers (initial BW = 342 ± 3.4 kg, n = 89) was tested over a 106-d period. Heifers were fed a forage-based diet allowing for ad libitum consumption. Feed intake was individually measured using the Insentec feeding system. Heifers were sorted into 2 groups based on frame score: small to moderate (< 5.5, average frame size = 4.27 ± 0.132, average BW = 317 ± 6.1 kg, n = 49), or moderate to large (≥ 5.5, average frame score = 6.45 ± 0.191, average BW = 371 ± 11.8, n = 40). Body weights were measured and blood was collected on d 1, 14, 28, 44, 59, and 106. Concentrations of glucose and urea-N were determined in plasma. Residual feed intake was calculated including body weight and gain (RFI_{Koch}) and by also including ultrasound for body composition (RFI_{us}). Heifers were divided into low (more efficient) and high (less efficient) RFI_{Koch} and RFI_{us} groups. Data were analyzed with the MIXED procedure of SAS using repeated measures. Glucose concentration did not differ between frame size groups (P = 0.60) or between RFI_{Koch} groups (P = 0.65). Plasma urea-N concentration was lower (P < 0.01) for small to moderate heifers in comparison to moderate to large heifers (14.27 vs. 14.94 mM). Plasma urea-N did not differ among RFI_{Koch} groups (P = 0.44). There was an interaction (P < 0.001) between RFI_{us} groups and sampling day for both plasma glucose (d 1, 28, and 44) and urea-N (d 1 and 28), as more efficient heifers had higher levels (4.55, 4.30 and 3.64 mM glucose; 16.41 and 15.28 mM urea-N; respectively) if compared to less efficient heifers (4.09, 3.75 and 3.02 mM glucose; 12.76 and 13.17 mM urea-N; respectively). These results indicate that glucose and urea-N may differ among body composition corrected efficiency groups and that urea-N may differ among frame size groups. Thus, accounting for body composition in the RFI model may result in a better prediction of physiological differences in blood metabolites, and consequently basal metabolism. In addition, supplementary studies will be conducted to further investigate the biological differences of blood analytes in animals differing in feed efficiency.

Key Words: glucose, residual feed intake, urea-N

314 A technique to ovariohysterectomize cattle for use in gestational research. K. J. McLean*[1], C. R. Dahlen[1,2], P. P. Borowicz[1,2], L. P. Reynolds[1,2], B. W. Neville[3], J. S. Caton[1,2], *[1]North Dakota State University, Fargo, [2]Center for Nutrition and Pregnancy, Fargo, ND, [3]Central Grasslands REC, North Dakota State University, Streeter.*

The time period from conception through the embryonic stage of development is critical in terms of establishment, recognition, and maintenance of pregnancy to term. Research on factors influencing embryonic development up to d 14 is relatively simple. Much less is known about the influences on conceptus (embryo and membranes) development from the time embryo flushing becomes impossible to the end of the embryonic stage (~d 16 to d 50 in bovine). To access this critical period we developed and optimized a standing flank hysterectomy procedure. Protocols for ovariectomy and cesarean section from veterinary medicine and research practices were combined and modified, resulting in the technique described herein. Briefly, heifers were placed in a cattle restraining chute and immobilized, administered local anesthetic into the left paralumbar fossa, and given an epidural nerve block. A vertical 18 to 25 cm incision was then made through the skin, muscle layers, and peritoneum into the peritoneal cavity via either blunt dissection or incision. Centauri knots were placed on the right and left uterine arteries, the right and left ovarian spiral arteries, and around the body of the uterus just cranial to the cervix and on the cranial end of cervix. Uterine/ovarian tissue was separated from the broad ligament and incised cranially from ligatures to include as much uterine body as possible. To optimize the procedure Angus crossbred heifers (n = 46; ~ 15 mo of age; BW = 362.3 ± 34.7 kg) were synchronized, bred via AI, and hysterectomized on d 16, 22, 28, 34, 40, or 50 of gestation or not bred (NP) and hysterectomized on d 16 of the estrous cycle. There was a strong negative correlation (r = −0.53, P = 0.0009) between time required for surgical procedure and progression of surgical optimization. Surgery time was least (P = 0.04) in NP controls (69.0 ± 20.8 min). Surgery times were also influenced by stage of gestation (P = 0.04). In pregnant animals, time decreased from d 22 (120.0 ± 12.0 min) to d 40 (79.5 ± 12.0 min); then increased at d 50 (90.5 ± 14.7 min). All heifers fully recovered, were placed on feed, and performed well in the feedlot (1.99 kg/d ADG; 13.77 DMI; 0.145 G:F; 2% Select, 71% Choice, and 27% Prime). This technique offers a plethora of opportunities to explore factors related to pregnancy success and document embryo and placental development in detail.

Key Words: Bovine, Early Gestation, Ovariohysterectomy

Table 316. Correlation of postnatal sampling times (h) for serum BUN, plasma glucose, serum total protein, and serum globulin concentrations (mg/dL) in beef calves through 72 h

	0 vs. 6	0 vs. 12	0 vs. 24	0 vs. 48	0 vs. 72	6 vs. 12	6 vs. 24	6 vs. 48
BUN	0.63**	0.30	0.09	0.04	−0.08	0.88**	0.57**	0.23
Glucose	0.69**	−0.07	0.02	0.39*	0.11	0.45*	0.43*	0.38*
Protein	0.19	0.15	0.18	0.03	−0.10	0.74**	0.45**	0.57**
Globulin	−0.12	−0.23	0.18	0.01	0.16	0.64**	0.44**	0.52**
	6 vs. 72	12 vs. 24	12 vs. 48	12 vs. 72	24 vs. 48	24 vs. 72	48 vs. 72	
BUN	0.11	0.83**	0.52**	0.45*	0.75**	0.57**	0.84**	
Glucose	−0.29	0.59**	0.04	−0.47*	0.34	0.15	0.24	
Protein	0.38*	0.84**	0.90**	0.40	0.97**	0.10	0.14	
Globulin	0.21	0.85**	0.90**	0.40	0.98**	0.71**	0.71**	

**$P \leq 0.05$, *$P \leq 0.10$

315 Relationship between ovarian reserve and preovulatory estradiol during a fixed-time AI protocol in beef heifers. M. Soares[*1], R. A. Cushman[2], E. J. Northrop[3], E. L. Larimore[4], G. A. Perry[5], *[1]Federal University of Santa Maria, Santa Maria, Brazil, [2]USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE, [3]Department of Animal Science, South Dakota State University, Brookings, [4]South Dakota State University, Brookings, [5]Department of Animal Science, South Dakota State University, Brookings.*

Estradiol production is essential for reproductive efficiency. This study compared numbers of follicles in beef cows that did or did not have elevated preovulatory estradiol during a fixed-time AI (FTAI) protocol. In experiment 1, 5 low estradiol (LowE2) and 5 high estradiol (HighE2) cows were slaughtered at time of FTAI. In experiment 2, 17 LowE2 and 12 HighE2 cows were slaughtered 16 d after FTAI. Ovaries were collected at slaughter and all visible surface follicles (AFC) were counted. A representative cross-section of the ovary was fixed in paraformaldehyde and embedded in paraffin for histological evaluation. Ovaries were sectioned and 5 sections (6-μm thick) were collected with a minimum of 10 sections between them. Sections were stained with hematoxylin and eosin. Follicles were counted and classified as primordial (oocyte surrounded by a single layer of squamous pregranulosa cells); primary (oocyte surrounded by a single layer of cuboidal granulosa cells); secondary (oocyte surrounded by 2 or more layers of granulosa cells) or antral. Follicle classification and AFC were analyzed using MIXED procedure (SAS) with estradiol group, experiment, and their interaction as fixed effects and animal as random effect. There was a tendency ($P = 0.06$) for an estradiol and experiment interaction on AFC. HighE2 in experiment 1 had the greatest AFC (57 ± 5.3), LowE2 in experiment 1 were intermediate (37.8 ± 4.3). Both HighE2 (20.2 ± 3.1) and LowE2 (16.4 ± 2.7) in experiment 2 were similar and had fewer AFC. There were no effects of treatment, experiment or interaction on number of primordial follicles ($P > 0.45$). There tended ($P = 0.06$) to be an effect of experiment on number of primary (6.2 ± 1.5 vs. 3.1 ± 1.0; experiment 1 and 2) and secondary (0.29 ± 0.32 vs. 0.95 ± 0.20; experiment 1 and 2) follicles. There was an estradiol by experiment interaction on number of antral follicles ($P < 0.01$). Antral follicles were greater in HighE2 in experiment 1 (9.1 ± 1.2), LowE2 in experiment 1 were intermediate (5.4 ± 0.68). Both HighE2 (2.4 ± 0.5) and LowE2 (0.8 ± 0.7) in experiment 2 had fewer antral follicles but HighE2 tended ($P = 0.07$) to have more than LowE2. These results indicate that cows with elevated concentrations of preovulatory estradiol have a greater number of antral follicles that is not associated with an increase in the ovarian reserve. USDA is an equal opportunity provider and employer.

Key Words: Fertility, Ovarian Reserve, Estradiol

316 Does sampling time matter? Relationships of circulating metabolites at various neonatal sampling times in beef calves. J. M. Larson[*1], B. L. Vander Ley[2], S. M. Bolen[1], N. B. Duncan[1], A. M. Meyer[3], *[1]Division of Animal Sciences, University of Missouri, Columbia, [2]Department of Veterinary Medicine and Surgery, University of Missouri, Columbia, [3]University of Missouri, Columbia.*

The objective of this study was to evaluate the relationships of neonatal sampling times for the analysis of circulating blood urea nitrogen (BUN), glucose, total protein, and globulin. A total of 66 fall-calving beef cows and heifers were monitored during calving, and calf blood samples were obtained from a subset ($n = 24$; average age = 4.4 ± 0.5 yr; average BCS = 5.2 ± 0.1; average calving date = September 11, 2015). Jugular blood samples were obtained from 8 bull and 16 heifer calves at 0, 6, 12, 24, 48, and 72 h postnatally for serum BUN, plasma glucose, serum total protein, and serum globulin analysis. Samples at 0 h were obtained before colostrum intake but after standing. Correlations were determined between each sampling hour within metabolite (Table 316). Metabolites at 0 h were correlated with few other sampling times. However, samples collected at 6 h had moderate or strong positive correlations with samples from 12 to 48 h. In general, there

were a greater number of positive relationships in metabolites from consecutive sampling times. In conclusion, a consistent blood sampling time is necessary for determination of metabolite concentrations in neonatal beef calves, especially in pre-colostral samples. These data suggest that circulating metabolites at neonatal sampling times are more related after colostrum consumption.

Key Words: colostrum, metabolites, neonates

317 Relationships between pig birth weight and expression of the immediate early gene EGR-1 in umbilical cord Wharton's jelly. J. M. Morton*, T. Rathbun, D. L. Davis, *Kansas State University, Manhattan.*

In humans the expression of EGR-1 in umbilical cord Wharton's jelly has been related to birth weight. In umbilical cords of small for gestational age (**SGA**) babies the expression of EGR-1 is increased compared to normal weight contemporaries. Expression of EGR-1 appears to indicate prenatal programming resulting from growth restriction. It is known that SGA babies develop slower compared to normal sized babies and in many ways are comparable to small birth weight pigs. Therefore we investigated whether EGR-1 expression in pig umbilical cord Wharton's jelly is related to birth and weaning weights. Fifty-seven umbilical cords were collected from 5 litters (PIC; 326 × 1050), along with birth and weaning weights. Wharton's jelly tissue was snap frozen and stored (−80°C) until RNA was extracted (Trizol method), RNA quantity determined using the Nanodrop method and quality was evaluated with an Agilent Bioanalyzer. Quantitative PCR was used to determine expression of EGR-1 compared to 18S and the data converted to relative expression using RNA from newborn pig testis as a calibrator. Birth weight ($P < 0.003$) and wean weight at d 21 ($P < 0.026$) were correlated negatively with EGR-1 expression. Larger pigs had decreased expression of EGR-1 compared to smaller pigs. The umbilical cords from the 14 pigs with the lowest expression of EGR-1 (bottom quartile) included only one pig with a birth weight < 1.11 kg while the top quartile included 9 pigs weighing less than 1.11 kg at birth ($P < 0.002$, chi square). In response to rising global demands for pork, swine producers have increased litter sizes and this has resulted in more small pigs at birth. We have identified that pigs with a birth weight below 1.11 kg have increased mortality rates by weaning age (3–4 wk). These pigs do not grow as well as their heavier contemporaries and result in lower value carcasses. Expression of EGR-1 in umbilical cords of low birth weight pigs appears to reflect prenatal programming comparable to that identified in SGA babies.

Key Words: pigs, prenatal programming, EGR-1

318 Impact of cyclical heat stress during follicular development on ovarian TLR4, PI3K and steroidogenic proteins in synchronized post-pubertal gilts. A. A. Al-Shaibi*, B. J. Hale, C. L. Hager, J. W. Ross, L. H. Baumgard, A. F. Keating, *Iowa State University, Ames.*

Heat stress (HS) is caused by the sustained elevation of core body temperature due to high ambient temperatures. HS is associated with seasonal infertility, which results in economic losses for the swine industry. Hyperinsulinemia and metabolic endotoxemia are physiological hallmarks of HS, both of which potentially modulate ovarian function via the toll-like receptor 4 (TLR4), the receptor for LPS, and/or the phosphotidylinositol-3 kinase (PI3K) pathways. Our previous findings demonstrated that HS enhanced phosphorylation of ovarian AKT (pAKT), increased TLR4, steroidogenic acute regulatory protein (StAR), and aromatase (CYP19A) protein abundance in pre pubertal gilts exposed to 7 or 35 d of HS. The current study investigated whether HS also altered TLR4, PI3K and enzymes involved in steroid hormone production in heat-stressed, post-pubertal gilts. The estrous cycles of 12 post-pubertal gilts were synchronized using Matrix®, administered orally for 14 d, followed by exposure to thermal neutral conditions (TN; 20.3°C ± 0.1°C) or cyclical HS conditions (26–32°C) during follicular development (5 d) preceding ovulation. Both TN and HS gilts were limit-fed 2.7 kg/d for the duration of the study. HS gilts had increased ($P = 0.01$) average rectal temperatures (39.8°C ± 0.2°) compared to the TN controls (38.8°C ± 0.2°) demonstrating hyperthermia in response to elevated ambient temperatures. Gilts were euthanized and ovaries collected for protein isolation and analysis. The abundance of ovarian pAKT, StAR, CYP19A and TLR4 were determined using western blotting. No impact ($P > 0.05$) of HS on protein abundance of CYP19A or StAR was observed. TLR4 was increased ($P < 0.05$) in ovaries from HS gilts relative to the TN controls. Additionally, HS decreased ($P < 0.01$) phosphorylation of ovarian AKT, relative to TN gilts. These findings demonstrate that ovarian signaling is altered by HS: activation of TLR4 indicates an ovarian response to elevated, systemic LPS, while decreased pAKT may reflect reduced altered PI3K activity. These data provide mechanistic insight into ovarian physiological alterations that could contribute to seasonal infertility in post-pubertal swine. This work was supported by the Iowa Pork Producers Association.

Key Words: Heat Stress, TLR4, PI3K, AKT, Endotoxemia

319 The protective effects of Butipearl™ Z during heat stress as measured through in vitro studies with swine intestinal epithelial cells and an in vivo swine trial. V. Mani*[1], J. K. Rubach[1], D. A. Koltes[2], N. K. Gabler[3], M. J. Poss[1], [1]*Kemin Industries, Des Moines, IA,* [2]*Universtiy of Arkansas, Fayetteville,* [3]*Iowa State University, Ames.*

Heat stress (HS) is a major issue and negatively impacts the performance and well-being of all animals. Each year, financial losses from HS in production animals is estimated to be more than a billion dollar worldwide. A significant portion of the damage due to HS occurs in the intestine which leads to compromised intestinal integrity, decreased feed intake, decreased nutrient adsorption and poor gut health. Currently, there are few effective products which provide HS protection. Zinc is an essential trace mineral involved in tight junction formation and butyric acid is an energy source and signaling molecule. Separately, both molecules have been shown to have consistent beneficial effects toward gut health. It was hypothesized that combining zinc and butyric acid together would harvest the benefits of both molecules. A novel formulation containing both zinc oxide and butyric acid was synthesized, encapsulated and is marketed as ButiPEARL™ Z (BPZ). The effectiveness of BPZ during HS was tested using pig intestinal epithelial cells (IPEC-J2) and a swine HS trial. The in vitro tight junction integrity in cell culture was determined by measuring the transepithelial resistance (TER) of the cells. To determine if BPZ is effective in mitigating HS, IPEC-J2 cells were incubated at thermoneutral (37°C) or HS (41.5°C) conditions. A 300 µM dose of BPZ with HS treatment resulted in TER values equivalent to cells grown at thermoneutral conditions ($P < 0.05$). To test the efficacy of encapsulated BPZ on mitigating HS in vivo, a swine trial was conducted with 24 pigs ($n = 12$ pigs/trt). Pigs were supplemented with BPZ or fed a control diet for 4 wk. Pigs were exposed to biphasic HS, 32°C for 8 h and 28°C for 16 h, for a week after the initial 4 wk. Pigs were euthanized at the end of the HS period. Fresh ileum and colon samples were collected and studied on Ussing chambers to measure ex vivo intestinal integrity. During the growth phase, there was a trend for higher ADFI and ADG in pigs fed the BPZ treatment ($P < 0.1$). During HS, ADG and Gain:Feed were statistically higher in BPZ group ($P < 0.05$) and ADFI was numerically higher. Additionally, macromolecule permeability in the ileum and colon was numerically lower and villus height and villus height to crypt depth ratio were numerically higher which indicates a more intact tight junction in the BPZ group. The data provides evidence BPZ may mitigate the negative effects of HS.

Key Words: swine, heat stress, zinc

320 Effect of hot temperature and drinker type on growth performance of and water disappearance by growing-finishing pigs. K. Vande Pol*[1], N. S. Grohmann[1], T. E. Weber[2], M. J. Ritter[2], M. Ellis[1], [1]*University of Illinois, Champaign-Urbana,* [2]*Elanco Animal Health, Greenfield, IN.*

This study evaluated the water disappearance of growing-finishing pigs using a split-plot design with a 2 × 2 factorial arrangement: Room Temperature (Thermoneutral (TN) vs. Hot; Main Plot). Drinker Type (Nipple vs. Cup; Sub Plot). A total of 320 pigs housed in 4 rooms (8 pens/room; 10 pigs/pen) were used. Two rooms were at a constant TN temperature (decreasing from 24 to 18°C from start to end of the study) and 2 rooms at a Hot temperature (30°C daytime and 20°C nighttime). Pens had fully-slatted concrete floors with 1 feeder/pen and either a nipple or a cup drinker; floor space was 0.67m^2/pig. Pigs were phase fed industry standard corn-soybean diets to meet or exceed NRC (2012) requirements. Pigs were weighed at the start and end of, and bi-weekly throughout the study; all feed additions were recorded. Water disappearance was measured using a meter fitted to the water line supplying each pen. Results are summarized below. There were no ($P > 0.05$) Drinker Type by Room Temperature interactions. Drinker Type did not affect ($P > 0.05$) growth performance, but water disappearance was greater ($P < 0.01$) for nipple than cup drinkers. Pigs on the Hot treatment were lighter ($P < 0.05$), grew more slowly ($P < 0.001$), and had numerically greater water disappearance ($P = 0.20$) than those on the Thermoneutral treatment. These results suggest that drinker

Table 320. Least squares means for the effect of drinker type and room temperature on growth performance and water disappearance of growing-finishing pigs.

	Drinker Type (DT)			Room Temperature (RT)			*P*-value		
Item	Nipple	Cup	SEM	Hot	TN	SEM	DT	RT	DT × RT
Body weight, kg									
Week 7 postweaning	27.0	26.8	0.39	26.9	27.0	0.35	0.51	0.18	0.81
Week 24 postweaning	131.2	130.6	0.54	126.7[b]	135.1[a]	0.31	0.56	0.04	0.15
Average daily gain, kg	0.91	0.91	0.007	0.87[b]	0.95[a]	0.009	0.93	< 0.0001	0.24
Average daily feed intake, kg	2.56	2.53	0.062	2.41	2.68	0.085	0.45	0.27	0.30
Gain:Feed, kg:kg	0.356	0.360	0.0058	0.362	0.354	0.0075	0.20	0.59	0.38
Average daily water disappearance, L/pig	6.74[a]	6.30[b]	0.092	6.94	6.10	0.152	0.004	0.20	0.93

[a, b] Means within a row with different superscripts are different ($P \leq 0.05$).

type can affect water disappearance rates; further research is needed to quantify the amount of water wastage from pigs under commercial conditions.

Key Words: Water disappearance, temperature, drinker.

321 Effects of room temperature on ear surface temperature of late-finishing pigs. M. Hayes*[1], K. Vande Pol[1], T. E. Weber[2], M. J. Ritter[2], M. Ellis[1], *University of Illinois, Champaign-Urbana, [2]Elanco Animal Health, Greenfield, IN.*

Thermal imaging can be used to monitor the thermal comfort of pigs. The objective was to establish the effect of room temperature on skin surface temperatures using thermal imaging of pigs kept under conditions similar to commercial practice. The study was performed as a RCBD; with 2 room temperature treatments: 1) Thermoneutral (TN constant 18°C); and 2) Hot (30°C from 0800–1900; 20°C from 2000–0700). There were 4 rooms of finishing pigs (2 on each temperature treatment). Rooms had fully-slatted concrete floors and there were 8 pens of 10 pigs in each room; floor space was 0.67 m2/pig. Images were taken on 20 randomly selected pigs from each room every 2 wk over an 8-wk period during which mean BW increased from 83.8 ± 11.21 to 129.1 ± 11.42 kg. Images were taken of the ear using 2 cameras (FLIR E6 and IRISYS IRI4010; sensitivity of 0.06°C and 0.15°C, respectively; resolution of 160 × 120 pixels). Emissivity on all images was set at 0.98. Images from each camera were processed with the respective program (FLIR Tools, IRISYS 4000 Series Imager) Surface temperature was measured at 5 points along the centerline of the ear: where the ear joins the head, near the tip of the ear, and 3 points equidistant between these 2 points. All observations for both cameras across the study period were averaged by temperature treatment for each point and an unpaired *t* test was used to compare the effects of room temperature. The average ear temperature across all 5 points for the Hot and TN treatments was 26.5 ± 3.3°C, and 23.0 ± 5.6°C, respectively ($P = 0.11$). Ear temperature was greater ($P < 0.05$) for the Hot than TN treatment the tip of the ear (23.96°C and 18.52°C, respectively) but not at the other measurement points ($P > 0.05$). The difference in ear temperature between the point closest to the head and the tip of the ear was greater for the TN than the Hot treatment (4.12 and 8.11°C, respectively; $P < 0.0001$). These results suggest that high environmental temperatures increase the surface temperature at the extremity of the ear due to increased vasodilation, and that the difference in temperature from the base to the tip of the ear may be the most appropriate measurement to assess the thermal comfort of the animal.

Key Words: Thermal imaging, heat stress, vasodilation

322 Fetal and postnatal nutritional programming of reproductive performance in ruminants. R. A. Cushman*[1], M. Soares[2], M. Abedal-Majed[3], A. S. Cupp[3], G. A. Perry[4], H. C. Freetly[1], *[1]USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE, [2]Federal University of Santa Maria, Santa Maria, Brazil, [3]University of Nebraska-Lincoln, Lincoln, [4]Department of Animal Science, South Dakota State University, Brookings.*

The influence of nutrition on reproductive function in females has been studied for decades. In cows, early studies focused on the influence of nutritional status on the hypothalamic-pituitary-ovarian axis, demonstrating that in circumstances of extreme negative energy balance estrous cycles cease. More recently, studies have focused on nutritional programming, and the hypothesis that differential feeding at key developmental stages can have long-term effects on physiology. Anecdotal data reported impacts of drought on performance of the offspring of cows that were pregnant during the drought. Subsequent controlled studies demonstrated that changes in intake during gestation altered reproductive performance and ovarian development of the female offspring. During the peri-pubertal development period, decreasing nutrient intake decreased development costs and adapted heifers to perform better as cows when nutrient intake was limited. In addition, there may be other advantages to developing heifers under reduced caloric intake. In rodents, caloric restriction during the peri-pubertal period increased numbers of primordial follicle in the ovaries, prompting investigations into the influence of decreased caloric intake in developing replacement heifers on follicle numbers. A review of the literature reveals that differences among studies are significant and emphasizes the need to understand the basic mechanisms that are being influenced by nutritional programming. It is hypothesized that some of these programmed changes are due to epigenetic modification of the genome. Differential methylation, histone modification, and changes in microRNA profiles have all been reported to alter the genomic response when nutritional status is altered in rodents, but these epigenetic modifications in response to nutritional programming in beef cows have not been reported to date. This is partially due to the challenges of performing such research as controlled studies. In practice, heifers are fed in groups, but for research purposes, either very large numbers of heifers are needed or heifers must be individually fed. Depending on the experiment and the endpoints to be examined, such experiments can take anywhere between 4 mo and 6 yr to complete, and this timeframe is increased dramatically if it is a multi-year study. Thus, understanding the mechanisms in play will require a combination of in vivo and in vitro studies. If we can understand these mechanisms; however, then it may be possible to harness them and use targeted feeding to program heifers to their niche in the production system. USDA is an equal opportunity provider and employer.

Key Words: Nutrition, epigenetics, reproduction

323 Postnatal programming and reproductive development. F. F. Bartol[*1], C. A. Bagnell[2], *[1]Auburn University, Auburn, AL, [2]Rutgers University, New Brunswick, NJ.*

The idea, suggested by Charles Stockard in 1921, that there are critical periods during which disruption of the developmental program can have lasting effects on the form and function of tissues, organs and even organisms, is now over 90 yr old. Twenty years later, Conrad Waddington coined the term 'epigenotype' to describe mechanisms regulating development, and ultimately proposed that cell fate could be determined or programmed by changes in the 'epigenetic landscape'. The 'thrifty phenotype hypothesis', proposed by David Barker in 1990, advanced these ideas, suggesting that development includes programming by the environment in fetal and infant life, and that disruption of development during critical organizational periods can have life-long consequences. Much attention has been focused on identification of critical organizational periods during fetal life. However, it is important to remember that developmental plasticity and, consequently, susceptibility of tissues to developmental disruption does not end at birth but can extend into the postnatal period. Data for laboratory as well as large domestic animals indicate that targeted disruption of steroid hormone-sensitive developmental events during early neonatal life can alter the form and/or function of adult reproductive tract tissues, including the uterus. The uterine gland knockout (UGKO) phenotype, characterized by the absence of endometrial glands in adult sheep, cattle and mice exposed neonatally to steroidal compounds, provides the prototypical example of such programming effects. Factors affecting reproductive development can also be communicated from mother to offspring in first milk (colostrum) via a lactocrine mechanism. In the pig, imposition of a lactocrine-null state by substituting milk replacer for colostrum for 2 d from birth altered patterns of uterine gene expression and retarded endometrial gland development. Transcriptomic analysis of neonatal uterine gene expression in nursed as compared to replacer-fed gilts on postnatal Day 2 revealed over 800 differentially expressed, lactocrine-sensitive genes. A subset of non-coding microRNAs targeting over 100 lactocrine-sensitive uterine transcripts was recently identified, indicating potential for further epigenetic regulation of uterine development. Evidence that minimal colostrum consumption at birth is associated with reduced lifetime fecundity in adult sows supports the idea that lactocrine programming is a factor affecting reproductive efficiency. Data for the mouse indicating lactocrine effects on hippocampal development and memory, and for primates indicating lactocrine effects on offspring temperament and growth support a role for lactocrine regulation of postnatal development. Potential for transgenerational epigenetic effects emphasizes the importance of understanding the biology of postnatal programming and reproductive development.

Key Words: Postnatal programming, Lactocrine effects, Uterus

324 Recent advances in boar management. W. L. Flowers*, *North Carolina State University, Raleigh.*

Sperm production in boars has both developmental and functional components. Management during the first 60 d of life coincides with active periods of Sertoli cell mitotic activity and has permanent effects on spermatogenesis. Birth weight appears to hold promise as a prospective screening tool for replacement boars as it has a strong positive relationship with adult sperm production. Boars weighing at least 1.5 kg at birth produced 10 billion more sperm per ejaculate compared with their counterparts weighing 1.0 kg or less. Strategic cross-fostering during lactation and socialization to humans between 4 and 8 wk of age also have been shown to increase spermatogenesis. Ejaculates of boars allowed to nurse in litters of 6 contained more fertile sperm compared with those that were reared in a conventionally-sized litter of 9 or more. Socialization increased training success; libido; and sperm per ejaculate without any negative effects on sperm quality. Management of boars after puberty affects how efficiently sperm are produced by Sertoli cells and their subsequent maturation in the epididymis and has temporary effects on spermatogenesis which can be corrected in most cases. The most common of these include exposure to elevated ambient temperature, poor nutrition, inconsistent collection frequencies, and inadequate housing conditions. There is increasing evidence that most of the stresses in commercial production systems that affect semen quality and quantity appear to be multifaceted and chronic in they that are present at low levels over extended time periods. Consequently, multiple deficiencies that occur simultaneously are common and it is not until their additive effect reaches some presumed threshold that sperm production is compromised. Therefore, successful mitigation strategies to correct these problems that arise during the functional phase require a holistic approach which includes an assessment of all conditions and activities that have the potential to negatively affect sperm production in an additive fashion even though individually their impact may be minimal.

Key Words: Swine, boars, spermatogenesis

325 The effects of the nitric oxide (NO) system and nutritional plane on ovarian function in sheep. C. Bass*, D. A. Redmer, A. T. Grazul, *North Dakota State University, Fargo.*

Numerous factors influence reproduction including hormones, growth and angiogenic factors, nutritional plane, and supplements such as arginine (Arg), a semi-essential amino acid and precursor for proteins, polyamines, and nitric oxide (NO). Nitric oxide is a reactive gas molecule made naturally in the body and is critical for angiogenesis, which is the development of blood vessels, generally capillaries, from preexisting blood vessels to allow for blood flow to specific tissues. During a fe-

male's reproductive cycle, certain reproductive tissues undergo rapid changes including vascular development and regression, and tissue growth and regression. One of those tissues, the corpus luteum (CL), is critical for pregnancy as the tissue produces progesterone (P4), a pregnancy maintenance hormone. Therefore, the objective of this research was to investigate how manipulation of the NO system via Arg supplementation to nutritionally compromised ewes impacts ovarian function and endocrine activity in non-pregnant sheep. Feeding non-pregnant sheep to achieve different planes of nutrition (i.e., overfeeding or underfeeding) for a prolonged period of time resulted in different body conditions, ovulation rates in both non-stimulated and FSH-treated ewes, angiogenic factor expression in luteal tissues, serum P4 concentrations, and in vitro luteal cells and oocyte functions when compared to control ewes. Our current study was performed using non-pregnant animals, and therefore it provides novel information regarding the effects of Arg supplementation on ovarian function in animals fed different nutritional plane. In vivo Arg supplementation to non-pregnant ewes resulted in increased luteal vascularity and selected angiogenic factor expression in luteal tissue, but did not affect ovulation rate, CL weight, and P4 production. Additionally, Arg supplementation was associated with increased vascularization (as noted by increased endothelial cell marker CD31), but did not lead to changes in production of P4. Supplementation of Arg during in vitro maturation and fertilization resulted in increased lipid droplet accumulation in oocytes and decreased cleavage rates after in vitro fertilization, respectively. Future research explaining how the oocyte, as well as reproductive tissues, utilize(s) Arg may assist in elucidating why Arg supplementation to pregnant mothers is beneficial, while supplementation to non-pregnant females has limited effects. In summary, these studies contribute to the knowledge of nutritional plane and the NO system and how they influence reproduction in female livestock. The results obtained provide beneficial knowledge for future research regarding the improvement of reproductive efficiency in females, which could additionally assist producers considering therapeutic supplements for reproductively-sound livestock.

Key Words: arginine, nitric oxide, sheep

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326 Rapid fluctuations in ambient temperature before conception reduce fetal viability in replacement gilts. J. S. Johnson*[1], K. L. Martin[2], K. R. Stewart[2], *[1]USDA-ARS Livestock Behavior Research Unit, West Lafayette, IN, [2]Purdue University, West Lafayette, IN.*

Recently, we determined that rapidly cooling pigs after acute heat stress (HS) resulted in a pathological condition, and because rapid temperature fluctuations are associated with seasonal infertility in sows it could be hypothesized that these conditions are linked. To determine the effects of rapid temperature fluctuations on reproductive efficiency, 36 replacement gilts (137.8 ± 0.9 kg BW) were estrus synced and then 14.1 ± 0.4 d after estrus was confirmed, gilts were exposed to thermoneutral conditions (TN; n = 12; 19.7 ± 0.9°C) for 6 h, or HS (36.3 ± 0.5°C) for 3 h, followed by a 3 h recovery period (R) of rapid cooling (HSRC; n = 12; immediate TN exposure and cold water dousing) or gradual cooling (HSGC; n = 12; gradual decrease to TN conditions) over 2 consecutive d. Vaginal (T_V) and gastrointestinal tract temperatures (T_{GI}) were obtained every 15 min, and blood was collected on d 1 and 2 during the HS and R periods at 180 and 60 min, respectively. Pigs were bred 8.3 ± 0.8 d after thermal treatments, and then approximately 28.0 ± 0.8 d after insemination reproductive tracts were collected and total fetus number and fetal viability were recorded. Overall, HS increased T_V and T_{GI} (P = 0.01; 1.07 and 0.88°C, respectively) in HSRC and HSGC compared to TN pigs, but no differences were detected between HSRC and HSGC pigs. During R on d1 and d2, T_V was reduced from 15 to 105 min (P = 0.01; 0.33°C) in HSRC compared to HSGC pigs, but no overall differences in T_{GI} were detected (P < 0.05; 39.67°C). Rapid cooling increased (P < 0.05) circulating TNFα compared to HSGC and TN pigs during R-d1 (55.2%), HS-d2 (35.1%), and R-d2 (64.9%); however, no differences were detected between HSGC and TN pigs. Through R-d1, [insulin]:[glucose] was greater in HSRC versus HSGC and TN pigs (P = 0.01; 50.0 and 41.2%), and reduced (29.4%) in HSGC compared to TN pigs. On R-d2, [insulin]:[glucose] tended to be greater (P = 0.07; 25.0%) in HSRC compared to HSGC pigs. The estrus interval increased (P = 0.01; 4.5 d) in HSRC and HSGC treatments compared to TN controls. Viable fetuses tended to be reduced (P = 0.08; 10.5%) and moribund fetuses tended to be increased (P = 0.09; 159.3%) in HSRC compared to HSGC and TN pigs, but no differences were detected between HSGC and TN pigs. In summary, rapid temperature fluctuations before conception increase circulating cytokines and insulin resistance and this may be linked to reduced fetal viability.

Key Words: pigs, fetal viability, heat stress, temperature fluctuations

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327 Gonadotropin-releasing hormone II receptor (GnRHR-II) knockdown reduces testis size and decreases testosterone secretion during pubertal development in swine. A. T. Desaulniers*[1], R. A. Cederberg[1], G. A. Mills[1], C. A. Lents[2], B. R. White[1], *[1]University of Nebraska-Lincoln, Lincoln, [2]USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE.*

The second mammalian isoform of gonadotropin-releasing hormone (GnRH-II) functions quite differently from the classical form (GnRH-I) as it is a poor stimulator of gonadotropin release. Unlike most species, a functional GnRHR-II has been identified in swine. Our laboratory detected GnRHR-IIs on Leydig cells and demonstrated that GnRH-II stimulates testosterone release as effectively as GnRH-I, despite minimal

luteinizing hormone (LH) secretion. These data suggest that GnRH-II acts directly on Leydig cells to stimulate steroidogenesis. Therefore, we produced a knockdown (KD) swine line to further examine the function of GnRHR-II. Here, the objective was to evaluate testis size and serum hormone levels in transgenic males during pubertal development. GnRHR-II KD (n = 7) boars and littermate controls (n = 5) were monitored throughout development; blood was collected and testis size measured using calipers at 40, 100, 150, 190, 225, and 300 d of age. Predicted testis volume was calculated and serum was isolated for testosterone and LH radioimmunoassay. For testis volume, we observed an effect of line (P = 0.0006), time *(P* < 0.0001) and a tendency for a line by time interaction (P = 0.0731). By 300 d of age, testes from transgenics were smaller than littermate controls (559.9 ± 34.3 versus 772.6 ± 39.7 cm^3; P < 0.05) despite similar body weights (P > 0.05). We also observed an effect of line (P < 0.0001), time (P < 0.0001) and a line by time interaction (P = 0.0018) for serum testosterone concentrations. Testosterone levels were similar (P > 0.05) between lines from 40– 100 d of age but lower in transgenic boars at 150 (1.3 ± 0.9 versus 3.7 ± 1.0 ng/ml), 225 (6.9 ± 1.5 versus 15.2 ± 1.5 ng/ml) and 300 (12.2 ± 1.5 versus 21.3 ± 1.5 ng/ml) d of age. Notably, LH levels were similar (P = 0.91) between transgenic (0.34 ± 0.08 ng/ml) and littermate controls (0.32 ± 0.09 ng/ml) at 300 d of age, suggesting that LH is not mediating the diminished testosterone secretion observed in transgenics. Together these data indicate that in swine, GnRHR-II is involved in LH-independent steroidogenesis and postnatal testicular development. Partially supported by NIFA Hatch (NEB-26–199; BRW) and AFRI (2011–67015; CAL) funds. USDA is an equal opportunity provider and employer.

Key Words: GnRH-II, GnRHR-II, Swine

328 Physiological characteristics of late puberty gilts administered P.G. 600.

E. B. Kennedy*, M. T. Knauer, W. L. Flowers, *North Carolina State University, Raleigh.*

The objective was to determine the effect of P.G. 600 in gilts that did not show estrus in response to boar exposure at 180 d of age. Landrace × Large White composite gilts (n = 217) were housed in groups of 15 pigs per pen (0.84 m^2). Starting at 181 d of age, gilts were checked daily for estrus. After 29 d of boar exposure, gilts were classified as either early puberty (EP; n = 45) or randomly assigned to non-pubertal control (CON; n = 40) or non-pubertal P.G. 600 (PG; n = 40). Gilts in the PG group were administered 5 cc of P.G. 600. At 240 d of age all gilts were eligible to be bred for 30 d. Reproductive tracts (RT) from non-cyclic gilts and weaned sows were obtained from an abattoir. Data was analyzed in SAS using PROC MIXED. Fixed effects for RT traits included treatment group, puberty status, parity and a covariate of harvest weight. Average daily gain was greater (P < 0.01) for EP than PG or CON (740 vs. 670 and 670 g, respectively). The proportion of PG and CON gilts that obtained puberty was 70% and 65%, respectively. Days to estrus after boar exposure for EP, PG, and CON differed (P < 0.01, 9.6, 40.0, and 46.8 d, respectively). Group means for RT traits are reported in Table 328. In general, RT of the PG group were comparable to CON. Early puberty females exhibited increased reproductive tract development compared with PG and CON. Ovarian characteristics were similar among the left ovaries of EP, PG, and CON females. However, weight and ovulation rate were greater (P < 0.05) for the right ovary of EP females compared with their PG and CON counterparts. Results indicate that P.G. 600 had little impact on reproductive tract development in gilts that did not respond to boar exposure at 180 d of age.

Table 328.

RT trait	Experimental Group EG	PG	CON	*P*-value
Total wt, g	984[b]	791[a]	830[a]	0.02
Uterus wt, g	666[a]	481[b]	549[ab]	0.02
Vulva wt, g	130[b]	112[a]	111[a]	0.02
Left ovary				
Wt, g	9.0	8.1	7.7	0.56
Width, mm	36.4[a]	32.5[b]	33.9[ab]	0.08
Corpora lutea	7.1	6.1	5.1	0.32
Corpora albicantia	6.8[b]	7.1[b]	4.4[a]	0.08
Right ovary				
Wt, g	9.5[b]	6.4[a]	7.0[a]	< 0.01
Width, mm	35.8[a]	30.7[b]	33.3[ab]	0.01
Corpora lutea	7.4[b]	3.7[a]	4.2[a]	< 0.01
Corpora albicantia	6.7[ab]	7.2[b]	4.6[a]	0.08

Means with different superscripts differ (P < 0.05).

Key Words: Estrus, Gilt, PG600

329 Effects of feeding melatonin during proestrus and early gestation in gilts and P1 sows to minimize the effects of seasonal infertility.

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Seasonal infertility is associated with heat stress and changing photoperiod in summer and fall and is thought to be the cause of delayed puberty, increased wean to estrus interval (WEI), pregnancy failure, and reduced litter size. Research suggests that changing photoperiod determines the seasonality of reproduction by modulation of the function of hypothalamic-pituitary axis and ovary. The aim of this study was to determine if extending the duration of the nighttime increase in melatonin during summer would reduce the incidence of seasonal infertility. Gilts and parity 1 (P1) sows were given oral melatonin once daily beginning in proestrus and extending into early gestation, coinciding with the periods of the follicular phase, corpus luteum (CL) formation, pregnancy recognition

and embryo survival. The experiment (Exp.) was conducted at a 6000 sow breed to wean farm in Illinois. Exp. 1a and 1b were performed in 11 sequential replicates from Jun to Sep. In Exp. 1a, only gilts (n = 392) that had expressed a heat-no-serve (HNS) were assigned for study by weight to receive either Melatonin (MEL, 3 mg once daily) or Control (CON) in a syrup solution at 1400 h for 3 wk starting 1 wk before insemination. In Exp. 1b, P1 sows (n = 416) were randomly assigned by lactation length and backfat to receive MEL or CON for 21 d starting 2 d before weaning. Data were analyzed for the main effects of treatment and week and their interaction. At this time, preliminary data are only available for estrus expression and returns following insemination. In Exp. 1a there was no effect (P = 0.87) of treatment on age at HNS (203d), cycle length (22.3d) or return to estrus (8.9%). However, for cycle length there was an effect of week (P < 0.0001). In Exp. 1b, there was no interaction of treatment with week but there was an effect of treatment (P = 0.02) with MEL having a lower WEI than CON (71 vs. 81%) and for return to estrus following insemination was an effect of week (P = 0.02) however there was no effect of treatment. At this time, these analyses suggest that supplemental MEL had no effect on the preliminary responses in gilts although farrowing rate and litter size data are needed. In weaned sows, MEL was associated with a 10% reduction in WEI. The mechanism is not clear but follicle measures may help explain this observation with the final farrowing and litter size data.

Key Words: melatonin; seasonal infertility; swine

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330 Effect of inducing high or low progesterone concentrations during ovulatory follicle development on double ovulation and fertility of lactating dairy cows. J. P. N. Martins*[1], D. Wang[1,2], N. Mu[1,2], A. P. Martini[1,3], G. F. Rossi[1,4], V. R. Martins[1], J. R. Pursley[1], *[1]Department of Animal Science, Michigan State University, East Lansing, [2]Shuozhou Vocational and Technical College, Shuozhou City, China, [3]Universidade Federal de Santa Maria, Santa Maria, Brazil, [4]FCAV-UNESP, Jaboticabal, Brazil.*

One objective of my dissertation work was to determine the effect of high vs. low progesterone during pre-dominance and dominance phase of ovulatory follicle development on follicular dynamics and fertility of lactating dairy cows. Cows that ovulated a d 7 first wave dominant follicle and started a second follicular wave were assigned to treatments. Progesterone was manipulated to reach high (H) or low (L) serum concentrations during the pre-dominance phase (0 to 4 d of the wave) and dominance phase (5 to 7 d of the wave) creating 4 treatments: HH, LL, HL, and LH. Luteolysis was induced with PGF2α on d 7 of the wave and ovulation was induced with GnRH 56h after PGF2α. Cows (n = 558) received AI 16 h following GnRH. Ovaries were evaluated by ultrasonography before and during treatment. Pregnancy was determined 23 and 28 d post-AI by serum concentrations of pregnancy-specific protein B (PSPB), 35 and 56 d post-AI by ultrasonography and 117 d and 194 d by milk concentrations of PSPB. Calving data was also collected. Percentage of cows with double ovulations to the last GnRH was greater in LL (49%) compared with HH, HL and LH (12, 34, and 34% respectively). Pregnancy/AI 23 d post AI was 49, 60, 61, and 66% for HH, HL, LH, and LL, respectively, and was greater for LL than HH cows. Full term pregnancies/AI was 33, 43, 43, and 43% for HH, HL, LH, and LL, respectively, and was not different between treatments. Pregnancy losses between 35 and 56 d post AI was 2, 10, 5, and 15% for HH, HL, LH, and LL, respectively, and was greater for LL than HH. Cows that had double ovulation after the last GnRH had greater pregnancy/AI 23 d (73 vs. 53%) and full term pregnancy/AI (38 vs. 47%) compared to cows with single ovulation. Pregnancy losses between 35 and 56 d after AI was greater in cows with double ovulation compared to cows with single ovulation (4 vs. 13%). In cows with double ovulation, majority of pregnancy losses between 35 and full term were in cows with ovulations on the same ovary. In summary, low P4 during development of the ovulatory follicle increased the percentage of cows with double ovulations and P/AI 23 d post AI, but decreased embryonic survival between 35 and 56 d post AI. Most losses post-attachment were likely due to unilateral twins.

Key Words: progesterone, dairy cows, fertility, follicle

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331 Reproducibility of heat stress susceptibility and future reproductive success during heat stress in pigs. J. T. Seibert*, K. L. Graves, T. Johnson, A. F. Keating, L. H. Baumgard, J. W. Ross, *Iowa State University, Ames.*

Identifying factors associated with susceptibility or resistance to heat stress (HS) is likely a prerequisite to developing mitigation strategies to improve pig reproductive efficiency. Study objectives were to determine if the HS response early in life predicts future reproductive success during HS. During phase I of the study, pre-pubertal gilts (n = 235; 78 ± 1.2 kg BW) were exposed to a TN period (24 h; 22 ± 0.5°C, 62 ± 13% RH; fed ad libitum) followed by a HS period (24 h; 30 ± 1°C, 49 ± 8% RH; fed ad libitum). Respiration rate (RR), skin temperature (T_S), and rectal temperature (T_R) were recorded at 16 regularly scheduled time points within each experimental period. Body weights (BW) and daily feed intake (FI) were also recorded during the experiment. Interestingly, HS T_R between gilts did not explain the variation in the decrease in FI during the acute phase of HS (R^2 < 0.01, P < 0.05). Also, a low proportion of variability in the severity of BW loss during HS could be explained by T_R (R^2 = 0.03, P < 0.05) or FI (R^2 = 0.09, P < 0.01). Gilts deemed the most tolerant (T; n = 48) and susceptible (S; n = 48), as defined by their ability to maintain a minimal T_R during HS, were subjected to phase II after puberty. During phase II, gilts were fed Matrix® for 14 d in TN conditions (18°C;

limit fed 2.7 kg/d). Following synchronization, estrus detection and artificial insemination were conducted over a period of 9 d during cyclical and progressive HS conditions (21 to 35°C for 9 d). Gilts were slaughtered after 43–48 d of gestation in TN conditions (21°C). Fetal weight and crown-rump length were increased by 7.4 and 2.8%, respectively, in gilts classified as S compared to T ($P < 0.01$). Fetal count, corpus luteum count and size, and embryo survivability were not correlated with post-pubertal HS T_R whereas fetal weight ($R^2 = 0.07$) and crown-rump length ($R^2 = 0.07$) were positively correlated with HS T_R ($P < 0.05$). Positive correlations existed between pre-pubertal and post-pubertal HS T_R ($R^2 = 0.40$, $P < 0.05$). Interestingly, pre-pubertal TN T_R was also correlated with post-pubertal HS T_R ($R^2 = 0.30$, $P < 0.01$) suggesting that pre-pubertal thermoregulatory responses to HS, despite variable between animals, were predictive of future responses to HS. Importantly, the thermoregulatory response (T_R, T_S, RR) and production response (decreased FI and BW) to HS appear to be only marginally related, indicating that production losses during HS are independent from the thermoregulatory response during HS. This project was supported by the National Pork Board and the Iowa Pork Producers Association.

Key Words: pigs, heat stress, reproduction

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332 Use of an electronic activity detection system to characterize estrus activity in crossbred beef heifers differing in follicle number. R. A. Cushman*[1], S. C. Tenley[2], M. Soares[3], A. K. McNeel[1], R. S. Gomes[4], R. G. Tait, Jr.[1], A. S. Cupp[4], L. A. Kuehn[1], W. M. Snelling[5], R. M. Thallman[1], G. A. Perry[6], C. C. Chase, Jr.[1], *[1]USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE, [2]University of Nebraska- Lincoln, Lincoln, [3]Federal University of Santa Maria, Santa Maria, Brazil, [4]University of Nebraska-Lincoln, Lincoln, [5]USDA, ARS, US MARC, Clay Center, NE, [6]Department of Animal Science, South Dakota State University, Brookings.*

Increased numbers of antral follicles have been associated with decreased calving day, increased fertility, increased serum estradiol concentrations, increased serum progesterone concentrations, and increased estrus behavior in cattle. In addition, cows with increased fertility have been shown to have greater activity during behavioral estrus when using electronic activity detection systems. Therefore, the objective of the current study was to evaluate an electronic estrus detection system to determine if differences in estrous cycle characteristics could be detected among beef heifers differing in antral follicle number. The hypothesis was that the percent of heifers demonstrating behavioral estrus and peak activity would be decreased in heifers with low numbers of antral follicles. Estrus activity collars were placed on crossbred beef heifers ($n = 359$) at 12.0 ± 0.1 mo of age to monitor estrus activity, and heifers were submitted for ultrasonographic evaluation of antral follicle number at 13.5 ± 0.1 mo of age, immediately before the start of the breeding season. During a 21 d period, heifers were artificially inseminated 12 h after estrus was diagnosed by the electronic system. Following the period of artificial insemination, heifers were placed with bulls for an additional 42 d, and submitted for ultrasonographic pregnancy diagnosis 45 d after removal of the bulls. Heifers were classified as low (< 16 follicles), medium (16–25 follicles) or high (> 25 follicles). The percent of heifers demonstrating behavioral estrus was analyzed using the GLIMMIX procedure of SAS with antral follicle group as the fixed effect with a binomial distribution and a logit link. Length of the estrous cycle before insemination and peak activity at insemination were analyzed using the MIXED procedure of SAS with antral follicle group as a fixed effect. The percent of heifers demonstrating behavioral estrus was lower in heifers with low numbers of antral follicles compared to heifers with medium or high numbers of follicles ($P = 0.02$; 46.2 ± 4.2 vs. 57.5 ± 2.4%). Peak activity and estrous cycle length; however, did not differ among antral follicle groups ($P > 0.1$). Combined with our histological and hormonal data, these results indicate that greater numbers of antral follicles contribute to increased behavioral estrus due to increased serum estradiol concentrations; however, this does not result in a difference in peak activity calculated by the electronic system during behavioral estrus. USDA is an equal opportunity provider and employer.

Key Words: Antral Follicle Count, Estrus, Estrous Cycle

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333 Influence of vaccination with an inactivated or modified live viral reproductive vaccine on reproductive parameters in beef cows. G. A. Perry*[1], E. L. Larimore[1], M. R. Crosswhite[2], B. W. Neville[3], V. Cortese[4], R. F. Daly[5], G. L. Stokka[2], J. C. Rodgers[4], J. T. Seeger[4], C. R. Dahlen[2], *[1]Department of Animal Science, South Dakota State University, Brookings, [2]Department of Animal Sciences, North Dakota State University, Fargo, [3]Central Grasslands REC, North Dakota State University, Streeter, [4]Beef Veterinary Technical Services, Zoetis, Florham Park, NJ, [5]Department of Veterinary and Biomedical Sciences, South Dakota State University, Brookings*

A 2 yr study involving 9 herds of well-vaccinated cows and heifers ($n = 1436$) was conducted to evaluate whether a pre-breeding MLV or inactivated reproductive vaccine administered per label instructions had negative impacts on conception rates or calving distribution compared to a non-vaccinated control (saline) group. Within herd, cows were blocked by parity and calving date and randomly assigned to receive 1 of the 2 treatments (MLV or Inactivated) or saline (Control). All females were synchronized with the 7-d CO-Synch + CIDR protocol and inseminated (AI) at the appropriate time after CIDR removal (cows 60 to 66 h; heifers 52 to 56 h). Cows remained

separated from bulls for at least 10 d after AI. Pregnancy success and fetal age were determined on d 28 after AI, and > 30 after the breeding season. Data were analyzed using the GLIMMIX procedure in SAS with herd as a random variable. Days postpartum influenced conception rates with heifers and short postpartum cows having decreased conception rates compared to cows that were further postpartum ($P < 0.05$). There was no difference in conception rates to AI between MLV and Control groups ($P = 0.21$; 40.0 ± 4% vs. 43.3 ± 4%) or between Inactivated and Control groups ($P = 0.49$; 46.5 ± 4% vs. 43.3 ± 4%). Rates tended to differ between MLV and Inactivated groups ($P = 0.055$). At 56 d after AI, MLV animals (88.9 ± 2%) had decreased pregnancy success compared to both the Inactivated (93.2 ± 2%) and Control groups (92.5 ± 2%, $P \leq 0.01$). Breeding season pregnancy success was similar between MLV and Control groups ($P = 0.34$; 95.2 ± 2% vs. 96.4 ± 1%) as well as between the Inactivated and Control groups ($P = 0.14$; 98.0 ± 1% vs. 96.4 ± 1%). Inactivated and MLV vaccine groups were different (98.0 ± 1% vs. 95.2 ± 2%; $P = 0.01$). When cumulative calving distribution was evaluated, the proportion of females that calved by d 12 and 30 of the calving season were similar between MLV vaccine and Control groups ($P > 0.30$) and between the Inactivated and Control groups ($P > 0.30$). However, Inactivated tended ($P = 0.09$) to be greater compared to MLV. In summary, treatment of well-vaccinated beef cows and heifers with a MLV or inactivated reproductive vaccine 30 d pre-breeding resulted in similar pregnancy rates and calving distributions as non-vaccinated Controls.

Key Words: Modified-live, Inactivated, Vaccine, Reproductive success

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334 Evaluation of physiological indicators of heat stress and their association with seasonal infertility in first parity sows. E. A. Hines*, J. T. Seibert, S. K. Stoakes, K. L. Graves, B. J. Hale, M. Abuajamieh, C. L. Hager, C. Rademacher, L. H. Baumgard, A. F. Keating, J. W. Ross, *Iowa State University, Ames*.

Understanding the biological mechanisms contributing to seasonal infertility in swine is essential for developing mitigation strategies to improve reproductive efficiency. Seasonal infertility is associated with increased wean-to-estrus-interval (WEI) and reduced reproductive efficiency. Study objectives were conducted to retrospectively analyze the relationship between physiological responses to heat stress during the WEI and phenotypes associated with seasonal infertility. Rectal temperature (Tr), skin temperature (Ts), and respiratory rate (RR) were collected 5 times daily for 7 d following weaning, during two 4-wk periods of heat detection and insemination associated with peak reproductive performance (Spring; n = 424 P1 sows) and the nadir of reproductive performance (Summer; n = 445 P1 sows). Plasma was collected on d 1 and 3 during the WEI and used to measure circulating insulin and lipopolysaccharide binding protein (LBP) levels on a subset of 80 sows representing 3 reproductive outcomes for each season: farrowed (serviced within 7 d of weaning), not farrowed (serviced within 7 d of weaning), and sows with a WEI greater than 15d (> 15WEI). Data were analyzed using SAS, either PROC MIXED for reproductive parameters or PROC GLIMMIX for farrowing rate. Compared to Spring, a substantial reduction in sows expressing estrus by 7 d post weaning was observed in the Summer (89.1 vs. 79.5 ± 1.7%, $P < 0.01$), and among these sows, farrowing rate was decreased in the Summer (91.1 vs. 82.3 ± 1.8%, $P < 0.01$). Still, of all litters produced total born, born alive, stillborn, and mummies per litter were not different between seasons ($P > 0.10$), even though Summer-weaned sows tended to have an increased WEI ($P = 0.06$). The relationship between reproductive, physiological, and environmental parameters were analyzed using PROC CORR. No effect of season was detected for Tr and RR, although Ts was increased in Spring-weaned sows ($P < 0.01$). Correlations across season were identified between WEI and Tr ($r = 0.07$, $P = 0.03$), Ts ($r = -0.12$, $P < 0.01$), and RR ($r = -0.12$, $P < 0.01$). Insulin and LBP were similar across seasons and were not different by reproductive status or day of WEI. These data indicate that thermal indices of heat stress during the WEI do not fully explain decreased reproductive efficiency observed during seasonal infertility in P1 sows. Future investigations are needed understand the underlying mechanisms of heat stress during the WEI transition. This project was supported by the National Pork Board and Iowa Pork Producers Association.

Key Words: heat stress, infertility, swine

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335 Divergent VEGFA signaling determines spermatogonial stem cell fate. K. M. Sargent*, J. R. Essink, M. L. Bremer, W. E. Pohlmeier, M. M. Laughlin, S. G. Kurz, A. S. Cupp, *University of Nebraska-Lincoln, Lincoln.*

The vascular endothelial growth factor A (*Vegfa*) gene can be spliced into angiogenic and antiangiogenic isoforms. Elimination of all isoforms from Sertoli and germ cells in mice altered expression of genes regulating spermatogonial stem cells (SSCs) and resulted in male subfertility. Treatment with antiangiogenic isoforms of VEGFA in donor mice reduced SSC colonization in recipient seminiferous tubules. Thus, we hypothesized antiangiogenic VEGFA isoforms reduce SSC numbers while angiogenic VEGFA isoforms contribute to SSC self-renewal. The objective of these studies was to determine how VEGFA signaling regulates SSC maintenance. Mouse models were utilized where all VEGFA isoforms or neuropilin-1 (NRP1), co-receptor that binds only angiogenic isoforms, was eliminated from the testis (KO). Each experiment had at least 10 animals, and data were analyzed using the Dunnett's test in JMP. Elimination of NRP1 using *Amhr2-Cre* (Sertoli/Leydig) resulted in KO males siring fewer pups in all litters ($P = 0.03$) with a tendency for increased days to get females pregnant vs. controls ($P < 0.1$). NRP1 KO males also tended to have reduced

whole testis *Gdnf* mRNA, an effector of SSC self-renewal ($P < 0.08$) and increased *Stra8*, a pro-differentiation factor ($P < 0.09$) at 6 mo. Their caput epididymides contained 36% fewer sperm ($P < 0.05$) compared to controls. Whole testis mRNA of SSC maintenance genes tended to be or were reduced in males from the same line at 3 mo: *Gdnf* ($P < 0.05$); *Ret* ($P < 0.09$), *Foxo1* ($P = 0.003$); *Sin3a* ($P < 0.04$), *Kitl* ($P < 0.1$), and *Neurog3* ($P < 0.01$). *Zbtb16* expression ($P < 0.001$) and ZBTB16+ undifferentiated spermatogonia per tubule were increased in KO males ($P < 0.002$). There were fewer spermatogonia that co-expressed ZBTB16 and ID4 ($P < 0.05$), a potential SSC marker, suggesting fewer viable SSCs. NRP1 loss also reduced phosphorylation of RET ($P = 0.04$); and pull down experiments demonstrated that RET and KDR, VEGFA receptor, co-immunopreciptate, suggesting they interact. Loss of either VEGFA or NRP1 isoforms via *Sry-Cre* (Sertoli) resulted in reduced male fertility vs. controls and recipient tubules devoid of germ cells when used as SSC donors at postnatal day (P) 30 or 60. VEGFA loss caused a compensatory increase in SSC renewal genes *Id4* ($P < 0.009$) and *Bcl6b* ($P < 0.003$) at P60, and NRP1 loss increased expression of the pro-differentiation gene, *c-Kit* ($P < 0.04$). Thus, VEGFA signaling is critical for regulating SSC maintenance and male fertility.

Key Words: testis, spermatogonial stem cell, VEGFA, NRP1

336 Heat stress affects the serum concentrations of free amino acids in growing pigs. A. Morales[1], M. Cota[1], N. Ibarra[1], N. Arce[1], J. K. Htoo[2], M. Cervantes*[1], *[1]ICA- Universidad Autûnoma de Baja California, Mexicali, Mexico, [2]Evonik Nutrition & Care GmbH, Hanau-Wolfgang, Germany.*

Exposure to heat stress (HS) may impair the intestinal epithelia of pigs resulting in decreased digestive and absorptive capacity. The serum concentration (SC) of free AA in pigs can be used as indicator of their availability. This study was conducted with 12 pigs (29.0 ± 2.8 kg initial BW) distributed into 2 groups to analyze the SC of free AA and some AA metabolites in pigs exposed to HS conditions. The treatments were: pigs housed under natural HS conditions with no ambient temperature control (23.6 to 37.6°C, HS); and pigs housed at thermo-neutral (TN) conditions (24 ± 2°C), pair-fed with their HS counterparts (TN_{pf}). The room ambient temperature and relative humidity were recorded during the whole study. All pigs received a typical wheat-SBM diet. Blood samples were collected at both the absorptive (2.5 h post-prandial) and post-absorptive (10 h post-prandial) phase. The absorptive SC of free Arg, Leu, Lys, Phe, Thr, and Trp were lower ($P < 0.05$), and His and Val tended to be lower ($P < 0.10$) in HS pigs. Also, the SC of Ala, Pro, Ser, and Tyr tended to be lower ($P < 0.10$). No effect of HS was observed in the SC of Ile, Met, Asn, Asp, Gln, Glu, and Gly. The post-absorptive SC of free Arg, His, and Met, as well as Asn, Gln, and Tyr were higher ($P < 0.05$) in HS pigs, but Ala was lower and Pro tended to be lower ($P < 0.10$) in HS pigs. The absorptive SC of carnosine, Orn, and Tau were lower ($P < 0.05$), and Cit, cystathionine, and urea tended to be lower (< 0.10) in HS pigs. The post-absorptive SC of 3-methyl-His, anserine, OH-Lys, and OH-Pro increased ($P = 0.05$), and Cit tended to increase ($P = 0.10$), but carnosine and sarcosine ($P < 0.05$) decreased in HS pigs. These results show a marked and differential effect of HS on the SC of AA, especially that of Arg, His, Met, and Thr. These data indicate that HS negatively affects the digestive and absorptive capacities of pigs, and that the metabolism of some AA is modified in pigs to counteract the negative effects of the HS

Key Words: Pigs, heat stress, serum amino acids

RUMINANT NUTRITION

337 Evaluation of the relative contribution of protein in distillers grains in finishing diets on performance and carcass characteristics. Z. E. Carlson*[1], G. E. Erickson[2], J. C. MacDonald[2], M. K. Luebbe[3], *[1]University of Nebraska-Lincoln, Lincoln, [2]University of Nebraska, Lincoln, [3]University of Nebraska, Scottsbluff.*

Crossbred calf-fed steers ($n = 324$; initial BW = 291 kg; SD = 24 kg) were utilized in a randomized block design to evaluate the energetic contributions of protein from wet distillers grains plus solubles (WDGS) on feedlot performance and carcass characteristics. Pen was the experimental unit and initial BW block ($n = 2$) was treated as a fixed effect. Pens within block were assigned randomly to 1 of 6 treatments (6 replications) for a total of 36 pens (9 steers/pen). The protein portion of WDGS was simulated using corn gluten meal (CGM; 8.75 and 17.5% inclusion; DM basis) to provide similar dietary protein concentration as 20 and 40% WDGS inclusion (DM basis). Linear and quadratic effects of WDGS inclusion and protein (CGM) concentration were evaluated. Pre-planned pairwise comparisons were used to determine effects of solubles inclusion to 17.5% CGM diet and feeding value of protein from WDGS. A linear decrease ($P < 0.01$) in DMI was observed as WDGS inclusion increased from 0% in the control (10.3 kg) to 40% (9.7 kg); G:F increased linearly ($P < 0.01$) as WDGS increased from 0% (0.161) to 40% (0.176). A quadratic increase ($P = 0.04$) in ADG was observed as CGM increased from 0% (1.65 kg) to 17.5% (1.73 kg). A linear increase ($P < 0.01$) in G:F was observed as CGM (protein) increased from 0% (0.161) to 17.5% (0.169). Addition of 10% solubles (DM basis) to the 17.5% CGM diet decreased ($P = 0.04$) ADG. Isolating the protein portion of 20% WDGS by feeding 8.75% CGM decreased ($P < 0.01$) G:F compared to 20% WDGS. Similarly, protein from 40% WDGS replaced by 17.5% CGM increased ($P < 0.01$) DMI and decreased ($P < 0.01$) G:F com-

pared to 40% WDGS. A quadratic response ($P = 0.04$) in HCW was observed as CGM increased from 0% (378 kg) to 17.5% (388 kg). The inclusion of solubles decreased ($P = 0.04$) HCW when added to 17.5% CGM. Using the calculated G:F of 0.161 for the control, 20% WDGS has 134% the feeding value of corn. Similarly the calculated feeding values relative to corn were: 125%, 110%, 129%, and 121% for, 40% WDGS, 8.75% CGM, 17.5% CGM, and 17.5% CGM with 10% solubles, respectively. Excess protein used as an energy source from distillers grains accounts for the majority of the feeding value response observed when feeding WDGS.

Key Words: distillers grains plus solubles, energy, protein

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338 Enhancing the feeding value of corn residues to improve beef cattle production. P. H. V. Carvalho[*1], W. T. Meteer[1], A. R. Schroeder[1], A. DiCostanzo[2], T. L. Felix[1], [1]*University of Illinois at Urbana-Champaign, Urbana,* [2]*University of Minnesota, Saint Paul.*

Objectives were to test the feeding value of corn plant residue, harvested at 2 maturities, and the effects of silage additive, propionic acid or lactobacillus, on in situ fiber disappearance, and growth performance and carcass characteristics of growing feedlot cattle. In Exp. 1, steers were allotted to 1 of 4 treatments: 1) corn stover wetted to 40% DM and ensiled (SV), 2) corn stalklage, harvested at 40% DM and ensiled (ST), 3) corn stalklage plus lactobacillus (STL; SiloKing at 0.225 kg/ton applied at bagging), or 4) corn stalklage plus propionic acid (STPA; Silage Savor plus at 0.5 kg/ton applied at bagging). Corn stover (71.5% NDF, 6.12% CP, and 5.88% lignin) was harvested on October 20, after dry corn (88% DM). Corn stalklage (68.3% NDF, 6.24% CP, and 5.39% lignin) was harvested on September 22, after harvesting high moisture corn (HMC; 77% DM). Diets were fed for 85 d, and contained 25% corn plant residue, 30% modified wet distillers grain with solubles (MWDGS), 35% HMC, and 10% supplement (DM basis). From d 86 to 186, all steers were fed a common finishing diet that contained 20% silage, 20% MWDGS, 50% HMC, and 10% supplement (DM basis). In Exp. 2, composite corn plant residue samples (SV, ST, STL and STPA) from Exp. 1 were incubated in 2 ruminally fistulated steers for 12, 24, 36, and 48 h to determine in situ DM disappearance (DMD) and NDF disappearance (NDFD). There were no treatments effects ($P \geq 0.19$) on ADG, DMI and G:F from d 0 to 85. During the first 85 d, when fed 25% of corn residue, steers gained 1.69, 1.80, 1.74, and 1.67 kg/d when fed SV, ST, STL, and STPA, respectively. There were no carry-over effects ($P \geq 0.66$) of treatment from d 86 to 186; thus, there were no effects ($P \geq 0.78$) of treatment on overall steer performance for the entire 186 d. Yield and quality grade distributions, HCW, marbling, back fat, ribeye area and dressing percentage also did not differ ($P \geq 0.14$) among treatments. There were no effects of treatment on DMD ($P = 0.40$) and NDFD ($P = 0.34$) over time. Average NDFD at 48 h were 27.39, 30.59, 32.50, and 29.45% for SV, ST, STL, and STPA, respectively. Feeding wetted corn stover resulted in similar ruminal fiber degradation, and steer growth and carcass performance as feeding corn stalklage, harvested after HMC harvest.

Key Words: corn stover, growing cattle, stalklage

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339 Effects of supplement type and forage quality on ruminal metabolism and diet digestibility of cattle. M. R. Stierwalt[*1], H. M. Blalock[2], T. L. Felix[1], [1]*University of Illinois at Urbana-Champaign, Urbana,* [2]*Quality Liquid Feeds, Dodgeville, WI.*

Objectives were to test the interaction of supplement type, liquid versus dry, and forage type, hay versus corn stover, on diet digestibility and ruminal metabolism of cattle. Rumen fistulated steers were used in a replicated 4 × 4 Latin square with a 2 × 2 factorial arrangement of treatments: 1) hay with a liquid supplement (HL), 2) hay with a dry supplement (HD), 3) stover with a liquid supplement (SL), and 4) stover with a dry supplement (SD). Steers were fed once daily for ad-libitum intake. Each period began with 14 d dietary adaptation, followed by 7 d of collections (5 d of fecal and 2 d of ruminal collections). In situ disappearance was determined by placing dacron bags, containing soybean hulls, in the rumen for 24 h. There were no interactions ($P \geq 0.25$) of supplement and forage type on DMI, apparent total tract digestibility, or ruminal pH. Nor were there effects ($P \geq 0.12$) of supplement type on DMI, apparent total tract or in situ digestibility, or ruminal pH. However, steers fed hay had increased ($P < 0.01$) DMI and increased (trend; $P = 0.07$) apparent total tract NDF digestibility when compared to steers fed stover, regardless of supplement type. Although apparent total tract NDF digestibility was driven by forage type, there was a tendency ($P = 0.09$) for a forage by supplement type interaction for in situ NDF disappearance (ISNDFD). There were no differences in ISNDFD in steers fed hay; but, liquid supplementation increased ISNDFD in steers fed stover. At 0, 1.5, and 18 h postfeeding, ruminal pH was greater ($P \leq 0.01$) in cattle consuming stover when compared to those fed hay, regardless of supplement type. There was a supplement by hour interaction ($P = 0.04$) on acetate concentrations (Ac). At 0 h postfeeding, there was no effect; however, at 3 and 6 h postfeeding Ac were reduced in steers fed liquid when compared to those fed dry supplements. In addition there was a supplement by hour ($P = 0.02$) interaction for butyrate concentration (Bu); where, at all time points, Bu increased ($P \leq 0.01$) in steers fed liquid when compared to those fed dry supplements. Steers fed hay, regardless of supplement, had increased ($P < 0.01$) concentrations of Ac and total VFA compared to steers fed stover. In the present trial, there tended to be an increase in ISNDFD when steers were fed SL, but this did not affect total tract digestibility.

Key Words: cattle, forage quality, liquid supplement

340 Rumen microbial protein dynthesis in multigrain and barley fed lactating dairy cows. A. Nikkhah*, *University of Zanjan, Zanjan, Iran.*

The objective of this research was to estimate rumen microbial protein synthesis in response to feeding diets based on either solely barley grain or a choice of multiple grains. Eight multiparous (642 ± 57 kg body weight; 72 ± 58 d in milk; mean ± SD) lactating Holstein cows were studied in a crossover design experiment with two 21-d periods. Cows were housed and managed in free individual boxes and fed alfalfa hay-corn silage based total mixed rations with either barley as the only grain (BR) or a mixture of barley, corn, wheat and sorghum (MG). Proportion of cereals in the multigrain treatment was equal, each being 25%. Grains were included as 30% of total dietary dry matter. Diets were prepared as total mixed rations and offered for 5–10% daily orts. Cows were milked at 0500, 1300, and 2100 h and fed at 0530, 1330, and 2130 h. Two mL of urine sample was taken daily from the whole collection during the third week of both experimental periods, diluted 5 times in distilled water, and stored at −20°C for analysis of purine derivatives including allantoin and uric acid to estimate duodenal flow of microbial proteins. Statistical data analysis was conducted using Mixed Models Procedures of SAS program. Feeding MG vs. BR numerically increased ($P < 0.12$) daily urinary excretion of allantoin (445 vs. 428 mmol/d), uric acid (49 vs. 39 mmol/d), and total purine derivatives (494 vs. 467 mmol/d), respectively. Findings suggest that feeding a multigrain choice of barley, wheat, corn and sorghum instead of solely barley grain secures healthy rumen fermentation and adequate microbial protein synthesis. Increased rumen pH and improved feed intake by feeding MG vs. BR supports the rumen microbial protein response and provides metabolic implications on improved viability of MG diets.

Key Words: Multigrain, Rumen, Microbial protein

341 Influence of dry-rolled corn processing and distillers grain inclusion rate on ruminal digestive enzyme activity. F. E. Keomanivong*, M. C. Ruch, J. D. Kirsch, C. R. Dahlen, M. L. Bauer, K. C. Swanson, *North Dakota State University, Fargo.*

Ruminal enzymes play a critical role in the breakdown and metabolism of nutrients. To determine the effect of degree of dry-rolled corn processing on ruminal α-amylase, trypsin and maltase activity, 8 ruminally and duodenally cannulated Holstein steers (526 ± 3.6 kg) were used. Treatments were assigned in a 2 × 2 factorial arrangement consisting of 1) 65% coarse-rolled corn (2.5 mm) with 20% dried distillers grains with solubles (DDGS), 2) 45% coarse-rolled corn with 40% DDGS, 3) 65% fine-rolled corn (1.7 mm) with 20% DDGS and 4) 45% fine-rolled corn with 40% DDGS. Diets were formulated with 10% forage and calculated to meet or exceed NRC recommendations and were offered for ad libitum intake. The experiment was designed as a 4 × 4 Latin square with 7 d of diet adaptation and 7 d of sample collection. To determine enzyme activity, approximately 200 mL of ruminal fluid were sampled from d 3 to 5 in a manner representing every other hour in a 24-h cycle. Data were analyzed using the Mixed procedure of SAS (SAS Inst. Inc., Cary, NC). Activity of α-amylase (U/L of ruminal fluid, α-amylase/kg starch disappearance) was greater ($P \leq 0.001$) in diets containing 20% DDGS compared with 40% DDGS. Diets containing fine-rolled corn and 40% DDGS had greater (interaction: $P = 0.01$) trypsin activity (U/kg CP disappearance). Maltase activity (U/L of ruminal fluid) also demonstrated an interaction ($P = 0.004$) with diets containing coarse-rolled corn and 40% DDGS having the least activity. In conclusion, α-amylase activity was greater in diets containing 20% DDGS, likely because of additional starch provided in rations containing more corn. Trypsin activity was greater in diets with 40% DDGS compared with the 20% DDGS diet which likely was caused by increased protein intake. Digestive enzyme activity of ruminal microbes responded to changes in nutrient composition resulting from variation in DDGS inclusion more so than variation in particle size of dry-rolled corn.

Key Words: corn, distillers, enzymes

342 Nutrient variability of distillers grains with solubles. K. J. Herrick, B. J. Breitling*, *POET Research, Inc., Sioux Falls, SD.*

Distillers grains with solubles (DDGS) is an ingredient that is commonly included in livestock ration formulations. Several reasons for the widespread use of DDGS include a favorable nutrient profile, competitive cost, and availability. However, as with all co-products, one reason for exclusion from ration formulation is a concern regarding variability. It was our objective to address this concern by characterizing the quality of DDGS across 27 ethanol biorefineries within the POET (Sioux Falls, SD) system. As part of the quality control process, all POET biorefineries periodically collect samples of DDGS which are then sent to a third-party laboratory for nutrient analysis. The 2 most recent years of this data was summarized and analyzed using JMP® Pro software (version 11.21.1, SAS Institute, Cary, NC). Nutrients in the analysis included: DM, CP, ether extract (EE), ADF, NDF, crude fiber, and S. Evaluation within JMP was completed using the Multivariate Chart option which focuses on descriptive statistics. In addition, the Variance Components with Main Effects option was used to give a variability estimate for location, time, and inherent variability. This value provided a percentage of the variance explained by all main effects. Time explained 25.6% of the variability in DM (89.2 ± SD 1.13%) while location accounted for only 7.1% of the variability. Typically, DM is intentionally adjusted during different seasons to optimize physical handling characteristics. Averages and standard deviations for CP (30.7 ± 1.57% DM), EE (5.36 ± 0.96% DM), ADF (10.6 ± 1.76% DM), NDF (27.8

± 3.27% DM), crude fiber (8.31 ± 0.82% DM), and S (0.92 ± 0.13% DM) were all within POET's quality assurance ranges. Differences between locations explained 38.9, 12.5, 11.1, 17.2, 14.8, and 25.5% of the variability for CP, EE, ADF, NDF, crude fiber, and S, respectively. Time explained the majority of variability for ADF (43.6%) and NDF (50.1%); however, after review of the data, it was apparent that a February 2015 change in the third-party laboratory resulted in greater estimates of ADF and NDF. This data demonstrates that DDGS produced by the POET biorefining system during the previous 2 yr has a very consistent nutrient profile. It also demonstrates that factors other than location and time account for a majority of the variability. As a result, nutritionists can be confident when formulating rations that DDGS sourced from a POET biorefinery will provide a consistent supply of nutrients.

Key Words: Distillers, Variability, Nutrients

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343 Effects of whole or rolled corn and 20 or 40% grass hay levels on finishing performance of yearling steers.

C. L. Engel*[1], A. Taylor[2], C. S. Schauer[3], R. J. Maddock[4], K. C. Olson[5], *[1]North Dakota State University, Carrington Research Extension Center, Carrington, [2]Cargill Nutrition Animal Innovation Campus, Elk River, MN, [3]North Dakota State University, Hettinger Research Extension Center, Hettinger, [4]North Dakota State University, Fargo, [5]South Dakota State University, Rapid City.*

A 141 d finishing study using 108 crossbred yearling steers (Initial BW = 415 ± 1.13 kg) evaluated whole (WC, 5.5 mm) or dry-rolled (RC, 2.8 mm) corn in diets with 20 or 40% grass hay (GH). The study was a 2 × 2 factorial, with WC or RC as one factor and 20 or 40% GH as another. Steers were stratified by BW and randomly assigned to pen (n = 12) and 1 of 4 treatments (n = 3 pens/treatment). Diets were formulated to meet or exceed NRC recommendations and included modified corn distillers grains (25% DM basis) and an ionophore/vitamin/mineral supplement (2%, DM basis). Initial BW were recorded on d 0 and every 28 d till harvest. No corn type × forage level interactions were detected ($P \geq 0.21$). Initial BW were similar (P = 0.96) among treatments, and for WC and RC ($P \geq 0.47$) across all 5 weight periods (WP). Overall ADG was similar ($P \geq 0.25$) across all WP, except d 56, steers on RC gained more compared to WC (P = 0.03). Overall DMI was similar for WC and RC ($P \geq 0.42$). While overall G:F tended (P = 0.09) to favor RC, all interim periods had similar ($P \geq 0.29$) G:F with the exception of d 56, when RC was lower than WC (P = 0.003). Carcass attributes were similar ($P \geq 0.11$) for WC and RC. BW was similar ($P \geq 0.69$) among GH treatments, at d 0 and through d 56; however greater ($P \leq 0.03$) for 20% GH at each subsequent period after d 56. ADG was greatest for 20% GH during periods 1−3 and overall. While DMI was similar ($P \geq 0.20$) among GH treatments across all periods and for the whole 141 d trial. G:F followed a similar pattern to ADG. The 20% GH cattle used less feed to gain a kg of body weight for periods 1−3 and overall, compared with 40% GH ($P \leq 0.03$). Marbling score, LM area, BF and DP were similar among GH levels ($P \geq 0.16$). HCW and YG tended (P = 0.06) to be greater for 20% GH. Results indicate corn type and GH level did not interact and feeding RC slightly improved feed efficiency over WC. 20% GH diets had higher calculated energy values which did translate into improved ADG and feed efficiency over the 40% GH diets.

Key Words: Corn, Forage Level, Beef Cattle

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344 Effects of different strategies for feeding alfalfa hay on productive performance, rumen fermentation and carcass characteristics of growing lambs.

M. M. Abdelrahman*[1], I. A. Alhidary[1], A. H. Alyemni[2], *[1]King Saud University, Riyadh, Saudi Arabia, [2]ARASCO company, Riyadh, Saudi Arabia.*

A study was conducted to evaluate the effects of different feeding managements of alfalfa hay (*Medicago sativa; NDF* = 43.30%) supplementation, to increase NDF intake, on performance, metabolic profile, rumen fermentation and carcass characteristics of growing lambs fed a pelleted commercial total mixed ration (TMR; Wafi®; NDF = 41.95%) diets. A total of twenty 5-mo-old Awassi male lambs (BW 28.5 ± 1.5 kg) were used in an 84-d trial. Lambs were individually housed in shaded pens and randomly allocated to 4 dietary treatments (n = 5 lambs/group) which were: 1) the basal diet without supplementary alfalfa hay (TMR; control), 2) TMR diet supplemented daily with 100 g of alfalfa hay, 3) TMR diet supplemented with 200 g of alfalfa hay every 2 d or 4) TMR diet supplemented with 300 g of alfalfa hay every 3 d. Feed intake was measured daily and lambs were weighed weekly. Blood and rumen fluid samples were collected from all lambs before feeding on d 1, 28, 56, and 84 for measurement of biochemical and rumen variables. At d 84, lambs were slaughtered to evaluate carcass characteristics and meat quality. Data were analyzed using repeated measures and the PROC MIXED model of SAS. DMI and final BW were greater ($P < 0.05$) for lambs on alfalfa hay diets compared to control lambs. Different feeding strategies for alfalfa hay supplementation resulted in increases ($P < 0.05$) pH and total VFA concentration in ruminal fluid, an improvement ($P < 0.01$) in lightness value of rumen tissues compared with un-supplemented lambs. The addition of alfalfa hay, with any strategy, to TMR diet improved ($P < 0.05$) carcass characteristics and meat quality in term of increased HCW and dressing percentage, improved meat color and reduced fatback thickness compared to control lambs. These results indicate that feeding TMR with different strategies of alfalfa supplementation improved rumen fermentation and had a positive effect on growth performance and meat quality which has important implications for the sheep industry.

Key Words: Alfalfa hay, growing lamb, rumen fermentation

345 A comparison of bale feeder types on forage waste by beef cows. K. Nenn*[1], N. Kenney-Rambo[2], A. DiCostanzo[1], [1]*University of Minnesota, Saint Paul,* [2]*University of Minnesota, St. Paul.*

Feed waste is an often underestimated or ignored cost in raising beef cattle. The impact of bale feeder type, hay ring (Ring), fence line bunk (Bunk), or a pull-type self-feeder Wagon, on hay waste was measured in 2 experiments utilizing Black Angus cows in their third trimester of gestation. In Exp. 1, 17 cows were permitted access to Ring or Wagon feeder over 8 72-h periods, 4 per feeder type. A large round orchard grass bale was fed whole (Ring) or processed in a vertical Patz mixer (Wagon). Feed was delivered at actual time h and waste was collected at 24, 48, and 72 h. Feed waste was considered as soiled hay that was outside the feeder. Feed remaining in the feeder at 72 h was considered refused feed. In Exp. 2, 18 cows were fed in Bunk or Wagon over 8 72-h periods, 4 per feeder type. The diet consisted of 64% alfalfa/orchard grass hay and 36% haylage (diet DM). Feed was processed in a Patz mixer for 20 min before delivery via either feeder type. Feed was adjusted daily for Bunk deliveries to be offered ad libitum with a minimum of refusals. Wagon deliveries were paired to feed amounts placed over 72 h in Bunk of the previous period. Feed waste was collected at 24, 48, and 72 h for both feeder types and forage refused at 72 h. In Exp. 1, feeding hay in Wagon reduced waste (4.0% vs. 22.3% ± 1.67 for Wagon and Bunk, respectively). Similarly, forage DM waste in Exp. 2 was 6.2% ± 1.73 DM while that from Bunk was 18.2% ± 1.73 DM. Results demonstrated that placing ground hay or a combination of dry and high-moisture forage in a Wagon self-led to lower DM waste than when feeding hay in a ring or through a fence-line bunk.

Key Words: feed waste, beef cows, feeder

346 Effects of a fenugreek extract (Nutrifen) in combination with organic trace minerals on feedlot performance in Angus heifers. J. W. Lemaster*, M. R. Bible, S. J. England, F. B. Sandberg, *Furst McNess Company, Freeport, IL.*

The objective of this study was to determine the effects of a fenugreek extract (Nutrifen) in combination with organic trace minerals (OTM; amino acid complexes– Availa-4) on feedlot performance of 94 Angus heifers. Heifers were allotted based on BW to Control (CON; n = 47) and Treatment (TRT; n = 47) and housed in 2 pens based on treatment. The CON group was fed a basal feedlot mineral, while the TRT group had added Nutrifen (1.25 g/hd/d) and OTM (7 g/hd/d). Heifers were given a 21-d acclimation period. Heifers were fed a common feedlot diet for 83 d with individual feed intake monitored utilizing the I.D.ology (Eau Claire, WI) feeding system. Heifers were weighed individually on d 0, 21, 28, 56, 72, and 83. Weights and feed disappearance were used to calculate ADG, DMI, and F:G. Heifers were ultrasounded (Aloka 500V, 3.5-MHz linear transducer; Corometrics Medical Systems, Wallingford, CT) on d 1 and 72 for 12th rib fat thickness (back fat), LM area, and % intramuscular fat (%IMF) by a certified technician. Data were analyzed as a completely randomized design using GLM in Minitab with Tukey's test to determine differences between dietary treatments. There were no BW differences ($P > 0.20$) observed for d 0, 21, 28, 56, or 72; however, on d 83 the CON group weighed less (431.2 vs. 456.5 kg; $P < 0.05$) compared to the TRT group. The TRT group had a higher ADG for d 0–28 (1.32 vs. 1.16 kg; $P < 0.05$), d 56–72 (1.13 vs. 0.75 kg; $P < 0.01$), d 72–83 (1.18 vs. 0.09 kg; $P < 0.001$), and d 0–83 (1.16 vs. 0.94 kg; $P < 0.001$). The TRT group was more efficient (7.84 vs. 9.26; $P < 0.05$) for d 0–28, and d 0–83 (8.79 vs. 11.21; $P < 0.001$) when compared to the CON group. The TRT group had a $0.039 lower cost per kg of gain ($P < 0.001$) than the CON group. There were no differences ($P > 0.1$) in DMI. No differences ($P > 0.3$) were observed between test groups for d 1 or d 72 BCS, back fat, LM area, or %IMF. In conclusion, the addition of a fenugreek extract (Nutrifen) in combination with organic trace minerals improved feedlot performance and reduced cost of gain with no effect on carcass composition.

Key Words: Beef, Botanical, Minerals

347 Evaluation of a commercial genetic test to determine tolerance to fescue toxicity in beef cattle. M. M. Masiero*[1], C. A. Roberts[2], M. S. Kerley[2], R. L. Kallenbach[2], [1]*University of Missouri, Columbia,* [2]*AgBotanica, LLC, Columbia, MO.*

Tall fescue (*Lolium arundinaceum* Schreb.) is the most predominant forage used in Southeastern United States for cow-calf production. Endophyte-infected tall fescue is easily established, adaptable to different environments and grazing tolerant, however alkaloids produced by the fungus cause metabolic disorders in animals referred to fescue toxicosis. Previous research has demonstrated cows consuming endophyte-infected tall fescue have decreased prolactin concentrations, decreased milk production and reduced growth performance in stocker calves. Animals have been shown to differ in degree of tolerance to endophyte-infected tall fescue. T-Snip is a commercial genetic test developed to identify tolerance of cattle to toxic tall fescue. The objective of this study was to analyze correlation between T-Snip test in cows consuming endophyte-infected tall fescue and 205-d weaning weights of their respective calves. We hypothesized T-Snip test score would be predictive of 205-d weaning weights of calves from cows consuming endophyte-infected tall fescue. Nine herds, with 4 herds tested 2 or more years, consuming endophyte-infected tall fescue were tested for fescue toxicity tolerance using the T-Snip genetic test between yr 2012 and 2015. Cows were scored from 0 to 5 for tolerance to fescue toxicity with zero being intolerant and 5 being most tolerant.

Total of 2494 tests were performed and number of animals per herd ranged from 75 to 647. Correlation coefficient between cow tolerance score and 205-d weaning weights were measured for each herd and year data set. Correlation from each data set was significant ($P \leq 0.02$). The correlation coefficient averaged 0.63 and ranged from 0.42 to 0.76. Calf weaning weights from cows scored 0, 1, 2, 3, 4, and 5 averaged 212, 218, 226, 233, 240, and 246 kg, respectively. In conclusion, T-Snip score from cows consuming endophyte-infected tall fescue was correlated to calf 205-d weaning weight and can be used as an indicator of tolerance to fescue toxicity. Difference in calf weaning weight between tolerant and intolerant cows averaged 28 kg. Tolerance to toxic tall fescue as determined by T-Snip analysis accounts for approximately one-half the effect of toxic tall fescue on calf weaning weight.

Key Words: beef cattle, fescue toxicity, tolerance test

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348 Stocking management effects on forage composition, cow methane emissions, and soil properties of cool season pastures. J. R. Russell[*1], J. Bisinger[1], W. J. Powers[2], *[1]Iowa State University, Ames, [2]Michigan State University, East Lansing.*

Forty-eight multiparous August-calving Angus cows (627 + 63.8 kg [2012, yr 1], 552 + 62.0 kg [2013, yr 2], 614 + 51.8 kg [2014, yr 3]) were allotted to six 4.04-ha cool season grass-legume pastures to graze by continuous (CONT), rotational (10 paddocks; ROT), or strip (10 paddocks with a mobile fence; STP) stocking from May to October. Daily live forage allowances in ROT pastures were 4.0, 4.8, and 6.0% BW from May 11, August 1, and September 14 in yr 1, 4.0, 6.0, and 7.2% BW from May 14, July 22, and August 19 in yr 2, and 4.8 and 6.0% BW from May 12 and August 1 in yr 3 with a single hay harvest from 40% of the area in yr 1 and 2. Daily forage allowances in STP pastures were one-half those in ROT pastures with no hay harvest. Forage was sampled to a height of 2.54 cm from each pasture, weighed, and analyzed for DM, IVDMD, NDF, ADF, and CP monthly. Methane emissions from 2 cows per pasture were estimated utilizing sulfur hexafluoride over 7 d beginning on June 21 and August 8 in yr 2 and June 19 and August 12 in yr 3. Simultaneous to methane measurements, forage was sampled from the top half of the sward in CONT pastures and in the stocked paddock of ROT or STP pastures. Live forage was separated and analyzed for DM, IVDMD, NDF, ADF, and CP. Soil penetration resistance, bulk density, and OM content were measured along 6 transects from the water source in CONT pastures and in one paddock of each ROT or STP pasture in May of yr 1 and October of yr 3. Monthly forage mass and composition differed little between treatments. However, during methane emission measurements, IVDMD and CP concentrations were greater ($P < 0.05$) and NDF concentrations lower ($P < 0.05$) in live forage in the upper canopy of ROT than STP pastures in August. There were no significant treatment effects on daily methane emissions per cow. In October of yr 3, soil bulk density did not differ between treatments, but soil penetration resistance at depths of 0, 12.5, and 15.0 cm were greater ($P < 0.05$) in CONT than STP pastures. While STP at a limited forage allowance reduces forage quality, it does not significantly affect methane emissions while reducing soil penetration resistance.

Key Words: cattle, grazing, methane

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349 Dimorphic chronological development of ruminant digestive system supports development of equivalent muscle fatty acid profiles in continuously suckled and weaned Katahdin lambs. Q. S. Baptiste[*1], M. Knights[2], A. K. Redhead[2], E. Felton[3], *[1]Berea College, Berea, KY, [2]West Virginia University, Morgantown, [3]Division of Animal and Nutritional Sciences, West Virginia University, Morgantown.*

Dimorphic chronological changes in gastrointestinal tract morphometry and muscle fatty acids profile, in Fall born Katahdin lambs reared in 2 different rearing systems (continuously suckled = CS and weaned = W) were characterized. The lambs were randomly allocated to be weaned (W, $n = 31$) at 2.5 mo of age or continuously suckled (CS, $n = 32$). Lambs (CS and W) were creep fed ad lib, then weaned or continuously suckled while accessing orchard grass hay and finisher feed ad lib until the end of the study. Four 2.5 mo old wether lambs (PW) and eight 4 mo old wether lambs (CS = 4 and W = 4) were euthanized. Harvested gastrointestinal tracts (GIT) gross morphometries and longissimus dorsi muscle fatty acid profiles of lambs were determined. Age effects (CS, W vs. PW; $P < 0.05$) but not rearing system effects on GIT weight (2221.88, 2104.95, vs. 1320.75g), rumen weight (559.70, 571.48, vs. 262.95 g), rumen weight as a percentage of total GIT weight (25.16, 27.25 vs. 20.13%), fore-stomach weight (727.60, 745.00 vs. 343.90g), fore-stomach weight as a percentage of the entire GIT weight (32.75, 35.53 vs. 26.04%) and cecum weights (118.53, 122.88 vs. 65.50g) were determined for CS, W and PW lambs, respectively. Age effects (CS, W vs. PW; $P < 0.05$) on abomasum weights (163.33, 146.68 vs. 77.55g), abomasum weight as a percentage of the entire GIT weights (7.23, 6.95 vs. 5.85%), small intestine weights (1006.23, 867.20, vs. 691.28g), small intestine weight as a percentage of entire GIT weight (45.09, 41.07 vs. 51.98%) and small intestine lengths (1077.50, 943.00 vs. 783.25 cm) were also determined, but notably presented a different numerical trend for subsections of the GIT harvested from CS and W lambs. Collectively, these descriptive statistics indicates dimorphic development of CS and W lambs' GIT to support relatively greater enzymatic intestinal versus ruminal fermentative digestion, in CS than in W lambs. Furthermore, pancreas weights (66.73 and 54.95) were significantly different ($P < 0.05$) between CS and W lambs, respectively. However, once again age ($P < 0.05$) but not rearing system

affected total fatty acids (13.25, 12.11 vs. 10.44 g/100g), SFA (5.61, 4.87 vs. 4.30 g/100g), and UFA (7.64, & 7.24 vs. 6.14 g/100g) in CS, W vs. PW lambs muscles. Conclusively, dimorphic chronological development of ruminant digestive system supports development of equivalent muscle fatty acid profiles in continuously suckled and weaned Katahdin lambs.

Key Words: Gastrointestinal tract development

350 Estimates of duodenal microbial protein in free housed dairy cows fed total mixed ration vs. component diet. A. Nikkhah*, *University of Zanjan, Zanjan, Iran.*

The objective was to determine effects of total mixed ration (TMR) delivery vs. component feeding of forage and concentrate (CF) in lactating dairy cows in a competitive housing environment. Twelve multiparous (650 ± 55 kg body weight; 45 ± 20 d in milk; mean ± SD) and 12 primiparous (579 ± 49 kg body weight; 59 ± 36 d in milk) lactating Holstein cows in free houses were monitored continuously in a completely randomized design experiment for 3 mo. A 10-d pre-trial adaptation period was allowed before data collection. Cows were offered an experimental diet (barley grain and corn silage-alfalfa hay based) as either TMR or CF of forage and concentrate for the entire experiment. The forage to concentrate ratio (dry matter based) was 50:50, allowing 5–10% daily orts. Cows were fed 3 times daily at 0530, 1330, and 2130 h. The daily TMR was divided to 3 equal portions and each portion was fed at each feed delivery. The CF was divided to one portion of forage fed at 0530 h, and 2 equal portions of concentrate fed at 1330 and 2130 h. Cows were milked 3 times daily at 0500, 1300, and 2100 h. Statistical data analysis was conducted with Mixed Models. Two mL of urine sample was taken, diluted 5 times in distilled water, and stored at −20°C for analysis of purine derivatives (allantoin and uric acid) to estimate duodenal microbial protein flow. Daily urinary excretion of allantoin (401 vs. 429 mmol/d), uric acid (43 vs. 48 mmol/d), and total purine derivatives (444 vs. 477 mmol/d) were not affected ($P > 0.15$) by feeding TMR vs. CF, respectively. Daily estimates of duodenal microbial protein were thus not different. Parity interaction with feeding system did not affect microbial protein flow estimates. The data suggest that feeding high-producing dairy cows TMR vs. CF did not any positive impact on rumen microbial protein estimates, suggesting that rumen conditions were not impacted by feeding system in a competitive environment.

Key Words: Total Mixed Ration, Microbial Protein, Component Feeding

351 Energy metabolism peripheral indicators in total mixed ration vs. component fed dairy cows in a competitive environment. A. Nikkhah*, *University of Zanjan, Zanjan, Iran.*

This objective was to establish effects of total mixed ration (TMR) delivery vs. component feeding of forage and concentrate (CF) on selected peripheral blood markers of energetic in lactating dairy cows in a competitive housing environment. Twelve multiparous (650 ± 55 kg body weight; 45 ± 20 d in milk; mean ± SD) and 12 primiparous (579 ± 49 kg body weight; 59 ± 36 d in milk) lactating Holstein cows in free houses were monitored continuously in a completely randomized design experiment for 3 mo. A 10-d pre-trial adaptation period was allowed before data collection. Cows were offered an experimental diet (barley grain and corn silage-alfalfa hay based) as either TMR or CF of forage and concentrate for the entire experiment. The forage to concentrate ratio (dry matter based) was 50:50, allowing 5–10% daily orts. Cows were fed 3 times daily at 0530, 1330, and 2130 h. The daily TMR was divided to 3 equal portions and each portion was fed at each feed delivery. The CF was divided to one portion of forage fed at 0530 h, and 2 equal portions of concentrate fed at 1330 and 2130 h. Cows were milked 3 times daily at 0500, 1300, and 2100 h. Tail vein blood samples were taken weekly before milking. Statistical data analysis was conducted with Mixed Models. Feeding CF vs. TMR increased ($P < 0.05$) peripheral blood concentrations of glucose (68 vs. 62 mg/dl) and BHBA (0.41 vs. 0.32 mmol/L), but did not affect ($P > 0.15$) those of NEFA (0.25 vs. 0.35 mmol/L) and urea nitrogen (13.6 vs. 14.1 mg/dL), respectively. Neither parity nor its interaction with treatment affected peripheral blood metabolites. The results do not suggest that feeding TMR instead of CF improves energetic of lactating cows. Findings provide evidence to more insightfully contemplate CF for high-producing dairy cows in postmodern times.

Key Words: Component feeding, Metabolism, Dairy cow

352 Improving milk production through evening feeding of dairy cows. A. Nikkhah*, *University of Zanjan, Zanjan, Iran.*

The objective of this experiment was to establish milk production effects of evening instead of morning feeding in once-daily fed high-producing lactating dairy cows. Eight multiparous (664 ± 62 kg body weight; 80 ± 40 d in milk; mean ± SD) lactating Holstein cows were studied in a crossover design experiment with two 21-d periods. Cows were kept under thermoneutral conditions and fed a total mixed ration (TMR) based on barley and corn grains, corn silage, and alfalfa hay at either 0800 h or 2000 h. The forage to concentrate ratio on a dry matter basis was 50:50 fed for 5−10% daily orts. Feed intake and milk production were monitored continuously for the entire experiment and subjected to data analysis for the third week

of both periods. Statistical data analysis was conducted with Mixed Models Procedures of SAS program. Feed intake was similar between morning-fed (21.2 kg) and evening-fed (21.4 kg) cows ($P > 0.15$). Milk yield was also similar, but milk fat content was higher in evening-fed vs. morning-fed cows (3.5% of 35.0 kg vs. 3.2% of 34.7 kg, $P < 0.05$). As a result, milk fat production was increased by evening instead of morning feeding (1.23 vs. 1.11 kg/d, $P < 0.05$). Milk protein content was not different between morning-fed (3.0%) and evening-fed cows (3.1%). Results demonstrated that timing of feeding is an external modulator of dairy cow physiology and metabolism and contributes significantly to peripheral supply of metabolites, thus, determining milk fat content and yield. Improved milk fat production despite the unaltered total daily feed intake demonstrates improved feed efficiency and economics.

Key Words: Evening feeding, Milk production, Dairy cow

353 Optimizing dairy cow production through multisource starch feeding. A. Nikkhah*, *University of Zanjan, Zanjan, Iran.*

The objective of this study was to determine feed intake and milk production responses to feeding diets based on either solely barley grain or a choice of multiple grains. Eight multiparous (642 ± 57 kg body weight; 72 ± 58 d in milk; mean ± SD) lactating Holstein cows were experimented in a crossover design study with two 21-d periods. Cows were kept in free individual boxes and fed alfalfa hay-corn silage based total mixed rations with either barley as the only grain (BR) or a mixture of barley, corn, wheat and sorghum (MG). Proportion of cereals in the multigrain treatment was equal or 25% each. Grains were included as 30% of total dietary dry matter. Diets were prepared as total mixed rations and offered for 5–10% daily orts. Cows were milked at 0500, 1300, and 2100 h and fed at 0530, 1330, and 2130 h. Feed intake and milk production were monitored for the entire experiment and subjected to data analysis only for the third week of both periods. Statistical data analysis was conducted using Mixed Models Procedures of SAS program. Feed intake was improved when MG was fed instead of BR (21.2 vs. 19.9 kg/d, $P < 0.05$). Milk yield was also increased by feeding MG vs. BR (35.0 vs. 33.1 kg/d, $P < 0.05$). As such, milk fat percent (3.5% vs. 3.2%) and yield (1.23 vs. 1.06 kg/d) were higher for MG vs. BR ($P < 0.05$). Milk protein content (3.0% vs. 2.9%) but not protein yield (0.99 vs. 1.02 kg/d) was higher for BR vs. MG ($P < 0.05$). Average rumen pH at 4 h postfeeding (5.7 vs. 5.9, $P = 0.06$) and fecal pH (5.9 vs. 6.4, $P < 0.05$) were lower for BR vs. MG. Results indicate that feeding a multigrain choice of barley, wheat, corn and sorghum instead of solely barley grain improves feed intake and milk production parameters. Increased rumen and fecal pH by feeding the multigrain diet possesses health and metabolic implications.

Key Words: Starch, Multigrain, Dairy cow

354 A pragmatic challenge of total mixed ration: time to contemplate component feeding. A. Nikkhah*, *University of Zanjan, Zanjan, Iran.*

The objective of this research was to establish prolonged effects of total mixed ration (TMR) vs. component feeding (CF) in high-producing lactating dairy cows in a competitive environment. Twelve multiparous (650 ± 55 kg body weight; 45 ± 20 d in milk; mean ± SD) and 12 primiparous (579 ± 49 kg body weight; 59 ± 36 d in milk) lactating Holstein cows in free group yards were monitored continuously in a completely randomized design experiment for 3 mo. A 10-d pre-trial adaptation period was allowed before sampling and data collection. Cows were offered an experimental diet (barley grain and corn silage-alfalfa hay-based) as either TMR or CF of forage and concentrate for the entire experiment. The forage to concentrate ratio on a dry matter basis was 50:50, allowing 5−10% daily orts. Cows were fed 3 times daily at 0530, 1330, and 2130 h. Cows were milked 3 times daily. The daily TMR was divided to 3 same portions and each portion was fed at each feed delivery. The CF was divided to one portion of forage fed at 0530 h, and 2 same portions of concentrate fed at 1330 and 2130 h. Statistical data analysis was conducted with Mixed Models composed of fixed (treatment, parity and their interaction) and random (cow within treatment by parity and residuals) effects. Feeding TMR vs. CF did not affect ($P > 0.15$) dry matter intake (21.7 vs. 22.0 kg/d) and milk yield (34.0 vs. 34.5 kg/d). However, feeding CF instead of TMR improved milk content of fat (3.6 vs. 3.3%) and protein (3.3 vs. 3.1%). As a result, milk protein and fat yields were increased by offering CF vs. TMR ($P < 0.05$). Daily duration of eating (350 vs. 330 min/d), ruminating (320 vs. 330 min/d), and total chewing (670 vs. 660 min/d) were similar ($P > 0.50$) between TMR and CF cows, respectively. The first meal length (FML), starting from feed delivery until the first non-eating bout of $\geq$ 20 min, was 175 min in the TMR cows vs. 201 min in the CF cows ($P < 0.01$). Urine (8.1 vs. 8.1) and fecal (6.1 vs. 6.0) pH were unaffected ($P > 0.30$). In conclusion, data suggest that in a competitive farm housing and eating environment, offering high-producing cows CF vs. TMR did increase milk fat, protein and energy production without affecting feed intake and eating and chewing behaviors. Findings will have significant economical and health implications for global dairy enterprises.

Key Words: Total mixed ration, Component feeding, Dairy cow, Milk production

355 Effects of wintering system on cow and calf performance in a summer-calving intensive production system. S. E. Gardine*[1], J. M. Warner[1], C. J. Bittner[1], R. G. Bondurant[1], K. H. Jenkins[2], R. J. Rasby[3], M. K. Luebbe[2], G. E. Erickson[1], T. J. Klopfenstein[1], [1]*University of Nebraska, Lincoln,* [2]*University of Nebraska, Scottsbluff,* [3]*Department of Animal Science, University of Nebraska, Lincoln.*

The objective was to test the effect of wintering system on cow-calf performance in a summer-calving intensively managed system. Multiparous (5.1 ± 1.4 yr old), crossbred (Red Angus × Red Poll × Tarentaise × South Devon × Devon), lactating beef cows (n = 65) with summer born calves (mean calving date = July 14) were used in a randomized complete block design. Pairs in eastern (ARDC; n = 36) or western (PHREC; n = 29) Nebraska were blocked by cow BW (4 blocks at ARDC, 2 blocks at PHREC), stratified by calf age, and assigned randomly within strata to 1 of 2 wintering treatments with either 4 (ARDC) or 2 (PHREC) replications (pens or paddocks) per treatment (4– 8 pairs per replicate). Treatments included: 1) drylot feeding (DL) or 2) corn residue grazing (CS). Drylot pairs were limit-fed (12.5 ± 0.23 kg (ARDC) or 12.4 ± 0.1 kg DM/pair/d (PHREC)) a common diet (60:40 distillers grains:crop residue, DM basis). Regardless of location, CS pairs grazed irrigated corn residue and were supplemented (2.4 kg DM/pair/d) with a dried distillers grains pellet. After cornstalk grazing, all calves were weaned (calf age = 267– 285 d). Cornstalks pairs at ARDC grazed from early-November to mid-April (158 d), while pairs at PHREC grazed for 62 d during 2 separate periods due to snowfall. At both locations, DL cows had greater ($P \leq$ 0.03) BW change. Ending BCS was not different (P = 0.63) between CS (5.2) and DL (5.4) cows at PHREC. At ARDC, DL cows had greater (P < 0.01) ending BCS (6.0) compared to cows that grazed cornstalks (4.6). Cow BCS change was not different (P = 0.34) between treatments at PHREC, but greater (P < 0.01) for DL cows at ARDC. Wintering system had no effect (P = 0.57) on calf ending BW at PHREC, but calves wintered in the drylot with their dams at ARDC were heavier (P = 0.02) than CS calves (305 vs. 253 kg, respectively). Likewise, calf ADG and BW per d of age were not affected ($P \geq$ 0.50) at PHREC, but were greater for DL ($P \leq$ 0.04) calves at ARDC. Diverging responses observed across locations are likely due to grazing d and residue diet quality. Grazing residue may be a viable option for summer-born pairs, but performance may be similar to or less than DL pairs.

Key Words: corn residue, cow-calf pairs, production

356 Feeding microbially-enhanced soy protein in starter pellets to dairy calves. N. D. Senevirathne*, J. L. Anderson, W. R. Gibbons, *South Dakota State University, Brookings.*

Our objective was to determine effects of feeding calves starter pellets with microbially-enhanced (fungi-treated) soy protein (MSP) compared to soybean meal (SBM) with different milk replacers (MR). Thirty-six Holstein calves (2 d old; 24 females, 12 males) in individual hutches were used in a 12-wk randomized complete block design study. Treatments were: 1) MSP pellets with accelerated growth MR (28% CP, 18% fat; MSPA), 2) SBM pellets with accelerated growth MR (SBMA), and 3) MSP pellets with traditional MR (20% CP, 20% fat; MSPT). Pellets were similar except for 23% MSP or 23% SBM (DM basis). Week 1 0.37 kg and wk 2 to 5 0.45 kg of MR was fed 2×/d, and 1×/d 0.45 kg was fed during wk 6. Pellets and water were fed ad libitum. Intakes were recorded daily. Body weights (BW) and jugular blood samples were collected 2 d every 2 wk at 3 h after the morning feeding. Fecal grab samples were collected 5×/d for 3 d during wk 12 for analysis of total tract digestibility (TTD) of nutrients. Results were analyzed using MIXED procedures with repeated measures and Tukey's test in SAS 9.4. Significant differences were declared at P < 0.05. Total and pellet DMI were greatest for SBMA and least for MSPT. Body weights were greatest for MSPA. Less ADG was found for MSPT versus MSPA. Gain: feed was least for SBMA. Serum glucose was similar among treatments. Plasma urea nitrogen (PUN) was greatest for MSPA and least for MSPT. Beta hydroxyl butyric acid (BHBA) and IGF-1 were greatest for SBMA. Plasma triglycerides were greatest for MSPT. Treatments had similar DM TTD, but MSPT had greater CP TTD versus SBMA. Results demonstrated calves fed MSP had improved gain: feed and improved or maintained growth performance depending on MR.

Key Words: microbially-enhanced soy protein, dairy calf, growth performance

Table 356.

	Treatment			
Item	MSPA	SBMA	MSPT	SEM
Total DMI, g/d	1650[b]	1759[a]	1388[c]	39.6
Pellet DMI, g/d	1272[b]	1380[a]	1010[c]	40.8
BW, kg	72.6[a]	68.5[b]	67.8[b]	3.99
ADG, kg/d	0.68[a]	0.63[ab]	0.59[b]	0.04
Gain: Feed	0.46[a]	0.41[b]	0.47[a]	0.02
Glucose, mg/dl	98.8	101.4	99.9	1.76
BHBA, mg/dl	34.5[ab]	35.6[a]	31.8[b]	1.27
Triglyceride, mg/dl	25.2[b]	27.7[ab]	28.8[a]	1.09
PUN, mg/dl	15.6[a]	14.2[b]	12.8[c]	0.35
IGF-1, ng/ml	63.8[b]	73.3[a]	60.8[b]	3.04
DM TTD, %	81.0	80.3	84.8	1.58
CP TTD, %	86.4[ab]	85.1[b]	89.7[a]	1.37

[abc]Means with unlike superscripts differ by P < 0.05.

357 Seasonal effects and husbandry practices on fat-soluble vitamin status of beef and dairy cows and their offspring. M. R. O'Neil*[1], D. C. Beitz[1], R. L. Stuart[2], [1]*Iowa State University, Ames,* [2]*Stuart Products Inc, Bedford, TX.*

The objective was to determine the impact of feeding and husbandry practices on fat-soluble vitamin status of beef and dairy cows and their offspring during the spring and fall seasons. To determine effects of breed and season of the year on vitamin status, 6 Holstein and 6 Angus cows and their respective female calves were enrolled in the study. Blood samples were collected in May, 2014 from Angus cows and their calves (avg. 57 d of age) and Holstein cows and their calves (avg. 16 d of age). All animals were bled again approximately 140 d later. All serum samples were analyzed for retinol, 25-OH-D_3, and α-tocopherol (vit E) and the fall samples also were analyzed for β-carotene. Spring serum retinol concentrations were not different between breed of cow or breed of calf. In the fall, serum retinol was higher in Holstein cows than Angus cows (0.40 vs. 0.24 ppm, respectively); however, serum retinol was higher in Angus calves compared with Holstein calves (0.31 vs. 0.29 ppm). Serum 25-OH-D_3 concentrations were similar in Angus and Holstein cows. However, in the spring, Angus calves had dramatically greater concentrations of 25-OH-D_3 than did Holstein calves (27.4 vs. 12.3 ng/mL, respectively). Compared with spring values, fall concentrations of 25-OH-D_3 were greater in Angus cows and calves and Holstein calves, but not Holstein cows. Concentrations of serum 25-OH-D_3were not correlated ($P < 0.05$) among the dams and their offspring of either breed in either spring or fall, but tended to be higher in the fall. Serum vit E was higher in the fall compared with spring for all animals. In spring, all cows averaged 2.0 ppm and the calves averaged 0.6 ppm. Compared to spring, fall serum vit E increased in Angus cows (5.3 vs. 1.9 ppm), Angus calves (1.6 vs. 0.7 ppm), and Holstein cows (7.2 vs. 2.0). Because of consumption of green grass, serum β-carotene was dramatically higher for Angus cows (8.20 ppm) and their calves (2.47 ppm) compared with that of Holstein cows (0.63 ppm) and their calves (0.08 ppm). Season and husbandry practices do alter fat-soluble vitamin status in beef and dairy animals, especially calves. There were no correlations observed between the vitamin status of the dam and their offspring indicating that vitamin supplementation of dams may not be effective in improving the fat-soluble vitamin status of the calf.

Key Words: Fat-soluble vitamins, status, beef, dairy

358 Effect of supplementing methionine hydroxy analog on beef cow performance, milk production and reproduction. A. R. Clements*, F. A. Ireland, D. W. Shike, *University of Illinois at Urbana-Champaign, Urbana.*

Mature Simmental × Angus cows (n = 214; 635 ± 7.4 kg) were utilized to determine the effects of late gestation and early postpartum supplementation of methionine hydroxy analog (MFP; Novus International, Inc.) on cow BW, BCS, milk production, milk composition, reproduction, and calf performance until weaning in a fall-calving, cool-season grazing system. Cows were confirmed pregnant before experiment, stratified by BW, cow age and AI sire, and assigned to 1 of 12 pastures (17 or 18 cows·pasture^{-1}). Pastures were randomly allotted to 1 of 2 treatments: control (0.45 kg·cow^{-1}·d^{-1} of wheat mid based pellets, n = 6) or supplement including MFP (0.45 kg·cow^{-1}·d^{-1} of wheat mid based pellets including 10 g MFP, n = 6). Treatments were fed 23 ± 1 d before calving through 72 ± 1 d postpartum. Cows were weighed post-calving, at supplementation end, AI breeding, AI pregnancy check, and the end of trial (192 and 193 ± 1 d postpartum). A subset of cow-calf pairs were used in a weigh-suckle-weigh 74 d postpartum to determine milk production; milk samples were taken to determine milk composition (n = 45·treatment^{-1}). A serum P4 assay was utilized to determine cow cyclicity. After supplementation, all cow-calf pairs were managed as a common group until weaning (191 ± 1 d of age). Cows were bred via AI 97 ± 1 d postpartum, clean up bulls were turned out 11 d post AI for a 55 d breeding season. Cow and calf performance were analyzed using MIXED procedure in SAS (SAS Inst. Inc., Cary, NC) and cow reproductive performance and calf health were analyzed using GLIMMIX procedure. Cow BW and BCS was not different ($P \geq 0.10$) at any time points between treatments. There was no treatment effect ($P \geq 0.62$) on calf birth BW, calf weaning BW (191 ± 1 d of age), or calf ADG. Calculated 24 h milk production did not differ ($P = 0.76$) nor did milk composition or component production ($P \geq 0.21$). There was no difference ($P = 0.69$) in percentage of cows cycling between treatments. Cow AI conception rate and overall pregnancy rate were not different ($P \geq 0.50$) between treatments. No differences ($P \geq 0.61$) in calf health were observed. Supplementation of MFP during late gestation continuing through estimated peak lactation did not affect cow performance, cow milk production, or calf performance when fall-calving cows grazed cool-season forages.

Key Words: cow-calf, methionine hydroxy analog, late gestatation supplementation

359 Effect of delayed wrapping and wrapping source on intake and digestibility of alfalfa silage in sheep.

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Delays often occur between baling and wrapping during production of baled silage that increases exposure time of the forage to oxygen. This study was conducted to investigate the effect of 2 different wrapping sources and time intervals between baling and wrapping on intake and digestibility of alfalfa silage by gestating sheep. Alfalfa silage was baled in large round bales, and then wrapped with plastic either with or without an oxygen-limiting barrier; wrapping occurred either the day of baling, or 1, 2 or 3 d after baling. Beginning in January, silages were chopped and packed into plastic-lined trash containers, and then offered randomly for ad libitum consumption to 16 gestating ewes (n = 16; 63.5 ± 1.71 kg BW) to provide 2 ewes per treatment for 3 experimental periods. Each period consisted of a 10-d dietary adaptation period followed by 7 d of total fecal and urine collection. Ewes were housed in individual 1 × 1.5-m pens with plastic coated expanded metal flooring and were re-randomized to different treatments each period such that ewes were not offered the same treatment in any subsequent period. Data were analyzed using PROC MIXED of SAS for a 2 × 4 factorial treatment arrangement and orthogonal polynomial trend analyses were used to assess effects of time delay for wrapping after baling. Intakes of DM responded with linear, quadratic, and cubic effects ($P < 0.05$), while OM responded with linear and quadratic effects ($P < 0.05$) as wrapping was delayed after baling. Digestibility of DM and OM responded cubically ($P < 0.05$), that of NDF increased linearly ($P < 0.05$), and digestible DM and OM intake (g/kg BW) responded linearly, quadratically, and cubically ($P < 0.05$) with time delay between baling and wrapping. In general, intake and digestibility were greatest in silage wrapped the day following baling. Type of wrap tended ($P = 0.10$) to affect DM digestibility, and digestible OM intake was affected ($P < 0.05$) by the wrap type × wrapping time after baling interaction, but other intake and digestibility measurements were not affected ($P \geq 0.15$) by wrap type and the interaction of wrap and wrapping time after baling. Therefore, delaying wrapping alfalfa silage bales beyond 1 d after baling may have detrimental effects on energy status in gestating ewes. The study was supported in part by USDA-ARS specific cooperative agreement 58–3655–4-052.

Key Words: alfalfa silage; sheep; digestibility

360 Effect of winter distillers grains supplementation level on spayed heifer performance.

R. G. Bondurant*, B. L. Nuttelman, C. J. Bittner, J. C. MacDonald, T. J. Klopfenstein, *University of Nebraska, Lincoln.*

A 2-yr study was conducted utilizing 220 spayed heifers (BW = 234; SD = 23 kg) each yr to determine the optimal level of modified distillers grains plus solubles (MDGS) supplementation during winter grazing. The 2 yr of data were analyzed separately due to variation in summer gains by yr. Treatments included the supplementation of MDGS at 1.36, 2.27, and 3.18 kg heifer daily during the winter corn residue grazing phase. Following winter grazing for 150 d, heifers grazed smooth bromegrass for 30 d and native range for 120 d. Heifers were then finished on a common ration. For both yr, ending BW and ADG for the winter phase increased linearly ($P < 0.01$), and summer phase ADG decreased linearly ($P < 0.01$) as winter supplementation level increased. For yr 1, ending BW for summer was not different ($P = 0.36$) however, yr 2 summer ending BW increased linearly ($P < 0.01$) from 415 to 433 kg as winter supplement increased. For yr 1, there were no differences ($P \geq 0.30$) in finishing performance and total system ADG (average of winter, summer, and finishing) was not different ($P = 0.91$) among treatments. In yr 2, final BW linearly increased ($P = 0.04$) from 591 to 616 kg due to winter MDGS supplementation. For both yr, ADG and G:F were not different ($P \geq 0.25$) during the fall finishing phase. Year 2 total system ADG linearly increased ($P = 0.02$) from 0.83 to 0.89 kg/d as MDGS supplementation increased during the previous winter. There were no differences in carcass characteristics ($P \geq 0.27$) for yr 1. However in yr 2, HCW increased linearly ($P = 0.04$) from 372 to 388 kg as winter supplementation increased. Similar with yr 1, there was no difference in LM area ($P = 0.23$) or marbling score ($P = 0.28$). Contrary to yr 1, there was a linear increase ($P = 0.04$) in 12th rib back fat thickness and consequently a tendency for linear increase in calculated yield grade ($P = 0.10$) as heifers were supplemented with increasing levels of MDGS in the winter phase. Level of winter supplementation had no effect on finishing ADG or G:F when backgrounded on summer grass without supplement before feedlot arrival. However, greater levels of supplementation increased total system gain when summer grazing is not limited. Supplementing heifers at 3.18 kg/d MDGS during winter corn residue grazing has the potential to increase HCW.

Key Words: spayed heifer, supplementation, distillers grains

361 Effect of increasing protein and fat inclusion in the diet of beef cows during gestation and lactation on performance, milk production, pregnancy rate, and pre-weaning progeny growth.
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This study was conducted to evaluate the effects of increasing CP and fat inclusion in the diets of Angus × Simmental cows (610 ± 16.8 kg; n = 48) pregnant with male progeny during late gestation through mid lactation on cow performance and pre-weaning calf growth. Cows were allotted by BW and BCS to 4 treatments arranged in a 2 × 2 factorial, with 2 CP (11.9 and 17.1%; LP and HP diets, respectively) and 2 fat concentrations (2.0 and 4.8%; LF and HF diets, respectively) in the diet DM. Cows were housed for 178 d in individual pens and fed rations formulated to be isocaloric. The average calving date was on d 85 ± 7.2. After the treatment period, cow-calf pairs were placed on pasture and managed as one group until weaning (d 279). Performance and milk production data were analyzed using the MIXED procedure of SAS. Pregnancy rate data were analyzed using the GLIMMIX procedure of SAS. Cows fed LP and HF had lower ($P < 0.01$) BW gains through 178 d compared to cows fed HP and LF, respectively, and BW gain for LP cows was much lower when HF diets were fed compared to LP cows fed LF diets (interaction; $P < 0.01$). In contrast, BW gain from d 179 to weaning was greater ($P < 0.01$) for LP and HF compared to HP and LF, respectively, and BW gain for LP cows was much greater when HF diets were fed compared to LP cows fed LF diets (interaction; $P \leq 0.01$). Body condition score and DMI on d 178 and from d 86 through 178, respectively, were greater ($P < 0.01$) for HP only when cows were fed the HF diet. In all periods, G:F was greater ($P < 0.05$) for cows receiving HP diets within both dietary fat inclusions. Milk production was greater for cows receiving HP and LF ($P \leq 0.02$) diets compared to LP and HF, respectively. Moreover, milk fat, true protein, urea nitrogen, and total solids were greater ($P \leq 0.05$) for cows fed HP compared with those fed LP. No effects of dietary CP or fat concentrations were observed for TAI ($P = 0.11$) and overall ($P = 0.99$) pregnancy rates, as well as for calf BW and ADG. In summary, increasing dietary CP inclusion had positive effects on cow performance, milk production, and milk composition. In contrast, with the exception of TAI, increasing fat inclusion had either neutral or negative effects on the analyzed variables.

Key Words: developmental programming; maternal nutrition; milk composition

362 Effects of enzymatically hydrolyzed yeast supplementation and supplementation frequency on nitrogen balance and apparent diet digestibility in periparturient beef cows.
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We evaluated effects of enzymatically hydrolyzed yeast (EHY) and supplementation frequency on nitrogen balance and digestibility parameters in periparturient beef cows. Eighty multiparous cows fed a common brome hay-based diet (CP = 8.0 ± 0.17%) were blocked by expected calving date and stratified by BCS before random assignment of treatment. Beginning 88 ± 5 d before parturition, cows were provided 1-kg daily or 3-kg every 3-d of a soybean hull-based supplement that contained 0 or 3 g/kg EHY. The daily supplement was designed to meet ruminal N requirements. Cows were provided a bolus of TiO_2 (10 g/d) at the time of supplement feeding for 10-d beginning 64-d before calving and again 34-d before calving. Fecal and urine samples were collected each 12-h for 6-d beginning 4-d after cattle first received TiO_2. Initiation of sample collection was delayed between each d so that composite samples of urine and feces were representative of every 2-h in a 24-h period. Samples of hay, supplement, feces and urine were analyzed for DM, OM, N, NDF, ADF and ADIA. Fecal TiO_2 allowed calculation of fecal output and ADIA was used to calculate hay intake. Urine creatinine acted as a urine output marker. Data were analyzed as a 2 × 2 factorial design. There were no interactions of EHY, supplementation frequency or sampling time. Neither EHY ($P = 0.31$) or supplementation frequency ($P = 0.57$) affected estimates of DMI, but DMI estimates tended to increase ($P = 0.08$) from 10.8 to 11.1 ± 0.2 kg/d as cattle neared parturition. Apparent total-tract digestibility of DM (54.4 ± 0.6%), OM (58.2 ± 0.6%), NDF (51.7 ± 0.8%) and ADF (46.0 ± 0.9%) was not different ($P > 0.10$) between EHY and control; however, daily supplementation increased ($P \leq 0.06$) apparent total-tract digestibility of DM (55.6 vs. 54.1 ± 0.8%), OM (58.9 vs. 57.5 ± 0.6%), NDF (52.6 vs. 50.8 ± 0.8%) and ADF (46.8 vs. 45.2 ± 0.9%) compared to supplementation every 3 d. We observed no effects of EHY ($P = 0.55$) or supplementation frequency ($P = 0.60$) on N retention (15.1 ± 4.6 g/d); however, N retention decreased ($P = 0.03$) from 21.3 to 8.8 ± 4.4 g/d as cattle neared parturition. These data suggest that daily supplementation can provide benefit to diet digestion, but increases in diet digestibility in response to more frequent supplementation were not related to changes in N retention.

Key Words: Cattle, supplementation, digestion

363 Evaluation of rumen bacterial composition in Holstein and Jersey cows under similar dietary conditions using different sampling methods.

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This study utilized 16S rRNA gene amplicon sequencing to describe the rumen bacterial community composition in Holstein and Jersey cows fed an identical diet by sampling the rumen microbiota via the rumen cannula or esophageal tubing. Five ruminally cannulated Holstein cows and 4 Jersey cows (not cannulated) were fed a diet composed of 51% forage and 49% concentrate during 4 wk. On the 28th day, rumen samples were collected from both Holstein and Jersey cows using the esophageal tubing, and an additional rumen sample was collected from Holstein cows via the cannula. After collection of the rumen sample via esophageal tubing, particles attached to the metal strainer were added to the sample to better represent whole rumen content and to include particle associated bacteria. Total rumen DNA was extracted using the PowerMag™ Soil DNA Isolation Kit, and the V3 region of the bacterial 16S rRNA was amplified and then sequenced using the Ion Torrent™ Personal Genome Machine. The resulting sequences were quality filtered and operational taxonomic units (OTUs) were generated at 97% similarity. Taxonomy assignment was performed using the Greengenes database. The 2 main phyla identified regardless of breed or sampling method, were *Firmicutes* and *Bacteroidetes*, which accounted for 44.3 and 42.9% of the sequences. Alpha diversity metrics, observed OTUs and Chao1 estimates, displayed higher ($P < 0.01$) bacterial richness in Holstein compared to Jersey cows. However, between the samples collected via the cannula and stomach tubing in Holstein cows, no difference in species richness was detected ($P > 0.40$). Principal coordinate analysis using the unweighted UniFrac displayed clustering by breed suggesting that Holstein and Jersey cows may harbor distinct rumen bacterial communities. Non-parametric multivariate analysis of variance supported the significant effect of breed ($P = 0.01$). No significant difference in bacterial community structure was detected by sampling method ($P = 0.18$). Linear discriminant analysis of effect size was used to identify OTUs that differ between breeds. Family level classification of most abundant differential OTUs identified OTUs from the bacterial families *Lachnospiraceae*, *Veillonellaceae*, *Ruminococcaceae,* and *Fibrobacteraceae* to be more predominant in Holstein compared to Jersey cows whereas an OTU from the family *Prevotellaceae* was more predominant in Jersey compared to Holstein cows. Overall, results suggest that the bacterial community between Holstein and Jersey cows differ and that esophageal tubing with collection of feed particles associated with the strainer provides an adequate sampling method for rumen bacterial community studies.

Key Words: Holstein cow, Jersey cow, rumen bacterial community composition

364 The influence of grain source and dried corn distiller's grains plus solubles oil concentration on finishing cattle performance and feeding behavior.

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Eighty-one steers (428 ± 3.5 kg of BW) were used to determine the effect of grain type (corn vs. barley) and oil concentration of dried corn distiller's grains plus solubles (DDGS; moderate = 7 to 9% vs. low = 4 to 5%) on feedlot performance, feeding behavior, and carcass performance. Steers were allotted by BW to 1 of 3 pens equipped with an Insentec feeding system. Within each pen, steers were assigned randomly to 1 of 4 dietary treatments (n = 6 or 7 steers/treatment): 1) corn and moderate fat DDGS, 2) corn and low fat DDGS, 3) barley and moderate fat DDGS, and 4) barley and low fat DDGS. Intake and feeding behavior traits were calculated from data generated via the Insentec feeding system. Steers were weighed 2 consecutive days at trial initiation, then every 28 d thereafter. Steers were marketed in 2 groups at 119 (n = 40) and 155 (n = 41) d (final BW = 668 ± 4.4 kg). Final BW and ADG ($P = 0.79$) were not affected by grain type or DDGS oil concentration. The ADG for the first 28 d was lower ($P = 0.002$) for the steers fed barley-based diets (1.23 ± 0.101 kg) than steers fed corn-based diets (1.65 ± 0.102 kg). Overall DMI decreased ($P = 0.002$) and G:F increased ($P = 0.01$) with steers fed barley-based diets. Steers on barley-based diets had less daily visits ($P = 0.05$) but increased eating time per visit ($P = 0.03$). Blood urea concentration was greater in steers fed barley-based diets ($P < 0.001$) as well as steers fed low-fat DDGS diets ($P = 0.05$). Blood glucose concentration was not affected ($P \geq 0.20$) by treatment. There was no effect ($P \geq 0.26$) of treatment on carcass traits; HCW, marbling, LM area, 12thrib fat, and KPH fat. These data indicate that steers fed barley diets were more efficient, having a greater G:F, than steers fed corn diets. Oil level of DDGS had no effect on feedlot performance. Steers fed barley diets spent more time eating per visit but visited the bunk less per day than steers fed corn diets which could account for the lower DMI with steers fed barley diets. Carcass traits were not affected by either grain type or oil concentration of DDGS. Our data indicates that including a lower fat DDGS as compared to a moderate fat DDGS in a feedlot diet may not influence feedlot performance, feeding behavior, or carcass measurements.

Key Words: finishing cattle, distillers grains, grain source

365 Impact of nutrition on the ruminal microbiome and epithelial tissue. J. C. McCann*[1], F. C. Cardoso[2], E. Khafipour[3], D. W. Shike[4], J. J. Loor[2], [1]*Texas A&M University, College Station,* [2]*University of Illinois, Urbana,* [3]*Department of Medical Microbiology and Infectious Diseases, Winnipeg, MB, Canada,* [4]*University of Illinois at Urbana-Champaign, Urbana.*

Ruminal microbiome composition and epithelial tissue function can influence the diet's ability to address the nutrient requirements of cattle, but these associative effects are poorly characterized. Experiments were conducted to determine the effect of 2 dietary strategies, subacute ruminal acidosis (SARA) and the inclusion level of condensed distillers solubles (CDS), on the ruminal microbiome and epithelial gene expression. In both experiments, rumen samples were separated into solid and liquid fractions while epithelial papillae were excised from the rumen. After using a feed restriction acidosis-induction model, relative abundance of Bacteroidetes was increased ($P < 0.01$) in the solid fraction of SARA cows compared with Non-SARA cows. Quantitative PCR indicated greater *Anaerovibrio lipolytica*, *Prevotella bryantii*, and *Succinimonas amylolytica* ($P < 0.03$) after induction in the solid fraction of SARA cows, while *Streptococcus bovis* and *Succinivibrio dextrinosolvens* were greater ($P = 0.02$) in SARA cows pre- and post-induction. The predicted functional profile of the solid fraction ruminal microbiome post-induction corresponded to known metabolites impacted by high-concentrate feeding. Beta-diversity metrics indicated that in the liquid fraction the effect of day was greater than the effect from differences in ruminal pH response. Effects of SARA on ruminal epithelium 24 h post-induction were modest. An increased expression of *CLDN1* and *CLDN4* ($P = 0.01$) was observed after feed restriction. Results suggest that a more rapid adaption to a single bout of SARA occurred within the solid fraction microbiome. As supplemental fat is often added to ruminant diets to increase the energy density of the ration, the effect of CDS inclusion at 0, 10, 19, and 27% in a coproduct based diet was determined. The greatest effects were observed in the liquid fraction as species richness and α diversity decreased with greater CDS inclusion. Linear increases of Firmicutes ($P < 0.01$) in the liquid fraction were driven by greater relative abundance of Ruminococcaceae ($P < 0.01$) with additional CDS. Decreased Bifidobacteriaceae and Spirochaetaceae (linear; $P < 0.02$) in the liquid fraction were observed with greater CDS. Relative abundance of Desulfovibrionaceae increased quadratically in the solid and liquid fraction with the highest levels at 19% CDS inclusion. No effect of CDS was observed in ruminal epithelium expression of genes related to ketogenesis and transcription regulation. Overall, dietary composition and ruminal pH affected the ruminal microbiome community and epithelial gene expression and may influence nutrient utilization.

Key Words: nutrition microbiome epithelium

366 Accurate amounts and nutritive values of corn residue. S. E. Gardine*[1], A. K. Watson[2], J. L. Harding[1], T. J. Klopfenstein[1], [1]*University of Nebraska, Lincoln,* [2]*Department of Animal Science, University of Nebraska, Lincoln.*

Corn residues are becoming more important as roughage sources for beef cattle as conventional forage supplies decline. Past research has assumed 10 corn plants yield a representative sample for nutrient analysis. This trial's objectives were to determine variation among individual plants and re-evaluate energy and protein values of corn residues. Samples were taken from an irrigated field in a corn, soybean rotation used for stalk grazing research for over 20 yr. There are non-grazed, fall grazed, and spring grazed areas (treatments) with 4 field replications of each. In the fall of 2014, 10 consecutive corn plants were harvested from each of these field replications (3 treatments × 4 reps = 12 sampling locations). Each of the 120 corn plants, harvested above the anchor roots just before grain harvest, was separated into grain, cob, leaf blade, leaf sheath, and husk. Each plant part was dried (60°C) and DM amounts determined. Statistical analysis was conducted using a model with 3 treatments and 4 replications, with corn plant as the experimental unit. The analysis was repeated 10 times using 1 corn plant, 2 corn plants, etc. until all 10 were included. Grain yield was not affected by grazing treatment ($P = 0.49$). As expected, all plants were not the same. Overall grain yield ranged from 160 to 293 g/plant. The SEM declined as more plants were added to the analysis from 18 with 1 plant to 4 with 10 plants, minimal decline in SEM was observed as plants 6 to 10 were added to the analysis. The average amount of leaf blade, leaf sheath, and husk was 23.8% of grain. As numbers of plants were added to the analysis SEM declined from 1.5 at 1 plant to 0.4 at 10 plants, with minimal decline from 6 to 10 plants. Leaf blades had 15.4% ash, therefore the amounts of digestible OM (DOM) were determined in vitro, adjusted for in vivo standards. Husks had 55.6% DOM, leaf blades 40.7% and leaf sheaths 38.6%. Husk and leaf CP was 3.75% and 5.75%, respectively. Using in situ and mobile bag techniques, the rumen degradable protein (RDP) contents were 2.72 and 4.43% of DM, respectively. Digestibility of the ruminally undegradable protein (RUP) was less than 25% for both husk and leaf. Six to 10 plants are necessary to obtain representative results and residue energy values may be less than previously reported.

Key Words: corn residue, TDN, variation

367 Evaluation of different byproduct combinations along with treated corn stover on growing steer performance.

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Changes in ethanol production, including secondary fermentation of fiber, may result in the use of other fibrous materials such as CaO-treated corn residue (TCR), to carry distillers solubles (DS) and protein in distillers grains (HPD). These processing and pelleting methods may allow other ingredients to be added. Both crude glycerin (CG) and DS have been shown to improve performance of growing cattle. The objectives of this research were to evaluate distillers grains products with different concentrations of DS and CG on the performance of growing steers. An 81-d growing study utilized 300 yearling crossbred steers (initial BW = 311, SD = 15 kg) in a randomized block design. Within a block, cattle were stratified by BW, assigned randomly to pen with 15 head per pen and 5 replications per treatment. All steers were fed 46% brome hay diet with 4% supplement. Treatments consisted of a control diet (CON) containing 50% modified distillers grains plus solubles (MDGS); product A (PRODA) consisting of 12.5% TCR, 18.75% DS, and 18.75% HPD; product B (SOL) consisting of 12.5% TCR, 30% DS, and 7.5% HPD; or product C (GLY) consisting of 12.5% TCR, 25% DS, 5% CG, and 7.5% HPD. Performance data (BW, DMI, ADG, G:F) were analyzed with the MIXED procedure of SAS with pen as the experimental unit and block treated as fixed effect. Steers consuming distillers grains products had greater DMI, but lower ADG compared to steers fed MDGS, which was reflected in reduced G:F, and ending body weight compared to CON. Utilizing up to 30% DS, 5% CG, and 12.50% TCR as a replacement for MDGS in a brome hay diet reduced steer performance.

Key Words: Growing cattle, Distillers grains, Treated stover

Table 367.

	Treatment					
	CON	PRODA	SOL	GLY	SEM	*P*-value
DMI, kg/d	10.7[a]	10.8[a]	11.4[b]	11.1[a,b]	0.14	0.01
ADG, kg/d	1.61[a]	1.40[b]	1.37[b]	1.40[b]	0.03	< 0.001
Gain:Feed	0.152[a]	0.130[b]	0.121[c]	0.126[bc]	0.003	< 0.01

368 Effects of co-ensiling high moisture corn stover with co-products on spoilage, aerobic stability, nutrient composition, and in situ digestibility.

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Objectives of this study were to determine the effects of co-ensiling high moisture corn stover (HMCS) with co-products on pack density, spoilage, aerobic stability, nutrient composition, and in situ digestibility. Plastic barrels ($n = 4$) were used to ensile 5 combinations: 1) CON; HMCS only, 2) CCDS; HMCS and corn condensed distillers solubles, 3) MIX30; HMCS and Mix30 liquid supplement (Agridyne, LLC, Springfield, IL), 4) MWDGS; HMCS and modified wet distillers grains and solubles, 5) STEEP; HMCS and corn steep water. Each combination was individually mixed in a feed truck and then manually packed into barrels. Barrels were packed to the same height then covered with plastic. Barrels were stored in an open-sided building for 183 d. After storage, the spoilage depth was measured and weighed. Pack density was calculated for each barrel. A subsample from each barrel was placed in an open bucket at room temperature. Subsample temperatures were assessed every 12 h for 4 d to determine aerobic stability. Additional subsamples were dried at 55°C, ground through a 4 mm screen, and incubated in 2 ruminally fistulated steers for 12, 24, and 48 h to determine in situ DM disappearance (DMD) and NDF disappearance (NDFD). Pack density, spoilage, aerobic stability, nutrient composition, DMD, and NDFD were analyzed using the MIXED procedure in SAS (SAS Inst. Inc., Cary, NC), with repeated measures for aerobic stability, DMD, and NDFD. There were no differences ($P \geq 0.21$) in spoilage. Pack density was greater ($P < 0.01$) for all co-ensiled combinations compared to CON. There was a combination by time interaction ($P < 0.01$) for aerobic stability. At 96 h, STEEP had the greatest ($P < 0.01$) temperature, CCDS and CON were intermediate, and MIX30 and MWDGS had the lowest temperature. Samples of CON had greatest ($P < 0.01$) NDF and ADF concentrations whereas CCDS, MIX30, and STEEP had least; MWDGS was intermediate and different from CON. The CP concentration differed ($P < 0.01$) among treatments (6.4, 11.7, 12.7, 14.1, and 14.8% for CON, CCDS, MWDGS, STEEP, and MIX30, respectively). The MWDGS DMD was greater ($P = 0.01$) than STEEP, CCDS, and MIX30, with CON being intermediate and not different. However, CON and MWDGS had greater ($P = 0.03$) NDFD than MIX30, with STEEP and CCDS intermediate and not different. Co-ensiling high moisture corn stover with co-products reduced fiber concentration, increased protein concentration, and increased pack density of the mix. Co-ensiling with Mix30 liquid supplement and MWDGS improved aerobic stability.

Key Words: co-ensiling, co-products, high moisture corn stover

369 The effect of delayed corn silage harvest on performance of yearling steers fed 15 or 45% silage finishing diets.

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Crossbred yearling steers ($n = 180$; BW = 428 kg; SD = 39 kg) were used in a feedlot finishing trial to evaluate the effects of harvesting drier corn silage and replacing corn with corn silage in diets with 40% modified distillers grains with solubles.

Previous data suggests DM yield and starch (i. e., grain) content may be increased if silage harvest is delayed and silage is drier. Factors were harvested corn silage DM (37 or 43%) and inclusion of corn silage in the finishing diet (15 or 45% of diet DM). Steers were blocked by BW and assigned randomly within block to pen (n = 20; 9 steers/pen). Steers were fed for an average of 108 d before harvest. On the day of harvest, HCW were recorded, and 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-h chill. Data were analyzed using the GLIMMIX procedure of SAS as a randomized block design with pen as the experimental unit and block as a fixed effect. There were no interactions between corn silage DM and corn silage inclusion ($P \geq 0.47$) for feedlot performance or carcass characteristics. As corn silage inclusion increased from 15 to 45%, ADG decreased ($P = 0.04$) while DMI did not differ ($P = 0.15$), which decreased G:F ($P < 0.01$) for cattle fed 45% corn silage compared to 15%. Carcass-adjusted final BW and HCW were lower ($P \leq 0.04$) for steers fed 45% corn silage compared to 15%. There were no differences ($P \geq 0.26$) in LM area, 12th rib fat, and marbling score as corn silage inclusion was increased. As DM of corn silage was increased from 37 to 43%, no differences ($P \geq 0.30$) in DMI, ADG, or G:F were observed. Additionally, there were no differences ($P \geq 0.68$) in carcass-adjusted final BW or HCW when drier corn silage was fed. No differences ($P \geq 0.27$) in 12th rib fat or marbling scores were observed due to DM of corn silage. While increasing corn silage inclusion from 15 to 45% in place of corn in finishing diets reduced ADG and G:F, feeding more corn silage than typical in finishing diets and or delaying corn harvest and ensiling drier corn silage to increase harvested tonnage could prove to be economical.

Key Words: Corn silage, Dry matter, Finishing cattle

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370 The effect of corn silage harvest DM and rumen undegradable protein supplementation in silage growing diets growing beef cattle.

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A 78-d growing study was conducted utilizing 60 crossbred steers (initial BW = 271; SD = 32 kg) to evaluate the effects of harvesting drier corn silage and response to rumen undegradable protein (RUP) supplementation. Previous data suggests DM yield and starch (i. e., grain) content may be increased if silage harvest is delayed. Treatments were arranged as a 2 × 5 factorial design. Factors included harvested corn silage DM (37 or 43%) and supplemental RUP inclusion (0.0, 2.5, 5, 7.5, or 10% of diet DM). Supplemental RUP was a blend of corn gluten meal and non-enzymatically browned soybean meal (Soypass). Steers were individually fed using Calan gates and were limit fed a common diet at 2% of BW for 5 d followed by weighing 3 consecutive d at the beginning and end of the experiment for accurate BW collection. Steers were stratified by initial BW using the average of d −1 and d 0 BW, and assigned randomly to treatment with 5 to 8 steers per supplemental RUP inclusion within each silage DM (n = 8 for 0% RUP; n = 5 for 2.5% and 5% RUP; n = 6 for 7.5% and 10.0% RUP treatments). Due to a limited number of bunks, a greater number of animals were used at 0%, 7.5% and 10% supplemental RUP inclusion as we hypothesized metabolizable protein needs would be met at 7.5%. No linear ($P \geq 0.33$) or quadratic ($P \geq 0.36$) interactions were observed between corn silage DM and supplemental RUP inclusion ($P \geq 0.22$) for growing performance. As DM of corn silage increased from 37 to 43%, there was a significant decrease ($P = 0.04$) in ending BW due to reduced ($P = 0.01$) ADG. Steers fed 37% DM silage had greater ($P < 0.01$) G:F compared to steers fed 43% DM silage. Increasing supplemental RUP in the diet increased ($P \leq 0.05$) ending BW, DMI, and ADG linearly as supplemental RUP increased from 0 to 10%. With both an increase in DMI and ADG, G:F increased ($P < 0.01$) linearly as supplemental RUP inclusion increased. Feeding silage in growing diets at 88% inclusion shows that 37% DM silage results in greater ADG and G:F compared to 43% corn silage. The addition of RUP to silage-based, growing diets will improve performance by supplying more metabolizable protein and suggests RUP of corn silage is limiting.

Key Words: Corn silage, Dry matter, Rumen undegradable protein

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371 Influence of two fat levels of dry distillers grains in diets with corn or barley on growing and finishing feedlot and carcass performance of steers.

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A 189 d growing (57 d) and finishing (132 d) study using 154 crossbred steers (initial BW = 310 kg) evaluated the effects of dry-rolled corn or dry-rolled barley and 2 fat levels of dry distillers grains with solubles (DDGS) on growing and finishing cattle performance. Steers were blocked by initial BW into 4 blocks and assigned randomly to 1 of 16 pens and 1 of 4 dietary treatments within block. In the 2 × 2 factorial study, factors were grain type (corn or barley; 30% and 51% diet DM, growing and finishing diets) and DDGS type (med-fat, 9.6% or low-fat, 5.8% fat; 26% diet DM for growing and finishing diets). Growing diets included 19% grass hay, 22% corn silage, and 3% supplement (DM basis). Finishing diets included 20% corn silage, and 3% supplement (DM basis). Steers were weighed on d 0 and every 28 d until harvest. No grain type by DDGS fat level interactions were detected ($P \geq 0.29$). Initial and final BW for the growing ($P \geq 0.18$) and finishing phases ($P \geq 0.11$) were similar for low- and med-fat DDGS.

Similarly, ADG, DMI, and G:F were similar for growing ($P \geq 0.19$) and finishing ($P \geq 0.17$) phases for low- and med-fat DDGS. Additionally, dressing percent, HCW, yield grade, Longissimus muscle area, marbling score, and back-fat did not differ among DDGS treatments ($P \geq 0.18$). Corn and barley had similar initial and final growing ($P \geq 0.16$) and finishing ($P \geq 0.17$) BW and ADG. Growing DMI was similar ($P = 0.37$) for corn and barley grain. However, cattle on corn finishing diets had greater ($P = 0.02$) DMI than barley resulting in similar ($P = 0.26$) growing phase G:F but a tendency ($P = 0.08$) for barley to be more efficient than corn in the finishing phase. Overall barley-fed steers had greater ($P = 0.002$) G:F than corn. The carcass parameters dressing percent, HCW, yield grade, LM area, marbling score and BF were all similar ($P \geq 0.09$) for barley and corn fed cattle. Feeding low or Med fat DDGS at 26% of diet DM, in the growing and finishing phases, appears to influence animal performance and carcass attributes similarly. When fed at similar diet DM levels, barley appears to provide a slight feed efficiency advantage over corn.

Key Words: DDGS, Fat levels, beef cattle, corn, barley

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372 Evaluation of the value of fiber in distillers grains plus solubles on performance of finishing cattle.

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A finishing experiment was conducted to determine the value of the fiber in distillers grains plus solubles for cattle. The experiment utilized 800 crossbred yearling steers (initial BW = 415 kg; SD = 24 kg) fed in 100 pens (8 steers/pen and one of 5 treatments ($n = 20$ pens/treatment). Cattle were split into 4 blocks by starting blocks each week for 4 consecutive weeks. Cattle were limit fed 5 d before starting experiment and were weighed on Day 0 and 1 for an accurate initial BW. The 5 treatments consisted of a corn control diet (CON), 20 (20MDGS) or 40% (40MDGS) modified distillers grains plus solubles (MDGS), plus 2 diets containing corn germ meal and corn bran balanced to equal the fiber content of the 2 MDGS diets (20FIB and 40FIB). Performance data were based on 134 d (blocks 1, 2, 3) or 148 d (block 4) and carcass data were collected at slaughter and following a 48 h chill. Statistics were completed using the mixed procedure of SAS with pen as the experimental unit. Initial BW ($P = 0.63$) was not influenced by treatment. Intakes were impacted by treatment ($P < 0.01$) and DMI increased quadratically ($P < 0.01$) as MDGS increased with steers fed 20MDGS having the greatest DMI. Steers fed 40MDGS or 40FIB had similar DMI ($P = 0.76$), whereas steers fed 20MDGS consumed more ($P < 0.01$) than steers fed 20FIB. When 20FIB and 40FIB were fed, DMI increased linearly ($P = 0.01$) relative to CON. Dietary treatment impacted ADG ($P < 0.01$) with ADG increasing quadratically ($P = 0.02$) as MDGS inclusion increased, and equal ADG between 20MDGS and 40MDGS ($P = 0.96$). Feeding 20FIB and 40FIB slightly reduced ADG but not statistically ($P > 0.14$) compared to CON. As a result of increased ADG, G:F increased linearly ($P < 0.01$) for steers fed MDGS. When steers were fed 20FIB or 40FIB, G:F decreased linearly ($P < 0.01$) due to an increase in DMI and numerical decrease in ADG compared to CON. The feeding value (change in G:F due to MDGS inclusion) of MDGS was 107 to 108% of corn that was replaced in CON. The isolated fiber component does not give equal performance to feeding MDGS and G:F was slightly reduced if only the fiber components replaced corn.

Key Words: Distillers grains plus solubles, Fiber, Finishing cattle

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373 Effects of feeding isolated nutritional components in distillers grains on growing cattle performance.

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The nutrient composition of distillers grains plus solubles (DGS) continues to change as ethanol producers may remove oil and fiber from DGS. Removal of these components may alter the energy content of DGS and, therefore, its value as a feedstuff. An experiment was conducted to evaluate the effects of fat, fiber, and protein found in distillers grains on performance of growing crossbred steers ($n = 450$; initial BW = 297, SD = 24 kg). All growing diets contained 50% grass hay, 5% Soypass® to meet protein requirements, and 5% supplement (DM basis). Treatments included a 40% corn control diet, a diet containing 40% modified distillers grains plus solubles (MDGS) replacing dry-rolled corn, or 1 of 4 diets designed to isolate the contribution of fiber, protein, or solubles to compare to the feeding value of MDGS. The 4 diets consisted of: 1) corn gluten meal replacing 20% corn to mimic the protein content of MDGS (PROT); 2) a combination of 16.4% corn bran and 3.6% germ meal to represent fiber in MDGS (FIB); 3) condensed distillers solubles included at 15% (SOL); and 4) a combination of FIB and SOL together (COMBO). Cattle were fed 81 d and performance data were analyzed by pen using the MIXED procedure of SAS. Ending BW, ADG, and G:F were influenced by treatment ($P < 0.02$). Treatment tended ($P = 0.06$) to impact DMI, which was greater for MDGS, SOL, and COMBO compared to FIB ($P < 0.04$). Steers fed MDGS had the greatest ADG while FIB had the least ($P < 0.01$). Feed efficiency was improved for steers fed MDGS and PROT, intermediate for FIB, and poorest for CON, SOL, and COMBO diets ($P < 0.02$). Ending BW was heaviest for MDGS and lightest for CON and FIB ($P < 0.01$). All remaining treatments had intermediate ending BW with PROT being greater compared to SOL or COMBO ($P < 0.01$).

Cattle fed 40% MDGS performed better than those fed CON. Though all diets met the metabolizable protein requirements of the steers, PROT resulted in feed conversions similar to MDGS. This suggests that protein in MDGS, when overfed to provide energy, explains improved performance of cattle fed MDGS in high forage diets. No other component appeared to contribute toward the greater energy value of MDGS relative to corn. Data from this study suggest that excess metabolizable protein as RUP contributes significantly to the feeding value of MDGS in growing diets.

Key Words: Distillers Grains, Energy, Protein

374 Effects of feeding corn condensed distillers solubles and crude glycerin alone or in combination on growth performance and carcass characteristics of finishing steers.

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Crossbred steers (n = 250; initial BW = 336 ± 16 kg) were used in a randomized complete block experiment to evaluate the effects of feeding corn condensed distillers solubles (CCDS) and crude glycerin (CG) alone or in combination on feedlot performance and carcass characteristics of finishing beef steers. Cattle were stratified by initial BW and randomly allocated to 32 pens with 8 steers/pen (8 pens/treatment). Six animals were removed from the trial due to reasons unrelated to treatment. Steers were fed a steam-flaked corn-based diet with 4 dietary treatments consisting of 0% CCDS or CG (CON), 10% CCDS (CDS), 10% CG (GLY), or a combination of 5% CCDS and 5% CG (C+G) included on a DM basis. All treatment diets contained 15% (DM basis) corn wet distillers grains (CWDG). Animals were fed for an average of 167 d and weighed by pen every 30 d of the experiment. At the end of the finishing phase, cattle were weighed and transported to an abattoir in Amarillo, TX. Liver abscess severity and HCW were collected on the day of harvest and USDA yield and quality grades, LM area, marbling score and 12th-rib subcutaneous fat thickness were determined after a 48 h chill. Performance data were analyzed using PROC MIXED of SAS with treatment, day, and the interactions as fixed effects, weight block as a random effect, and pen as the experimental unit. Growth performance and gain efficiency were not different ($P > 0.10$) across all treatments. The CDS steers tended ($P = 0.09$) to have a greater fat thickness than GLY but treatment had no effect ($P > 0.10$) on carcass weight, marbling score, yield grade, LM area, or % grading USDA choice. Therefore, feeding additional byproducts such as CCDS and CG alone or in combination in a finishing diet did not alter live animal performance or carcass characteristics of beef steers compared to the control treatment.

Key Words: wet distillers grains, condensed distillers solubles, crude glycerin

375 Effect of crude glycerin concentration on growing steer performance in forage diets.

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Crossbred steers (n = 60, initial BW = 361; SD = 42 kg) were utilized to evaluate increasing concentrations of crude glycerin (GLY) in forage diets on steer performance for a 91 d growing trial. Treatment diets consisted of 0, 4, 8, and 12% GLY (diet DM) in diets containing 50% wheat straw, wet corn bran, soybean meal, and 5% supplement. The GLY replaced wet corn bran in basal diets while soybean meal was increased to maintain equal dietary CP across treatments. Supplements were formulated to provide 200 mg/d monensin and equilibrate Na concentrations across treatment diets. Steers were limit fed for 5 d at the beginning and end of the trial with a 3 d BW collected to serve as initial and ending BW. Steers were implanted with Ralgro on d 1 of the trial. Steer final BW was not different ($P = 0.40$) among treatments. There was a quadratic increase ($P = 0.03$) in DM intake from 0% GLY to 8% GLY and subsequent decrease at 12% GLY. There was no difference in ADG or G:F ($P \geq 0.14$) among GLY concentrations. Therefore, GLY appears to have a similar energy value to wet corn bran in a forage diet.

Key Words: crude glycerin, growing, forage

Table 375.

	Glycerin Concentration (Diet DM)					*P*-value	
	0%	4%	8%	12%	SEM	Linear	Quadratic
Initial BW, kg	361	360	360	362	1	0.83	0.23
Final BW, kg	481	476	478	475	4	0.40	0.74
DM intake, kg/d	9.35[ab]	9.81[ab]	9.99[a]	9.26[b]	0.27	0.93	0.03
ADG, kg/d	1.32	1.27	1.30	1.25	0.05	0.37	0.99
G:F	0.142	0.131	0.131	0.136	0.005	0.50	0.14

[ab] Means within rows differ $P < 0.05$.

376 Effects of ruminal alkalinizing and/or buffering agents fed to feedlot steers on performance and carcass characteristics.

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When added directly to the ration, calcium oxide and calcium hydroxide have the ability to increase rumen pH, fiber digestibility, and performance of feedlot cattle fed high concentrate/distillers grains (DG) diets. However, it is unclear which alkali is most effective, if safer, more economical buffers have the potential to improve performance, or if alkali/buffer combinations can significantly improve cattle performance over alkali or buffers fed alone. Thus, this study was performed to determine which alkali, buffer, or alkali/buffer combination is most effective at increasing performance of feedlot cattle fed a corn/DG-based diet. One hundred and twenty Angus ×

Simmental steers (395.3 ± 12.49) were allotted to 5 treatments based on BW, breed composition, and frame size. Four pens of 6 steers were fed rations supplemented with: no alkali/buffer (control), 1% calcium oxide (CaO), 1% calcium hydroxide ($Ca(OH)_2$), 1% potassium bicarbonate (K_2CO_3), or 1% CaO + 1% K_2CO_3. Animals were slaughtered at an average BW of 590 kg. Data were analyzed using the MIXED procedure of SAS. No differences among treatments were found for BW or DMI throughout the study ($P \geq 0.55$). Overall ADG was greatest for CaO and least for control ($P = 0.09$), while overall average daily gain for $Ca(OH)_2$, K_2CO_3, and $Ca(OH)_2$ + K_2CO_3 was intermediate and did not differ from CaO or control ($P \geq 0.10$). Gain:feed was greatest for CaO for the first half of the study ($P = 0.10$), while G:F during the first half was intermediate for $Ca(OH)_2$ and did not differ from any of the treatments ($P \geq 0.10$) No differences in G:F were noted for the second half of the study or overall ($P \geq 0.16$). Days on feed was greatest for control steers intermediate for steers fed $Ca(OH)_2$, K_2CO_3, and $Ca(OH)_2$ + K_2CO_3 and lowest for steers fed CaO ($P = 0.005$). Hot carcass weight, fat thickness, LM area, % KPH, yield grade, and marbling score did not differ among treatments ($P \geq 0.14$). Dressing percentage was greatest for steers fed $Ca(OH)_2$, and $Ca(OH)_2$ + K_2CO_3, intermediate for control steers and lowest for steers fed CaO or K_2CO_3 ($P = 0.05$). In conclusion, all alkali and buffer additions decreased the number of days for cattle to reach market weight compared to control; however, CaO appears to be the most effective at improving performance.

Key Words: alkali, buffer, beef cattle

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377 Effects of different inoculum used for in vitro and in situ digestion procedures performed on corn residue samples.

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Neutral detergent fiber digestibility (NDF digestibility) is an important assay in determining the energy content of forage. In vitro and in situ procedures are traditionally performed using an inoculum retrieved from a donor on a 30% concentrate diet. However, the diet fed to the donor may impact NDF digestibility estimates. Therefore, a study was conducted to assess the effects of donor diets on in vitro and in situ NDF digestibility. Four ruminally canulated steers were utilized to compare 2 forage diets. A mixed diet consisting of 70% brome and 30% dry distillers grains (DDGS) was fed to 2 steers and a high corn residue diet with 70% stalks and 30% Sweet Bran was fed to the remaining 2 steers. Residue samples consisting of 2-row, 4-row, 6-row, 8-row, conventional bale, leaf, husk, stalk and cob, along with 5 grass hays, were evaluated in situ and in vitro using inoculant from both sets of steers. All samples were tested with each inoculum from each individual steer, to test for an interaction of inoculum and sample type. This process was repeated in 3 runs, and steer inoculum source within run was the experimental unit ($n = 6$). The NDF digestibility of the corn residue was also determined utilizing in situ rumen incubation. No 3-way interaction was observed, in vitro or in situ, for time by sample by diet ($P = 0.99$). There were no interactions for time by sample ($P = 0.79$) or diet by sample ($P = 0.99$) in vitro. There was a tendency for an interaction for diet by time ($P = 0.11$) where diet significantly ($P = 0.03$) affected NDF digestibility at 48 h, but not at 24 h. There was an effect ($P < 0.01$) for diet in situ. That is, average NDF digestibility was consistently greater for both residue and grass samples when the donor was fed a high corn residue diet. At 28 and 48 h, in situ, diet impacted NDF digestibility ($P < 0.01$). However, there was no effect of diet, in situ, fed to donor at 36 h ($P = 0.45$). This study shows that the diet of the donor animal does affect NDF digestibility estimates of corn residue samples. Therefore, when trying to assess energy values using these techniques a set of standards with established in vivo digestibility values should be used for adjustment.

Key Words: corn residue, in situ, in vitro, neutral detergent fiber digestibility

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378 Relationship between TDN and OM digested in beef cattle finishing diets.

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Organic matter digestibility (OMD) is related to TDN. However, the relationship is unestablished for diets containing by-products. Three digestion studies were used to evaluate the relationship between TDN and OM digested. Total tract collection and OM analysis of feed and feces determined OMD which was multiplied by dietary OM content to determine OM digested (% of diet DM). Gross energy of feed and feces was determined by bomb calorimetry. Dietary DE was calculated and was converted to TDN using 4.4 Mcal DE/kg TDN. Experiment 1 utilized 45% high moisture corn, 40% Sweet Bran, and 10% corn silage diets (DM basis); Experiment 2 used diets containing 40% modified distillers grains plus solubles (DGS; DM basis) and increasing amounts of a corn stover pellet replacing dry rolled corn (DRC); Experiment 3 compared 80% DRC-based diets with 1 of 2 supplemental fat sources to diets with 25.5% distillers solubles, or 56% wet DGS. Regression was used to relate digestible OM to TDN. The initial model included experiment, animal within experiment, and treatment within experiment. A significant treatment within experiment effect ($P < 0.01$) resulted in independent regression models for each experiment. Experiment 1 and 2 showed no treatment effect and no interaction between treatment and OM digested. Therefore, a single slope with a linear relationship was used. In Experiment 3, there was a tendency for a treatment effect ($P > 0.14$). Results from Experiment 1 indicate OM digested

was 3.58% units (PU) greater than TDN content. In Experiment 2, OM digested was 11.1 PU less than TDN content. In Experiment 3, the OM digested in the corn diet was 3.96 PU greater than TDN. For the tallow diet, OM digested was 0.34 PU less than TDN, while in the corn oil diet, OM digested was 0.37 PU greater than TDN. In the solubles and wet DGS diets OM digested were less than TDN, 5.88 PU and 9.96 PU, respectively. These results suggest OM digested is consistent relative to TDN content of traditional, corn based diets. In finishing diets containing DGS, the additional DE supplied by DGS is not accounted for when evaluating only OM digested. This is likely due to the protein and fat content of DGS, which supplies additional energy relative to its OM content. Reporting both DE and OM content of diets is beneficial as there is not a simple conversion factor between DE and OM digested.

Key Words: Bomb Calorimetry, OM digested, TDN

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379 Effects of diet type and feeding phase on intake and feed efficiency of beef cattle. C. Cassady*, T. L. Felix, D. W. Shike, *University of Illinois at Urbana-Champaign, Urbana.*

Objectives were to evaluate test period length and repeatability of intake and efficiency measures during the growing and finishing phases, and determine the relationship between intake and efficiency evaluated in cattle fed different diet types. Over a 2-yr period, DMI, ADG, and 12th rib fat thickness were evaluated in crossbred cattle (n = 628) fed for two 70 d periods. During the growing period (first 70 d), a forage-based diet (equal parts corn silage and alfalfa haylage) was fed to heifers and a grain-based diet (50% corn, 15% DGS) was fed to steers. All cattle were fed the grain-based diet for the finishing period (last 70d). Individual DMI was recorded using the GrowSafe (Airdrie, AB, CAN) system. Residual feed intake (RFI) was calculated for each period and was assumed to represent a multiple regression equation, regressing DMI on mid-test metabolic BW, ADG and 12th rib fat thickness. Overall wean to slaughter ADG was calculated for steers by regressing all weights from the start of the growing phase to final BW, calculated as HCW divided by standard dressing percentage (63%). Dry matter intake and RFI were correlated (r = 0.56; P < 0.01, and r = 0.63; P < 0.01, respectively) for growing and finishing periods of steers fed grain. Although, steer ADG was not repeatable (r = 0.11; P = 0.06) across test periods. Growing and finishing ADG were both correlated (r = 0.58; P < 0.01, and r = 0.69; P < 0.01, respectively) to overall ADG. To test the potential of shortening the intake period, DMI for grain-fed steers were evaluated for 7, 14, 21, 28, 35, 42, 49, 56, or 63d. All intake evaluation periods were correlated ($r \geq 0.72$; P < 0.01) to total DMI during the growing phase and overall DMI. Intake of forage and forage RFI during the growing phase were correlated (r = 0.58; P < 0.01, and r = 0.42; P < 0.01, respectively) to intake of grain and grain RFI during the finishing period in heifers. Forage ADG was negatively correlated (r = −0.30; P < 0.01) grain ADG. In conclusion, intake and efficiency were repeatable from growing to finishing periods. Although gain was not repeatable for growing and finishing periods, each test period was correlated to gain over the entire feedlot phase. Correlations between shorter duration intake evaluation periods and overall DMI suggest that the intake evaluation period can be shortened to 35 d. Intake and feed efficiency on forage and grain were moderately correlated.

Key Words: beef cattle, feed efficiency, intake

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380 Effect of backgrounding system on feedlot performance and carcass characteristics of beef steers. J. L. Cox*[1], K. E. Hales[2], K. M. Ulmer[1], R. J. Rasby[1], S. D. Shackelford[2], H. C. Freetly[2], M. E. Drewnoski[1], *[1]Department of Animal Science, University of Nebraska, Lincoln, [2]USDA, ARS, U.S. Meat Animal Research Center, Clay Center.*

The objective of this study was to evaluate feedlot performance and carcass characteristics of steers that were backgrounded using 1 of 3 treatments: 1) corn residue grazing supplemented 6 d a week with 2.77 kg DM/hd of distillers (CRD), 2) oat-brassica forage grazing (OBF) or 3) drylotting on a grower ration (DGR). Steers (n = 355) were stratified by BW (277.6 ± 0.52 kg) and assigned to treatment and replicate (n = 4 reps). The OBF forage consisted of 28% purple top turnip, 14% daikon radish, and 59% oats (DM basis). The grower ration contained 51% corn silage, 25% alfalfa hay, 20% wet distillers, and 4% supplement (DM basis). The CRD and OBF calves grazed for 65 d and then were fed grower ration for 21 d while DGR was fed grower ration for 54 d before being transitioned to the finishing ration. At the start of finishing, BW of OBF (381 kg) was greater (P < 0.01) than DGR (365 kg) and CRD (365 kg). The finishing diet was fed for 160 d and consisted of 55.8% dry-rolled corn, 32.3% wet distillers, 8.7% corn silage, and 3.2% supplement. Finishing DMI of OBF and CRD were not different (P = 0.39) but were greater ($P \leq 0.01$) than DGR. Finishing ADG (P = 0.63) and 12th rib fat (P = 0.65) at harvest didn't differ among treatments. However, HCW of OBF (402 kg) was greater (P < 0.01) than both CRD (389 kg) and DGR (391 kg). The LM area tended (P = 0.06) to differ among treatments, with CRD, OBF, and DGR having a LM area of 85.2, 85.0, and 82.8 cm^2, respectively. Calculated yield grade of OBF (3.48) and DGR (3.49) did not differ (P = 0.88) but were greater ($P \leq 0.01$) than CRD (3.29). Marbling score tended (P = 0.06) to differ among treatments; with DGR, OBF, and CRD having marbling scores of 423, 419, and 402, respectively. Calves backgrounded by grazing oat-brassica forage produced more pounds of carcass than calves fed a corn silage based grower ration and calves grazing corn residue receiving distillers. Additionally, based on marbling, the quality of the carcass produced by grazing oat-brassica forage did not differ from calves fed a corn silage

based ration during backgrounding.

Key Words: Backgrounding, Brassicas, Carcass quality, Corn residue, Feedlot

381 Effects of feeding rumen protected amino acids in finishing cattle diets on performance and carcass characteristics. C. R. Oney*[1], A. K. Watson[2], C. J. Bittner[1], P. W. Rounds[3], F. H. Hilscher[1], T. J. Klopfenstein[1], G. E. Erickson[1], *[1]University of Nebraska, Lincoln, [2]Department of Animal Science, University of Nebraska, Lincoln, [3]Kemin Industries, Inc., Des Moines, IA.*

A 190-d calf fed finishing study, utilizing 240 steers, was conducted to evaluate growth implications of supplementing finishing cattle with bypass amino acid products, MetiPEARL and USA Lysine® of Kemin Industries, Inc. (Des Moines, IA). Three treatments were evaluated with 8 pens/treatment. Treatments consisted of a control (CON) diet; 8 g methionine/steer daily (26 g MetiPEARL/steer daily; MET); and 8 g methionine and 12 g lysine/steer daily (26 g MetiPEARL and 28 g USA Lysine/steer daily; MetLys). The common finishing diet for all treatments consisted of 40% Sweet Bran (Cargill Corn Milling; Blair, NE), 50% high moisture corn, 5% wheat straw, and 5% supplement (DM basis). All diets contained monensin (330 mg Rumensin®/steer daily) and tylosin (90 mg Tylan®/steer daily), and all cattle were fed ractopamine hydrochloride (300 mg Optaflexx®/steer daily) the final 28 d from Elanco Animal Health (Greenfield, IN). All cattle received a Revalor®-XS (Merck Animal Health Madison, NJ) implant on d 0. Cattle performance was measured throughout the study with 4 pen weights recorded throughout the trial and carcass data collected on harvest. There was no difference in DMI ($P = 0.46$) among the 3 treatments, averaging 10.2 kg/d. No differences in ADG during the feeding period were observed using interim pen weights ($P \geq 0.41$). Using carcass-adjusted performance, no differences were observed in final BW ($P = 0.79$), averaging 615 kg, or ADG ($P = 0.77$), averaging 1.76 kg due to treatment. Therefore G:F was also unaffected ($P = 0.79$) by treatment. While no differences were observed for HCW ($P = 0.78$) or LM area ($P = 0.33$), averaging 388 kg and 86.5 cm^2, respectively, there was a difference in USDA marbling score ($P \leq 0.01$). The CON and MetLys treatments were similar with scores of 508 and 498, respectively ($P = 0.38$), while the MET treatment had a score of 465 ($P \leq 0.01$). Fat thickness among treatments also varied slightly. The CON had the greatest 12th rib fat thickness ($P = 0.02$). However, all cattle were well finished, with an average fat thickness of at least 1.5 cm. Bypass amino acid supplementation did not affect cattle performance. Although gluten feed provides less bypass protein than distillers grains, it appears that a 40% Sweet Bran, 50% high moisture corn diet provides sufficient lysine, methionine, and metabolizable protein to meet finishing steer requirements.

Key Words: Amino Acid, Bypass protein, Supplementation

382 Effect of energy source, level, and sex on growth and performance of lambs. J. R. Jaborek*[1], H. N. Zerby[1], F. L. Fluharty[2], *[1]The Ohio State University, Columbus, [2]The Ohio State University, Wooster.*

The objective of the study was to compare ad libitum or restricted intake of whole shelled corn (WSC) versus alfalfa pellets, and the sex of lamb, on lamb growth and performance. Ewe ($n = 48$) and wether ($n = 48$) lambs were blocked by sex and stratified by initial weight to pen. The 3 diets were ad libitum WSC (AC), 85% of ad libitum intake WSC diet (LC), or an ad libitum alfalfa pellet diet (AA). There were 4 lambs per pen, and 8 replicate pens per dietary treatment. Ewe and wether lambs were removed from the study when pens reached an average weight of 59.0 and 63.5 kg, respectively. Statistical analysis was conducted using PROC MIXED statement in SAS with diet and sex as fixed effects, diet and sex nested within pen as the random effect, and initial weight interactions and final weight were used as covariates if $P < 0.20$. For daily DMI, gain efficiency, and feed cost of gain data, pen averages were used for the analysis and the random effect was removed. Initial and final weight covariates were the deviations from the average ewe or wether weights. The LSMEANS and DIFF statements were used to distinguish significant ($P < 0.05$) differences between treatments and record the standard error. Average daily gain (ADG) of lambs fed the AC diet was greater ($P < 0.001$) than lambs fed the LC and AA diets, which resulted in fewer ($P < 0.01$) days on feed for AC fed lambs. Lambs consuming the AA diet had greater ($P < 0.001$) DMI than lambs fed the AC or LC diets. Wether lambs had greater ($P < 0.01$) DMI compared to ewe lambs. Gain efficiency was greatest ($P < 0.001$) for lambs fed AC, followed by lambs fed the LC diet, and finally the AA diet. Whole shell corn cost \$0.15/kg, alfalfa pellets cost \$0.60/kg, and supplements cost \$0.51/kg on an as-fed basis. The resulting feed cost of gain was greatest ($P < 0.001$) for AA fed lambs, followed by LC fed lambs, and lastly AC fed lambs. There was a trend ($P = 0.06$) for ewe lambs to have a lower feed cost of gain than wethers. The AC diet resulted in the most efficient gain, fewest days on feed, and the lowest feed cost of gain.

Key Words: energy source, growth, lambs

383 Metabolic and body temperature responses to environmental conditions across seasons in finishing steers. B. M. Boyd[*1], T. L. Mader[2], C. J. Bittner[3], D. B. Burken[3], F. H. Hilscher[3], G. Wijffels[4], J. B. Gaughan[4], M. L. Sullivan[4], A. J. Cawdell-Smith[4], G. E. Erickson[3], *[1]University of Nebraska-Lincoln, Lincoln, [2]Mader Consulting, LLC, Gretna, NE, [3]University of Nebraska, Lincoln, [4]The University of Queensland, Gatton, Australia.*

Two finishing trials were conducted utilizing 80 crossbred beef steers (in each) across 2 seasons (summer and winter; initial BW = 489 ± 20.4, 387 ± 15.9 kg, respectively) at the University of Nebraska-Lincoln Agricultural Research and Development Center near Mead, Neb. Continuous rumen temperature was collected throughout the duration of both trials. Blood samples were taken via jugular venous puncture every 2 wk until 4 wk before harvest for a total of 6 collections during the summer and 8 collections during the winter. Cattle in both trials were fed the same diet consisting of 51% HMC, 40% Sweet Bran, 5% wheat straw, and 4% supplement. Individual steer rumen temperature was used in the statistical model as a covariate. Only blood measures where rumen temperature was significant as a covariate were chosen to be reported. These selected blood measures were correlated to the 3-d prior average environmental temperature and the 3-d comprehensive climate index (CCI) relative to that blood collection day. Correlations between the change in blood measures and the respective change in rumen temperature, across collection points, were also analyzed. Additionally, environmental conditions were correlated to DMI and rumen temperature. Direct bilirubin, red blood cell count, hematocrit, and hemoglobin levels were all correlated ($R > 0.22$), during at least one season, to both the 3 d average environmental conditions and 3-d rumen temperature. Lactate dehydrogenase was negatively correlated ($R < -0.62$) to both 3-d averaged environmental conditions during the winter trial and also during the summer trial ($R > -0.28$). Red blood cell count was negatively correlated ($R < -0.23$) to 3-d environmental conditions during the winter trial however, was not correlated ($R > -0.10$) to environmental conditions during the summer trial. Rumen temperature was positively correlated to CCI and environmental temperature ($R = 0.65$, $R = 0.63$; respectively) during the summer. During the winter, rumen temperature was negatively correlated to CCI and environmental temperature ($R = -0.27$ and $R = -0.19$). Intake was negatively correlated to both CCI and environmental temperature ($R = -0.32$; $R = -0.30$) in the summer trial, however, during the winter trial DMI was positively correlated to CCI and environmental temperature ($R = 0.22$ and $R = 0.24$). Some blood metabolites change in accordance to environmental conditions and may be important during times of environmental stress. Additionally, environmental conditions affect both DMI and rumen temperature.

Key Words: body temperature, environmental stress, metabolites

384 The effect of feeding a yeast supplement or finely ground fiber during the summer on body temperature, performance, and blood metabolites of finishing steers. B. M. Boyd[*1], T. L. Mader[2], C. J. Bittner[3], F. H. Hilscher[3], G. Wijffels[4], J. B. Gaughan[4], M. L. Sullivan[4], A. J. Cawdell-Smith[4], G. E. Erickson[3], *[1]University of Nebraska-Lincoln, Lincoln, [2]Mader Consulting, LLC, Gretna, NE, [3]University of Nebraska, Lincoln, [4]The University of Queensland, Gatton, Australia.*

Crossbred beef steers (n = 96) were utilized in a study conducted at the University of Nebraska-Lincoln Agricultural Research and Development Center research feedlot near Mead, NE to determine the effect of feeding Agrimos (Lallemand Animal Nutrition; Montreal, Canada) and 2.5-cm ground wheat straw to finishing steers during the summer on body temperature and panting score in addition to performance, carcass characteristics and blood metabolites. Three treatments with 4 replications per treatment were set up in a completely randomized design. Treatments consisted of a basal control diet (CON); consisting of 68.5% corn, 20% modified distillers grains plus solubles, 7.5% sorghum silage, and 4% supplement, the inclusion of Agrimos (MOS; 30 g/steer daily), and 2.5-cm ground wheat straw replacing 5% corn (WHT). Cattle were stratified by initial BW between pens and pen was assigned randomly to treatment. Rumen boluses to collect body temperature were inserted on d 21 of the trial after cattle were adapted to finishing diets. Blood was collected in July and August (7 collection wk) of the trial via jugular venous puncture. There were no differences ($P > 0.19$) observed for final BW, ADG, and DMI among treatments. Additionally, no difference ($P > 0.24$) was observed for carcass-adjusted final BW or ADG. Feed efficiency was decreased ($P < 0.02$) on both a live- and carcass-adjusted basis for cattle fed WHT when compared to CON and MOS. Hot carcass weight, dressing %, LM area, and marbling score were not different ($P > 0.36$) among treatments. Cattle fed the CON had greater 12th rib fat depth and USDA yield grade ($P < 0.02$) than cattle fed WHT and MOS. Both average and maximum body temperatures were greater ($P < 0.01$) for cattle fed MOS than for cattle fed CON or WHT. There was no difference ($P = 0.18$) for area under the curve body temperature between treatments. Panting scores were least ($P < 0.01$) for cattle fed the WHT when compared to CON and MOS. Time and treatment interactions ($P < 0.05$) were observed for bilirubin, blood urea nitrogen, calcium, chloride, carbon dioxide, creatinine, potassium, lactate dehydrogenase, phosphorus, total protein, triglyceride, uric acid, red blood cell count, hemoglobin, and hematocrit levels. No effect on animal

performance was realized from the addition of Agrimos to the diet, however, body temperature was increased slightly. Adding 5% finely ground wheat straw decreased G:F and reduced panting score but did not affect body temperature.

Key Words: Body Temperature, Feedlot Steers, Heat Stress

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385 Effect of feeding a corn hybrid containing α amylase as dry rolled or high moisture corn on finishing performance and carcass characteristics.

M. L. Jolly-Breithaupt*[1], C. J. Bittner[1], D. B. Burken[1], G. E. Erickson[1], J. C. MacDonald[1], M. K. Luebbe[2], *[1]University of Nebraska, Lincoln, [2]University of Nebraska, Scottsbluff.*

A 173 d finishing trial was conducted to compare feeding a corn hybrid containing an α amylase enzyme (Syngenta Enhanced Feed Corn; SYT-EFC) or a near isoline negative control (NEG) as dry rolled (DRC) or high moisture corn (HMC) on steer performance and carcass characteristics. Three hundred eighty four calf-fed steers (310 ± 20 kg) were utilized in a randomized block design with 8 steers per pen and 6 replications per treatment. Dietary treatments were designed as a 2 × 2 × 2 factorial arrangement. Factors included corn trait (SYT-EFC or NEG), by-product type [Sweet Bran (SB) or modified distillers grains plus solubles (MDGS)], and corn processing (DRC or HMC). No 3-way interactions were observed ($P \geq 0.21$) between corn trait, byproduct type, and corn processing for performance and carcass data. However, steers fed SYT-EFC as DRC with MDGS had a 3.9% increase in G:F compared to NEG. When fed as HMC with MDGS, G:F was improved by 2.1% for SYT-EFC over NEG. Feed efficiency was improved 1.5% for steers fed SYT-EFC as DRC with SB compared to NEG. However, when processed as HMC, G:F decreased by 2.1% when steers consumed SYT-EFC compared to NEG with SB. A corn processing × corn trait interaction was observed for final BW and ADG ($P = 0.02$ and $P = 0.04$, respectively). Steers that consumed SYT-EFC as DRC had the greatest final BW and ADG while steers fed SYT-EFC as HMC had lower final BW and ADG. A tendency for a corn processing × corn trait interaction was observed for HCW ($P = 0.08$), marbling score ($P = 0.09$), and 12th rib fat thickness ($P = 0.07$). Steers consuming SYT-EFC as DRC had increased HCW and marbling scores compared to NEG DRC whereas the opposite was true when fed as HMC. Cattle consuming SYT-EFC as HMC had the greatest 12th rib fat thickness with SYT-EFC as DRC had the lowest. A tendency for a byproduct × corn trait interaction ($P = 0.13$) for G:F was observed. Steers fed SYT-EFC with MDGS had a 3.0% increase in G:F compared to NEG. Accounting for corn grain concentration in the diet, G:F increases to 4.5% for SYT-EFC over NEG corn. However, differences in G:F when fed with SB were reduced by less than 1%. These data suggest that when processed as DRC, SYT-EFC improves G:F of feedlot steers, however mixed results were observed when fed with different byproducts.

Key Words: Alpha amylase, Corn processing, Finishing cattle

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386 Effect of a zinc injection on finishing performance and carcass characteristics of Limousin steers.

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The objective was to evaluate the effects of zinc injection at start of finishing on growth performance and carcass characteristics of steers, in experiments completed over 2 yr. In experiment 1, Limousin steers (487.4 ± 45.5 kg, SD) blocked by initial BW (3 to 4 steers per pen), were assigned to 1 of 2 treatments: injection of zinc disodium EDTA ($n = 20$ steers) or sterile saline ($n = 19$ steers) on d 0 of the finishing period. Blood samples were collected on d 0, 5, 28, and 84 for blood glucose and alkaline phosphatase (ALP) analysis. In experiment 2, Limousin steers (571.2 ± 32.4 kg) blocked by initial BW (2 to 4 steers per pen), were assigned to the same treatments as experiment 1 ($n = 22$ zinc steers and $n = 23$ saline steers). Steers received a concentrate-based finishing diet, supplemented with 30 mg zinc/kg DM ($ZnSO_4$) for 84 (experiment 1) or 56 d (experiment 2) and on average the zinc injection provided 381 mg zinc/steer. Ultrasound and carcass data were collected from all steers in both experiments. Data for both experiments were analyzed using the MIXED procedure of SAS, with year, treatment and the interaction as fixed effects. Steer was the experimental unit, except for DMI and G:F, where pen was the experimental unit. Treatment × year was not different for any variable ($P \geq 0.43$). Zinc or saline injection did not affect final BW (1472, 1451 ± 14.8 kg, for saline and zinc, respectively), ADG, DMI, or G: F ($P \geq 0.25$; G:F = 0.145, 0.138 ± 0.0046, for saline and zinc, respectively). Blood glucose and ALP were not affected by treatment × day ($P > 0.40$) or treatment ($P > 0.22$), but day affected glucose and ALP ($P < 0.0001$), as blood glucose concentrations decreased throughout the finishing period. Blood ALP levels decreased from d 0 to d 5 ($P < 0.0001$) but concentrations increased on d 28 ($P < 0.0001$). Ultrasound determined body composition included intramuscular fat, ribeye area, and backfat were not affected by treatment ($P \geq 0.27$). Carcass characteristics including HCW, backfat, ribeye area, KPH, marbling score, and yield grade were not affected by treatment ($P \geq 0.22$). Overall, a single injection of zinc in addition to dietary zinc supplementation at start of finishing had no effect on heavy Limousin steer performance or carcass characteristics.

Key Words: carcass, growth, Limousin, zinc

387 Impact on site and extent of digestion of feeding a corn hybrd containing α amylase in finishing cattle diets. M. L. Jolly-Breithaupt*[1], J. L. Gramkow[1], G. E. Erickson[1], J. C. MacDonald[1], M. K. Luebbe[2], [1]*University of Nebraska, Lincoln,* [2]*University of Nebraska, Scottsbluff.*

For cattle to maximize feed efficiency, full utilization of starch digestion must occur. Our objectives were to evaluate feeding cattle corn containing an α amylase enzyme (Syngenta Enhanced Feed Corn; SYT-EFC) on site and extent of digestion and ruminal pH parameters. Four ruminally and duodenally cannulated steers (BW = 264 ± 13 kg) were utilized in a 6x4 Latin rectangle design with a 2 × 2 + 1 factorial arrangement of treatments. Factors included corn trait (SYT-EFC or CON), corn by-product type [Sweet Bran (SB) or modified distillers grains plus solubles (MDGS)], and a 50:50 blend of SYT-EFC and CON with MDGS. Period length was 21 d which consisted of 16 d adaptation and 5 d fecal and duodenal collection. Rumen microbial samples were collected via whole rumen contents on d 21 and were analyzed for purines. Titanium dioxide was dosed intraruminally on d 10–20 as a marker to determine digestibility and fecal output. Ruminal pH was measured continuously from d 17 to 21 with submersible, wireless pH probes. No interactions ($P > 0.18$) or main effect of corn trait ($P > 0.43$) were observed for true ruminal starch or OM digestibilities. However, a tendency was observed for postruminal starch ($P = 0.11$) digestibility to be greater for steers fed SYT-EFC than CON. Postruminal OM digestibility was also increased in steers fed SYT-EFC compared to CON ($P = 0.08$). This resulted in steers fed SYT-EFC to have a decrease in fecal starch ($P = 0.01$) and OM ($P = 0.05$) output compared to CON. Ultimately, steers fed SYT-EFC had increased total tract starch, OM, and DM digestibilities ($P = 0.01$, $P = 0.07$, and $P = 0.08$, respectively) compared to CON. There were no interactions ($P > 0.19$) or main effect of corn trait ($P > 0.30$) for ruminal pH characteristics. These data would suggest that steers fed SYT-EFC were able to utilize starch in the small intestine to a greater extent than cattle fed CON leading to an overall greater total tract starch digestibility and ultimately improved feed efficiencies.

Key Words: Alpha amylase, Finishing cattle, Starch utilization

388 An initial look at the nutrient requirements of heavy finishing steers. N. Kenney-Rambo*, A. DiCostanzo, *University of Minnesota, St. Paul.*

Although there has been a long-term trend toward finishing cattle at increasingly heavier weights, diets are formulated based on nutrient requirements extrapolated from lighter cattle. A dataset derived from 40 studies containing 216 means for treatments testing β-agonists during the final 14 to 42 d of finishing was subjected to a meta-analysis to determine if the Nutrient Requirements of Beef Cattle (NRC) correctly predicted energy and protein requirements for heavy finishing steers. Reported DMI and NE_g were used to partition DMI into feed required for maintenance and feed available for gain. Net energy of maintenance was determined as 77kcal/kg $BW^{0.75}$. Feed available for gain and diet NE_g were used to calculate retained energy and a regression approach was used to generate NE_g predictive equations. Metabolizable protein intake (MPI) requirement was determined by regressing empty body protein gain (g/kg $BW^{0.75}$) on MPI (g/kg $BW^{0.75}$). Best-fit models were determined using an F-test with a value of $P < 0.05$. Predictive NE_g and MPI equations for cattle not fed a β-agonist suggest that, at low rates of gain, they are more efficient at nutrient utilization than predicted by the NRC but less efficient than predicted by the NRC at higher rates of gain. Cattle finished at lighter weights transitioned from being more efficient to less efficient a higher rate of gain. In cattle fed a β-agonist, NE_g requirements decreased across all weight classes and rates of gain in a consistent manner. The MPI requirement in cattle fed β-agonist followed the same trend as cattle not fed a β-agonist; cattle were more efficient at MPI utilization than predicted at low rates of gain but less efficient than predicted at higher rates of gain. However, at the same end weight, β-agonist-fed cattle retained greater efficiency of MPI utilization at greater rates of gain compared to cattle not fed a β-agonist. This data suggests that expectations of steer performance at a given NE_g should be re-evaluated, which would allow for more precision in targeting specific feedlot out-weights. Also, MPI is undersupplied in high-performing cattle fed or not fed a β-agonist.

Key Words: cattle, energy requirement, protein requirement

389 Antimicrobial resistance in direct-fed microbials used in cattle. F. Giok*, *Kansas State University, Manhattan.*

The use of antimicrobials in animal feed has come under increasing scrutiny from the public and regulatory agencies. Direct-fed microbials (DFM) or probiotics are considered valuable alternatives to antimicrobials in food animal nutrition. They are live organisms, when given orally in the feed, have proven beneficial in improving the gut microbial balance. Studies in Europe have reported antimicrobial resistance (AMR) in DFM organisms. This is of serious concern because of their potential for transferring resistance to pathogenic bacteria in the gut. The aim of the present study was to characterize phenotypic and genotypic AMR profiles of bacterial strains isolated from 9 commercially available DFM used in cattle to 20 different antimicrobials. Two methods, disc diffusion and broth microdilution based assay (MIC) were performed to determine phenotypic AMR. Based on our disc diffusion and MIC assays, *Enterococcus faecium* isolates showed resistance toward metronidazole ($n = 8$) with an MIC of > 64 μg/mL, erythromycin

(n = 3) with an MIC of ≥ 8 μg/mL, rifampin (n = 5) with an MIC of > 4 μg/mL, and clindamycin (n = 4) with an MIC of > 4 μg/mL. A *Propionibacterium freudenreichii* isolate showed resistance toward kanamycin with an MIC of > 64 μg/mL. The same strain also had an MIC of 21.33 μg/mL for levofloxacin. A *Lactobacillus plantarum* isolate showed no inhibition zone for vancomycin, ciprofloxacin and metronidazole. An isolate of *Bacillus subtilis* showed resistance toward clindamycin with an MIC of > 4 μg/mL, erythromycin with an MIC of > 8μg/mL, and chloramphenicol with an MIC of > 8 μg/mL. Spotted DNA microarray was used to detect the diversity of resistance genes in the DFM. Microarray analysis revealed the following resistance genes in *E. faecium* strains isolated from 3 different DFMs: Strain 1 carried an aminoglycoside resistance gene [*ant(4')-Ia)*], erythromycin resistance gene [*ere(*A2*)*] and 3 tetracycline resistance genes (*tet39, tet*31, *tet*K); Strain 2 carried a β-lactam resistance gene (*pbp*5) and 2 tetracycline resistance genes (*tet*31, *tet*39); Strain 3 had an erythromycin resistance gene (*erm*B) and a tetracycline resistance gene (*tet*C). These studies show that AMR is prevalent among probiotic bacteria used in cattle industry in the U.S., and justifies further characterization and detection of such resistance.

Key Words: Antimicrobial Resistance, Direct-Fed Microbials, Cattle

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390 Impact of metabolizable protein source on performance and carcass quality in finishing cattle fed dry-rolled corn-based diets. M. R. Fiene*, D. W. Brake, M. R. McDaniel, *South Dakota State University, Brookings.*

Previous reports have indicated that finishing cattle performance is linearly increased among cattle consuming corn-based diets with increasing amounts of MP. We evaluated effects of added MP from either dried distillers' grains or porcine blood meal and corn gluten meal to finishing cattle fed dry-rolled corn-based diets designed to meet CP requirements. Two hundred and sixteen cross bred steers (362.3 ± 3.4 kg BW) were blocked by BW and randomly assigned to 18 pens. Subsequently, cattle were adapted to 1 of 3 dry-rolled corn-based diets formulated to meet or exceed cattle CP requirements. Treatments were a dry-rolled corn-based diet with added urea designed to meet CP requirements (Control), a diet designed to provide 200 g/d of additional MP from distillers' grains (DGS), and a diet designed to provide 100 g/d additional MP from blood meal and 100 g/d of additional MP in from corn gluten meal (BMCGM). Samples of each feed ingredient, diet and refusals were collected weekly and composited before analyses for DM, OM, and N. Pen weight was measured each 28 d and initial and final body weight were determined by 2 sequential daily measures of individual steer BW. Overall DMI (9.6 ± 0.11 kg/d) was not different ($P \leq 0.18$) between Control, DGS and BMCGM. However, feed efficiency was increased (P = 0.02) by additions of MP, but overall feed efficiency did not differ (P = 0.85) among source of added MP. Nonetheless, feed efficiency was greater (P = 0.05) from d 1 to 56 when additions of MP were from BMCGM compared to DGS. Similarly, ADG was greater ($P < 0.01$) for cattle fed additional MP, but did not differ (P = 0.22) between BMCGM and DGS. Metabolizable protein source had no effect ($P \geq 0.16$) on USDA calculated yield grade (3.04 ± 0.05), marbling score (423.5 ± 4.9) or ribeye area (12.48 ± 0.1). However, there was a numerical tendency (P = 0.16) for cattle fed BMCGM to have greater back fat depth compared to Control.

Key Words: Cattle, Metabolizable Protein, Performance

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391 Veterinary feed directive (VFD) and its practical considerations for the beef industry. N. A. Pyatt*, G. D. Hufstedler, C. A. Guthrie, B. W. Hoffman, K. Keffaber, *Elanco Animal Health, Greenfield, IN.*

The U.S. Food and Drug Administration (FDA) published 3 reports outlining changes for the use of feed and water antibiotic products in production animals. The goals of these changes were to 1) promote judicious use of antibiotics, 2) protect public health, and 3) help limit the development of antimicrobial resistance. Guidance for Industry (GFI) #209 established therapeutic use principles (including prevention, control and treatment) for medically important antimicrobial drugs with veterinary oversight. A limited number of products (i.e., tilmicosin for beef and swine) require a VFD currently; however a number of classes of antimicrobials will be transitioning from over-the-counter to VFD (targeted) by January 2017. Animal only or non-medically important drugs (ionophores, polypeptides, carbadox, bambermycin, and pleuromutilin) per GFI #152 will not require a VFD and may retain use of therapy and production claims. Shared class or medically-important drugs deemed "important for human medicine" and used in both animals and humans include Penicillins, Cephalosporins, Quinolones, Fluoroquinolones, Tetracyclines, Macrolides, Sulfas, and Glycopeptides. Additional classes used exclusively in humans were outlined. The most commonly effected classes in the beef industry are Tetracyclines and Macrolides. These shared-class drugs may be utilized for therapy with veterinary supervision (by VFD in feed or prescription in water), however production indications, labeling, and promotion will be discontinued per GFI #213. In June 2015 a modernized VFD (21 CFR 558) was finalized to improve program efficiency, streamline FDA administrative procedures, and provide veterinarians greater implementation flexibility (effective October 1, 2015). Authorization must be in written or electronic form by a licensed veterinarian with a valid veterinarian-client-patient relationship (VCPR; as defined by the state or federal VCPR in states without VCPR regulations). Extra label use of VFD drugs is not permitted. VFD expiration will be product specific with a maximum up to 6 mo. VFD forms must be retained for 2 yr by the veterinarian, producer, and feed distributor. Recognition of what prod-

ucts and diets will be affected and proper planning remain critical to future use of these valuable animal health technologies. The VFD process will help ensure that medically important antimicrobial drugs may continue responsible therapeutic use with veterinarian oversight in medicated feeds according to label directions and only when appropriate to meet specific animal health needs.

Key Words: antibiotics, beef, veterinary feed directive

392 Gut bacterial communities and their association with production parameters in beef cattle.

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Within the past decade, the development and use of novel nutritional, genomic, and genetic improvement technologies has promoted and lead to great increases in the genetic propensity of beef cattle for a variety of traits including growth, carcass composition, and specifically feed efficiency. However, the optimization of feed efficiency has primarily focused on host genetics, management, and diet. The rumen and lower gastrointestinal tract (GIT) contain diverse microbial ecosystems that are essential for the host to digest plant material and regulate nutrient uptake and utilization, necessitating their examination to fully understand the microbial-associated interactions throughout the gut with production parameters. To assess the association of the microbial community with variation in feed efficiency, ADG, and average daily DMI (ADFI), we examined the microbial community of the GIT from steers differing in feed efficiency using deep 16S rRNA gene-based community profiling. Steers were selected from 2 contemporary groups and were ranked based on their standardized distance from the bivariate mean (ADG and ADFI), assuming a bivariate normal distribution with a calculated correlation between ADG and ADFI. Four steers with the greatest deviation within each Cartesian quadrant were sampled (n = 16/group; 2 groups). Bacterial 16S rRNA gene amplicons were sequenced from the GIT content using next-generation sequencing technology. Bacterial diversity and richness metrics revealed no differences among the quadrants. However, finer changes in the relative abundance of microbial populations and operational taxonomic units did reveal differences between feed efficiency groups ($P < 0.05$), including shifts in dominant phyla and functionally significant genera in several segments of the GIT such as Proteobacteria ($P = 0.030$) and *Butyrivibrio* ($P = 0.019$) in the jejunum. These studies suggest the GIT microbial community differs at the 16S level in cattle that vary in ADG, ADFI, and feed efficiency; however, it is not clear whether host factors are driving changes in the microbiome or changes in the microbiome are contributing to differences in feed efficiency.

Key Words: feed efficiency, microbiome, 16S rRNA

393 Alternatives to antibiotics.

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Increased regulation of feed grade antibiotics has resulted in a vast array of products to be introduced and has compelled researchers to explore strategies that improve performance without the use of antibiotics. There are a number of techniques and strategies available to help cattle producers replace antibiotics, including non-antibiotic feed additives. Feed additives are defined as dietary ingredients that produce a desirable response in animals in a non-nutritive role. Several feed additives contain nutrients, however, they are not fed to meet an animal requirement, rather, they are fed to alter ruminal or post-ruminal metabolism to enhance nutrient utilization and animal productivity. Feed additives act in many different ways– some affect the ruminal environment, others impact post-ruminal digestion and metabolism; and still others act to depress subclinical problems (acidosis, liver abcesses, heat stress) in which there are no visible disease symptoms or to improve immune response. A reduction in human pathogenic bacteria and benefits to health, safety, and quality of meat products may also result from use of feed additives. Because of the benefits for the host ruminant in terms of health and energy utilization, improvements in the microbial ecosystem and ruminal function have been a goal for ruminant nutritionists and microbiologists for decades and will be the primary focus for this presentation. The mode of action and effectiveness of several antibiotic alternatives will be discussed, including methane inhibitors, essential oils, and yeast and bacterial probiotics and direct-fed microbials. Several of these feed additives are effective; however, their practical implementation has been hindered by the variability in animal responses under experimental conditions and increased cost. In addition, while some of these strategies may be used to replace antibiotics, many of them may be effective in conventional systems in conjunction with antibiotics to enhance animal health and productivity. Thus, producers should evaluate potential strategies for use of feed additives under specific feeding and economic conditions.

Key Words: antibiotic alternative, feed additive, ruminal function

TEACHING

394 Evaluation and subsequent modification of a traditional, land grant animal sciences curriculum.

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The curriculum drives student experiences and learning opportunities at an institution. While other experiences are critical, the curriculum provides the core educational components for

the development of undergraduates. As such, the curriculum should be consistently reviewed and evaluated for effectiveness. Like many animal sciences programs, the program at the University of Missouri has a high percentage of students from urban areas who aspire to be veterinarians. Many lack an understanding of what an animal sciences degree entails, and knowledge of career opportunities that do not involve veterinary medicine. With this in mind, an animal sciences curriculum has the added task of educating students about the many facets of animal sciences. Recently, the Division of Animal Sciences at the University of Missouri underwent a curriculum review and subsequent modification. The review was guided by an Academic Affairs Committee, chaired by the Director of Undergraduate Studies and input was sought from all faculty, regardless of appointment. Faculty were placed on sub-committees relative to species and discipline within animal sciences. Sub-committees were tasked with identifying core competencies of an animal sciences major relative to species/discipline. Individuals were asked to do the same. The information was categorized, and the existing curriculum evaluated with respect to the summarized information. A curriculum map was created to illustrate the breadth and depth of the core competencies, and to explore deficiencies. The information provided by the map guided the revision of the existing curriculum such that strengths were identified and deficiencies were addressed. Through the process it was determined that the greatest area for revision existed in the first 2 yr, with an additional need to provide students with a more consistent senior capstone experience. Specifically, this process led to an effort to increase experiential learning early in the undergraduate coursework and the integration of required courses into a more streamlined, stair step progression to address breadth and depth of knowledge as well as application of skills. A revised curriculum proposal was presented to the faculty which identified the core competencies as recommended by the faculty and highlighted the integration of these competencies into the curriculum proposal. Subsequent discussions were held with the faculty, and feedback regarding the proposal was considered before a final plan was developed and voted on. Feedback was positive, and the Division of Animal Sciences is currently transitioning to the modified curriculum. Faculty input at all levels and appointments has been critical in this process, and led to greater support of the proposed changes.

Key Words: curriculum review, curriculum map, experiential learning

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395 Changing animal science curriculum at a non-land grant university. J. W. Rickard*, *Illinois State University, Normal.*

Teaching is central to the mission of many non-land grant universities. In these settings many faculty may have primarily teaching appointments, while also being expected to maintain research programs. There may also be a service expectation that includes service within the university, as well as service to professional organizations, industry, and the community. New faculty may be faced with the obligation of meeting each of these criteria, while remaining focused on teaching. Young faculty members may begin their employment well versed in teaching, research, or service, but the combination of those may be overwhelming. Furthermore, as a new faculty member you may be faced with delivering a curriculum that was developed before your employment, which can bring both opportunities and challenges. Positions teaching existing curriculum provide new instructors a platform for beginnings while not necessarily having to build a program from the ground up. However, as many agriculture departments increase in enrollment, they may also be faced with stable or declining faculty numbers. At Illinois State University, enrollment in the Department of Agriculture increased from approximately 235 undergraduates in 2007 to 580 in 2015. During this time period faculty numbers declined. Increases in animal science enrollment followed addition of a pre-veterinary medicine sequence. This can be challenging in that fewer faculty imply either more courses being required per instructor or more students per course. As an animal science instructor, increasing class sizes are problematic. When utilizing live animals, increasing enrollment is not only an issue in the areas of assignments and grading; student safety issues become more pronounced. At times these issues can be difficult to express to non-laboratory disciplines as well as administration if they are without a lab-intensive background. Maintaining a quality level of education becomes a challenge in courses conducive to writing assignments, as class sizes increase from fifteen students (when the curriculum was written) to forty or more. More classes per semester per faculty member while maintaining research and service obligations leave less time for grading. As animal science programs are faced with not only increasing enrollment, but also a changing student dynamic it may be even more important to openly discuss strategies for moving forward. To effectively teach the next generation of agricultural professionals, it is imperative that a high quality of education be maintained in a manner that is beneficial to the students while not discouraging the newest generation of educators.

Key Words: animal science, curriculum, teaching

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396 The next generation of animal science students: Changing demographics dictate curriculum changes. J. A. Sterle*, H. D. Tyler, *Iowa State University, Ames.*

It is well established that the demographics of undergraduate students entering Animal Science programs across the country are ever changing. What used to be considered a major for "farm kids" has seen a large influx of students from non-traditional, non-agricultural backgrounds. With the high demand for graduates in most areas of agriculture, this is exciting, but not without challenges. The 2105 incoming freshmen class at Iowa State University (ISU), 42% of 315 responded

identified "Rural/Farm" as their background, 32% answered "Small Town/City (under 100,000 population)", and 26% indicated "Urban/City". Even "farm kids" typically have either only 4-H/FFA (showring) experience with livestock, or if they have commercial industry experience, it is usually with a single species. Therefore, it is more important than ever to include the science and husbandry associated with Animal Science throughout the curriculum and not make any assumptions on previous knowledge. Courses such as "Practicum in Safe Equine Handling and Welfare" and "Livestock Handling, Safety and Welfare" have been introduced as electives into the Iowa State University Animal Science curriculum, with a Lab Animal Science course to be started in the fall of 2016. Other courses, especially at the introductory and 200-level, have also incorporated more basic information that was previously thought to be understood prior. There are advantages to this: 1) previous assumptions of understanding may have overestimated students' background knowledge; and 2) all students receive the same, correct and updated information on topics; and 3) exposure to all species and disciplines may spark new areas of interests for all students, regardless of previous animal experience. Many animal science students (62% of 315 ISU Animal Science freshmen in 2015) have an interest in vet school. This percentage is much higher than the current demand by the veterinary industry. Therefore, exposing all Animal Science students to the wide array of career opportunities associated with the various scientific disciplines may lead to rewarding careers in fields that were previously never considered. The primary interest of the 2015 ISU Animal Science freshmen was companion animals (34%), followed by equine (19%), beef (16%), exotics (12%), swine (8%), dairy (6%), sheep (2%), goats (2%) and finally poultry (1%) at the beginning of their first semester. Anecdotal evidence and job placement would suggest that these interests change by the end of a student's college career. Exposure to new species may encourage students to explore careers in areas beyond their initial primary interest.

Key Words: undergraduate, curriculum, animal science, change

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397 An administrator's perspective on meeting changing curriculum needs with limited resources.

G. P. Lardy*, *North Dakota State University, Fargo.*

Several factors are driving change in how we deliver animal science courses. These include budgetary pressures, changing student demographics, high facility costs, and increasing pressure to replace tenure track faculty with non-tenure track teaching positions. All of these are occurring at the same time enrollment in most animal science programs is growing. Animal science is often singled out as a high cost area of undergraduate education. The fact is, we are more costly. There are significant costs to maintain animals, teaching farms, and provide labs which utilize animals. These costs continue to rise at a time when most teaching budgets are flat or declining. In addition to growing enrollments, the typical student no longer comes from a farm/ranch background. This increases the need to provide additional hands on experiences with animals. I believe we provide a much better education for our students when we offer opportunities for hands on experiences, but those experiences are costly. Deans and provosts want more than just fundamental beliefs. They want to see proof these experiences result in a better educational experience for students. As faculty members and administrators, we need to do a better job at providing the data and information which makes this case. Academic departments are also under increasing pressure to use more instructors and less tenure track faculty in our teaching programs. Instructors and lecturers have an important role to play in the education of our undergraduate students. However, it has been my experience that it is important to have faculty with a greater depth and breadth of training in upper division courses. This is especially important in the core disciplinary courses and in senior level capstone courses. Faculty teaching these courses must have the depth required to develop meaningful material and answer highly technical discipline related questions raised by students. As the rigor of the course increases so does the likelihood that a faculty member with a terminal degree will be best equipped to teach the course. It is also important to have a framework in place to ensure continued professional development for all teaching faculty, regardless of rank or classification. In summary, there will be continued pressure from multiple sources that will necessitate changes in how we teach animal science courses in the future.

Key Words: Change, teaching, students, costs, faculty

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398 Evaluation of case-based reasoning to promote learning and swine industry interest in an undergraduate reproductive physiology course.

A. T. Desaulniers*, R. M. McFee, B. R. White, *University of Nebraska-Lincoln, Lincoln.*

Case studies can be a useful teaching tool but are not commonly utilized in undergraduate courses. Notably, others have demonstrated that case-based reasoning enhances information retention in a veterinary physiology course. Thus, case studies may be an undervalued teaching tool for undergraduate physiology courses. Accordingly, our objective was to evaluate whether swine-based case studies enhanced learning in an undergraduate reproductive physiology class. In addition, interest in pigs and swine industry careers will also be assessed to determine if case-based reasoning can serve as a recruitment tool. At the beginning of the semester, all students (n = 80) completed a pre-test to assess baseline knowledge of swine reproductive physiology and a pre-survey (n = 72; Likert-like scale; 1 = strongly agree and 5 = strongly disagree) evaluating their species interests. Then, students were given the option to complete 4 case studies for extra credit throughout the semester (n = 40- 42). Case studies were industry-based

scenarios that encompassed 4 different aspects of swine reproduction (puberty, boar management, breeding and parturition/lactation); students were asked to individually solve the issues using their notes and supplementary papers. Student demographics: 71.2% were female, 79.2% were juniors and 46.5% originated from a farming/ranching background. About 8% of the population indicated that their family actively raised pigs while 79.1% of students did not have a pig background. Students reported that their primary species of interest was as follows: cattle (42.5%), horses (23.3%), companion animals (17.8%), exotics (11.0%), pigs (2.7%), poultry (1.4%) and wildlife (1.4%). However, 35% of students stated that swine are among the species relevant to them. In contrast, 40.5% of participants indicated that they were not interested in swine. Logically, students did not yet feel knowledgeable about swine reproductive physiology (mean survey response = 3.2), despite having learned about pigs in previous classes (2.0). In addition, students did not feel able to advise producers on reproductive issues (4.1) and were uninterested in pursuing a career in the swine industry (3.7). Pre-test data revealed the following: 53.8% of students answered boar management questions correctly, followed by puberty (44.1%), breeding (43.1%) and parturition/lactation (42.5%). At the end of the semester, all students will take a post-survey and post-test to re-evaluate their swine interest and assess concept mastery, respectively. Ultimately, these data could validate case-based reasoning as a teaching tool in undergraduate physiology courses as well as expose new avenues to recruit young scholars to swine-based careers.

Key Words: Teaching, Case studies, Swine

399 Integrating experiential learning into animal science curriculum through a hands-on Beef cattle management and marketing contest.

C. J. Malone*, J. W. Rickard, K. W. Tudor, *Illinois State University, Normal.*

According to Illinois Agricultural Education's 2014 annual report, nearly 61% of students beginning their undergraduate studies in Agriculture at a 2-yr college in Illinois came from non-farm backgrounds. Yet, knowledge of and experience in livestock operations is still a requirement for many careers in the animal science industry. In response to this, the Department of Agriculture at Illinois State University has implemented a course that provides students an opportunity to gain hands-on experience with beef cattle management and marketing. The course was designed to enhance learning by requiring students to develop and execute a management and marketing plan for a pen of steers at the University Farm, which encouraged practical application of classroom instruction. The objective of this study was to determine if participation in the course enhanced student learning and knowledge retention. Eight student teams, composed of 3–4 students each, executed their own management and marketing strategies with the goal of obtaining the highest return on production, measured by subtracting expenses from revenue. Quantitative data was derived from gain scores on a pre-test at the beginning of the course and a post-test at the conclusion of the course. Qualitative data was obtained by having the students reflect on what they had learned. This reflection occurred at the end of each unit using Likert-scale and open-ended questions. Results obtained demonstrated that the contest enhanced learning and knowledge retention. Post-test means improved significantly (P = 0.000) over pre-test means with gain scores being the highest in the unit topic areas of meat science, marketing and health. In addition, student reflection indicated the students believed that the contest enhanced learning, noting that it increased their beef cattle knowledge by making them aware of all of the factors that go into raising and marketing feedlot cattle.

Key Words: Feedlot, Teaching, Curriculum

UNDERGRADUATE STUDENT COMPETITION: ORAL

400 Spinning straw into milk: Can a 95% byproduct diet support milk production?

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Agriculture is challenged with the need to support increasing human populations without additional land. One way the livestock industry has addressed this is by using human inedible feedstuffs, including industrial byproducts. Many dairy and feedlot diets incorporate 20–40% byproduct feeds, but few studies have evaluated responses of lactating dairy cattle to diets composed almost entirely of byproducts. Our objective was to evaluate such a diet in comparison to a more traditional lactation diet. The control diet was primarily composed of alfalfa hay, corn silage, corn gluten feed, and corn grain. The by-product diet included wheat straw, corn hominy, post-extraction algae residue, and corn gluten feed; in addition, 4% molasses was included to improve palatability. The control and by-product diets had similar concentrations of DM (50.6%) and CP (17.2%), whereas the byproduct diet included slightly more NDF (32.9 vs. 30.5%) and less fat (4.7 vs. 5.2%). Twelve Holstein cows (154 ± 20 DIM) were blocked by parity (primiparous vs. multiparous) and randomly assigned to treatment sequence in a crossover design. Diets were fed for 20 d, with data and sample collections over the final 3 d of each period. One cow was removed from byproduct diet after refusing to consume it, and data from this period were not included in the analysis. Data were analyzed with mixed models to assess fixed effects of diet, parity, and their interaction as well as the random effects of cow and period, and significance was

declared at $P < 0.05$. The one selective cow notwithstanding, DMI was not affected by treatment. Milk yield of multiparous cows was decreased by the byproduct diet (38.7 vs. 42.3 ± 2.2 kg/d) but there was no treatment effect in primiparous cows (39.3 vs. 39.4 ± 2.2 kg/d). The byproduct diet decreased milk fat content (3.3 vs. 3.6 ± 0.12%) and tended to decrease protein content (2.94 vs. 2.99 ± 0.05%), and energy-corrected milk yield was decreased by 5.4 kg/d in multiparous cows and 1.5 kg/d in primiparous cows. No effects on BW or BCS were detected. Despite negative productivity responses, calculated recoveries of human-edible protein and energy in the diet were increased by approximately 50% with the byproduct diet, changing from a net loss to a net gain in human-edible energy and protein. A diet composed of 95% byproduct feeds supported milk yield of 39 kg/d and increased the efficiency of production from a human-edible input perspective.

Key Words: sustainability, byproduct feeds, lactation, dairy

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401 Impact of initiating a fixed-time AI program on herd calving date and weaning weight. L. K. Quail[*1], R. A. Cushman[2], G. A. Perry[3], *[1]South Dakota State University, Brookings, [2]USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE, [3]Department of Animal Science, South Dakota State University, Brookings.*

Improved reproductive efficiency is critical for profitability in cow-calf operations. Cows that give birth early wean more pounds of calf and stay in the herd longer. Thus the objective of this study was to determine the impact of implementing a fixed time AI protocol in a herd that had a defined 60-d breeding season, on the calving distribution and reproductive efficiency. Individual performance data (calving date, birth weight, and weaning weight) were collected annually (yr 1 and 2 no reproductive technology was used; yr 3, 4, and 5 fixed-time AI was used; $n = 225$ to 296 cows annually). These data were analyzed using the glimmix and mixed procedures of SAS. There was no effect of year ($P = 0.34$) on calving date during these years (103.6 ± 1.1, 101.7 ± 1.0, 102.8 ± 1.0, 101.0 ± 1.1, and 101.0 ± 1.1 for each year). However, weaning weights were influenced by year and calf sex ($P < 0.01$). Weaning weights were similar between yr 2 and 3 ($P = 0.50$), but increased each year after fixed-time AI was implemented (212.6 ± 2.2, 220.1 ± 1.9, 222.0 ± 2.0, 242.0 ± 2.1, 265.2 ± 2.2 kg for each year). Males weaned heavier than females (239.4 ± 1.3 and 225.3 ± 1.4 kg). In yr 3, calving distribution shifted ($P < 0.01$) from 1% and 4% (for yr 1 and 2) to 60% calving within the first 21 d. Over all years, there was a negative correlation between calving date and weaning weight (−0.53 kg; $P < 0.01$). Animals were retrospectively assigned to a group based on if they did or did not conceive to fixed-time AI in yr 3. Cows that conceived to AI tended ($P = 0.08$) to calve earlier in both yr 1 (102.0 ± 1.4 and 105.0 ± 1.1) and yr 2 (100.1 ± 1.4 and 102.9 ± 1.1). Furthermore, cows that conceived to fixed-time AI in yr 3 also calved earlier in yr 4 ($P < 0.01$; 99.8 ± 1.3 and 104.9 ± 1.4). Implementing a fixed-time AI program in a herd with a short defined breeding season did not impact Julian calving date, but did increase the proportion of cows giving birth early and pounds weaned per cow. Cows that conceived to AI during the first year of implementation tended to be the earlier calving cows the previous years.

Key Words: Fixed-time AI; Reproductive efficiency;Calving distribution

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402 Circulating blood urea nitrogen and glucose concentrations of neonatal beef calves during the first 72 h. K. A. Pearl[*1], J. M. Larson[1], A. M. Meyer[2], *[1]Division of Animal Sciences, University of Missouri, Columbia, [2]University of Missouri, Columbia.*

The objective of this study was to determine changes in neonatal calf serum blood urea nitrogen (BUN) and plasma glucose concentrations during the first 72 h postnatally and their relationship with calf birth weight. A total of 66 fall-calving beef cows and heifers were monitored during calving, and calf blood samples were obtained from a subset ($n = 24$; average age = 4.4 ± 0.5 yr; average BCS = 5.2 ± 0.1; average calving date = September 11, 2015). Jugular blood samples were obtained from 8 bull and 16 heifer calves at 0, 6, 12, 24, 48, and 72 h postnatally for serum BUN and plasma glucose analysis. Samples at 0 h were obtained before colostrum intake but after standing, and calf birth weight was collected at 14.0 ± 2.3 h. Serum BUN was analyzed using a commercially available kit based on the diacetylmonoxime method. Another commercial kit based on the glucose-6-phosphate dehydrogenase method was used to analyze plasma glucose. Data were analyzed using sampling hour as a fixed effect. Correlations of birth weight and circulating metabolite were determined for each sampling hour. There was an effect of hour ($P < 0.001$) on serum BUN, where BUN increased ($P < 0.001$) from 0 to 6 h, but was similar ($P = 0.49$) from 6 to 12 h. From 12 to 24 h, serum BUN increased ($P = 0.04$), but there was no change ($P > 0.10$) in BUN between 24 and 72 h. Sampling hour also affected ($P < 0.001$) plasma glucose. There was an increase ($P \leq 0.001$) in plasma glucose from 0 to 24 h. Glucose concentrations were similar ($P = 0.59$) between 24 and 48 h, then tended to increase ($P = 0.09$) from 48 to 72 h. Calf birth weight was positively correlated with BUN at 6 h ($r = 0.49$, $P = 0.03$) and 12 h ($r = 0.51$, $P = 0.04$) and tended to be positively correlated at 24 h ($r = 0.36$, $P = 0.10$). There was no relationship between calf birth weight and serum BUN at 0, 48, or 72 h ($P \geq 0.12$) or glucose at any hour ($P \geq 0.36$). In conclusion, circulating BUN and glucose in beef calves increase during the first 24 h postnatally. Serum BUN concentrations positively correlate with birth weight at some hours of neonatal life, and therefore may indicate pre- or postnatal nutrient supply.

Key Words: beef calves, metabolites, parturition

403 Effects of neonatal litter size and age on ovarian gene expression and follicular development in gilts. M. W. McClure*[1], R. A. Cushman[2], D. J. Nonneman[2], C. A. Lents[2], *[1]University of Tennessee Martin, Martin, [2]USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE.*

Gilts raised in small litters have greater ovulation rate, stay in the herd longer and produce more pigs. The objective was to understand how neonatal litter size affects gilt development. The hypothesis is that gilts reared in smaller litters have greater ovarian follicular development. Within 24 h of birth, Yorkshire-Landrace crossbred pigs were cross fostered into normal (13.6 ± 0.2 pigs) or small (8 ± 0.2 pigs) litters. Pigs were cross-fostered between dam pairs such that piglets from each dam were reared in each litter size. Pigs were weaned at 4 wk of age, placed in a nursery building until 8 wk of age, and then moved to a finishing building. Ovaries were collected from necropsied pigs at weaning, 60, 100, and 140 d of age (n = 8 per treatment at each age). For each animal, one ovary was snap-frozen for RNA extraction and one was placed in fixative for histological sectioning. Three representative histological sections from each ovary were examined and the number of primordial, primary, secondary, and antral follicles was quantified. Relative abundance of mRNA in the ovarian cortex was determined using quantitative PCR and analyzed by ANOVA using litter size and age as fixed effects with sire as a random effect. Target genes were chosen for known function in primordial follicle formation or as candidate genes from a GWAS for ovulation rate. There was no effect of neonatal litter size on the number of follicles in ovaries during development. The number of primordial and primary follicles decreased (P < 0.0001) whereas the number of antral follicles increased (P < 0.001) with age. The number of secondary follicles in the ovary was greatest (P < 0.01) at 60 and 100 d of age. Expression of mRNA for AMH and HSD17β4 was greatest (P < 0.04) at 100 d of age. Abundance of ZFYVE9, BMP4, GDF9, and DDX9 mRNA was greatest (P < 0.02) at weaning and least at 140 d of age. Expression of ADAMTS19, ESR1, POU5F1, BMP7, and BCL2 mRNA was greater (P < 0.01) at weaning and 60 d of age compared with 100 and 140 d of age. There was no effect of neonatal litter size on ovarian gene expression. These data indicate that increased ovulation rate of gilts raised in smaller litters is not a result of neonatal programming causing greater primordial follicle formation. USDA is an equal opportunity provider and employer.

Key Words: pig, ovary, litter size, development, follicle, gene expression

404 Effects of copper oxide bolus supplementation on performance of stocker calves grazing endophyte infected tall fescue. G. R. Pettig*[1], B. C. Shanks[1], J. D. Caldwell[2], A. L. Bax[3], H. L. Bartimus[1], C. A. DeOrnellis[1], C. L. Boeckmann[1], J. J. Markway[1], M. J. Kramer[1], *[1]Lincoln University, Jefferson City, MO, [2]Purina Animal Nutrition Center LLC, Gray Summit, MO, [3]Department of Agriculture and Environmental Science, Lincoln University, Jefferson City, MO.*

Loss in performance of cattle grazing endophyte-infected tall fescue [*Lolium arundinaceum* (Screb.) Darbysh; E+] has been quantified in a number of studies. Evidence also suggests lowered Cu status in cattle consuming the fungal endophyte associated with E+. Therefore, an experiment was conducted to examine the effects of copper oxide bolus supplementation on performance of stocker calves grazing E+. On September 8, 2014, commercial Angus stocker calves (n = 21; 263.7 ± 38.01 kg LW) were stratified by calving date, body weight, and sex, and allocated randomly to 1 of 3 treatments. Treatments consisted of an intraruminal bolus containing 12.5 g of CuO needles on d 1 (CB), the same bolus on d 1 and d 30 (CB2), or no bolus (Control). All boluses were administered using a balling gun. Calves were then rotationally grazed on E+ pastures for the entirety of the 60-d trial. Performance was measured and blood was collected at 30-d intervals. Intraruminal CuO bolus supplementation did not affect ($P \geq 0.21$) 30-d weight, 30-d ADG, 30-d gain, final weight, total ADG, or total gain. White blood cell count on d 30 (P = 0.08) and d 30 WBC change (P = 0.07) tended to be higher in calves administered CB vs. CB2. Also, platelet change at d 30 tended (P = 0.08) to be lower and total platelet change was lower (P = 0.01) for CB vs. CB2. Lymphocyte change at d 30 tended (P = 0.09) to be higher for CB and CB2 relative to controls. Calves receiving either 1 or 2 CuO boluses had lower (P = 0.05) total RBC change and tended (P = 0.07) to have lower total hemoglobin change compared with calves receiving no CuO bolus. Therefore, supplementation with an intraruminal bolus containing 12.5 g of CuO may not affect performance of stocker calves grazing endophyte-infected tall fescue. However, administration of CuO boluses may affect some blood parameters depending on dosing rate and time of administration.

Key Words: copper oxide, calves, tall fescue

405 Evaluation of parasite resistance to commonly used commercial anthelmintics in meat goats. M. K. Goolsby*[1], M. L. Leite-Browning[2], R. Browning, Jr.[1], *[1]Tennessee State University, Nashville, [2]Alabama A&M University, Huntsville.*

Anthelmintic-resistant parasites pose a major threat to small ruminant industry sustainability. To evaluate resistance, meat goat does were orally administered one of 4 anthelmentics [ivermectin (IVE, n = 18, 303% recommended goat dosage rate),

moxidectin (MOX, n = 18, 153% of recommendation), levamisole hydrochloride (LEV, n = 17, 129% of recommendation), or albendazole (ALB, n = 19, 162% of recommendation)] or water (H_2O, n = 18). Fecal samples were collected immediately pretreatment and 2 wk after treatment. The modified McMaster technique was used to determine fecal egg counts (FEC). Arithmetic mean FEC reduction percentages were calculated using 3 published equations. To assess drug efficacy, Eq. [1] (FECRT1) used post-treatment control and anthelmintic group values without pretreatment values. Equation [2] (FECRT2) used pre- and post-treatment anthelmintic group values without a control group. Equation [3] (FECRT3) used pre- and post-treatment control and anthelmintic group values. Geometric FEC means were analyzed by treatment and goat breed. Mean pretreatment FEC differed by breed ($P < 0.05$), but not by treatment ($P = 0.21$). Savanna (1348 eggs/g) had higher ($P < 0.05$) pretreatment FEC than Kiko (675 eggs/g) or Myotonic (467 eggs/g). No other breed comparisons differed (Spanish, 932 eggs/g). Pretreatment anthelmintic group averages were 1071 eggs/g for MOX, 547 eggs/g for IVE, 932 for LEV eggs/g, 976 for ALB eggs/g, and 723 eggs/g for H2O. Post-treatment FEC means differed ($P < 0.001$) by treatment group but not by breed ($P = 0.12$). Post-treatment values were higher ($P < 0.05$) for H2O (1147 eggs/g) compared to ALB (92 eggs/g), MOX (41 eggs/g), or IVE (21 eggs/g). Post-treatment mean FEC was higher ($P < 0.05$) for LEV (233 eggs/g) than for IVE. No other paired means differed. Anthelmintic resistance determinations were based on FEC reductions below 95% or 80% depending on the equation applied. For FECRT1 and FECRT2, no treatment met the 95% efficacy threshold: MOX, 85.0% and 66.9%; IVE, 85.6% and 74.9%; ALB, 78.5% and 64.4%; LEV, 42.21% and 36.5%. Efficacy of LEV was significantly lower than the other 3 in FECRT1. Efficacy of H2O (−120.1%) was significantly lower than the 4 anthelmintics in FECRT2. For FECRT3, no treatment met the 80% efficacy threshold: MOX, 42.7%; IVE, 56.5%; ALB, 38.3%; LEV, −10%. Resistance was detected to all anthelmintics using each equation. Results suggest that alternative methods of internal parasite control need to be utilized as opposed to current reliance on commercial anthelmintics.

Key Words: goats, anthelmintics, resistance

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406 Differential expression of genes in the liver associated with gain and intake in beef steers.

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The purpose of this study was to identify genes associated with gain and intake in the liver in beef cattle. The liver uses 25% of the body's energy, while constituting less than 2% of total body weight. It is likely that the liver plays a key role in gain and intake due to its high energy utilization and role in metabolism. Yearling, crossbred-steers were put on a 78-d feed trial. Average daily gain and average daily intake were calculated at the end of the trial. The 16 steers with the greatest deviation from the bivariate mean were selected for slaughter: 4 steers with high gain-high intake (HG-HI); 4 with high gain-low intake (HG-LI), 4 with low gain-low intake (LG-LI); and 4 with low gain-high intake (LG-HI). Liver samples were collected during the slaughter and flash frozen in liquid nitrogen. RNA was extracted from the samples, and used for a microarray assay. Genes were evaluated for differential expression by one-way between-subject ANOVA and were considered differentially expressed with fold changes of ≤ -1.75 and ≥ 1.75 and $P \leq 0.05$. The differential expression of genes was determined HG-LI vs. HG-HI, HG-LI vs. LG-LI, and HG-LI vs. LG-HI steers. Genes involved in growth and differentiation (i.e., *GDF3, ANGPT2, EGR1*) were upregulated in HG-LI animals, compared to HG-HI and LG-LI animals. Genes involved in protein metabolism were downregulated in the HG-LI steers compared to the HG-HI steers (i.e., *FARSB*, *NT5E*). Several genes involved in glucose and lipid metabolism pathways are differentially expressed between HG-LI and LG-HI animals (i.e., *LPIN1*, *ADIPOR2*, *PDK4*). USDA is an equal opportunity provider and employer.

Key Words: differential gene expression

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407 The effect of diet on serum antibody response to vaccine in horses.

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It is important to identify management strategies, which contribute to optimal horse health. One strategy is to select diets that support health through increased antibody response to disease or vaccination. The objective of this study was to evaluate the effects of test diets on serum antibody concentrations in adult horses following vaccination. Testing was completed as third party blind analysis. Horses (n = 10 per treatment) were fed a control diet or 1 of 2 proprietary diets beginning 111 d before vaccination. The control group received a pelleted feed meeting the NRC minimum nutrient requirements. Test diet 1 (TD1) was a pelleted feed, which provided a higher plane of nutrition and added functional ingredient matrix. Test diet 2 was comprised of the control diet with added fatty acid. Serum samples were collected from each horse on d 0, 7, 14, 28, 35, and 42 post-vaccination. Vaccine response was measured through analysis of antibody production. Horses are assumed to be naïve to bovine diseases. The experiment was designed to test the equine antibody response to vaccine for bovine diseases: bovine respiratory syncytial virus (BRSV), bovine viral diarrhea virus (BVDV), and infectious bovine rhinotracheitis (IBR). Four subclasses of IgG have been identified in

the equine body; IgGb, IgGt, IgGa, and IgGc. These 4 subclasses of IgG and IgM were included in testing. The immune response to each of these diseases was measured separately through Enzyme Linked Immunosorbent Assays (ELISA). ELISAs were completed using IDEXX BRSV IgG Antibody Test Kits, IDEXX BVDV Antibody Test Kits, and IDEXX Infectious Bovine Rhinotracheitis Virus Antibody Tests Kits, respectively. Manufacturer's instructions were followed with the exception of using our own detection antibodies at a dilution of 1:20,000. IgGb, IgGt, IgGa, IgGc, and IgM antibodies were pooled and included in each ELISA. No difference of antibody response was found between horses from the 3 dietary groups, with the exception of an elevated antibody response to BVDV in horses fed TD1 and 2 compared to the control group on d 21 post-vaccination ($P < 0.05$). Therefore, IgGb, IgGt, IgGa, and IgM isotypes were tested individually from the d 21 BVDV sample. No differences were observed between the groups for individual isotypes, although there was a trend for enhanced antibody response in horses fed test diets. The test diets may support elevated antibody response in the horse.

Key Words: equine, antibody, immune, diet, vaccine response

408 Determining the standardized ileal digestible lysine requirement of 6.8 to 15.9 kg pigs.

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A total of 300 maternal line barrows (DNA; 200 × 400, initially 6.75 ± 0.23 kg BW) were used in a 21d trial to determine the standardized ileal digestible (SID) Lys requirement of nursery pigs from 6.8 to 15.9 kg. Pigs were randomly allotted to pens at weaning based on BW and were fed a common diet for 9 d after weaning. There were 10 replicate pens/treatment and 5 pigs/pen. Pens of pigs were allotted to experimental diets based on average BW, in a completely randomized design. The 6 dietary treatments consisted of 1.05, 1.15, 1.25, 1.35, 1.45, and 1.55% SID Lys and were achieved by increasing the inclusion of crystalline amino acids, allowing soybean-meal to stay constant across dietary treatments. Experimental data was analyzed using general linear and nonlinear mixed models with heterogeneous residual variances and pen as the experimental unit. Competing models included linear (LM), quadratic polynomial (QP), broken-line linear (BLL), and broken-line quadratic (BLQ). The best-fitting model for each response was selected using Bayesian information criterion (BIC). Increasing SID Lys linearly improved ($P = 0.001$) G:F. There was a marginal quadratic response for ADG ($P = 0.067$) with increasing SID Lys. The ADFI increased in a quadratic manner ($P = 0.019$) from 1.05 to 1.25% SID Lys. For ADG, the best-fitting comparable models were BLL [predicted equation: 462– 271 × (1.29– Lys), if SID Lys < 1.29%] and BLQ [predicted equation: 465– 372 × (1.47– Lys)^2, if SID Lys < 1.47%], estimating the requirement at 1.29% (95% CI: [1.23, 1.35]%) and 1.47% (95% CI: [1.31, > 1.55]%), respectively. For G:F, the best-fitting models were QP [predicted equation: 0.750– 0.317 × (Lys) + 0.214 × (Lys)^2] and LM [predicted equation: 0.392 + 0.241 × (Lys)], estimating the requirement at greater than 1.55% for both models. In conclusion, the estimated mean SID Lys required for nursery pigs from 6.8 to 15.9 kg ranged from 1.29% for maximum ADG to at least 1.55% for maximum G:F.

Table 408. Effect of SID Lys on growth performance of 6.8 to 15.9 kg pigs

	SID Lys, %							Probability, $P <$	
Item	1.05	1.15	1.25	1.35	1.45	1.55	SEM	Linear	Quadratic
ADG, g	404	404	453	444	458	458	9.07	0.001	0.067
ADFI, g	616	621	653	635	612	599	13.61	0.158	0.019
G:F	0.651	0.652	0.699	0.704	0.752	0.768	0.009	0.001	0.349

Key Words: growth, lysine, nursery pig

409 Comparison of delayed weaning on lamb growth and parasitism while grazing red clover.

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The objective of this study was to compare weaning at 60 versus100 d of age on lamb growth and parasitism while grazing red clover, followed by a feedlot phase where lambs were taken to a similar final weight. Each weaning treatment consisted of 3 replicate fields of 6 lambs per field, blocked by initial starting weight. Single lambs were used. Treatments were weaned (WEAN) lambs and lambs left with its mother for the pasture phase (NURSE). Paddock size matched stocking density between ewes with lambs and weaned lambs. At 100 d of age lambs were moved into a feedlot and finished on an 85% grain 15% forage diet to approximately 59 kg. Statistics were run using SAS Proc Mixed with PDIFF for mean separation. At the end of the pasture phase, lamb live weight was greater ($P < 0.05$) for the NURSE lambs (LSM ± SEM) (38.92 ± 2.09 kg) compared with the WEAN lambs (31.82 ± 2.09 kg). When grazing pasture, ADG was greater ($P < 0.05$) for the NURSE (360 ± 27 g/d) compared with the WEAN (196 ± 27 g/d) lambs. Packed Cell Volumes were lesser ($P < 0.05$) for the WEAN lambs (30.9 ± 0.5) at 35 d than the NURSE lambs (34.2 ± 0.5). Fecal egg counts were not different for the WEAN lambs (66.4 ± 12.3) at 35 d compared to the NURSE lambs (31.9 ± 12.3) ($P > 0.05$). Weaning at 100 d produced greater gains and lower measures of parasitism on red clover compared to weaning at 60 d.

Key Words: Lamb, Growth, Weaning

410 Effects of commercial formaldehyde inclusion and lysine level on nursery pig performance.
L. G. Sica*, R. A. Cochrane, J. C. Woodworth, S. S. Dritz, C. R. Stark, C. K. Jones, *Kansas State University, Manhattan.*

Previous research has demonstrated that commercial formaldehyde products may reduce the risk of microbiological hazards in feed, but there is concern about the product binding Lys and reducing growth performance. Therefore, the objective of this experiment was to evaluate the role of 2 commercially-available formaldehyde sources on growth performance of pigs fed a Lys-sufficient or Lys-deficient diet. A total of 299 pigs (PIC 327 × 1050; initial BW 15.2 kg) were used in a 14-d study. Dietary treatments were arranged in a 3 × 2 factorial design with 3 formaldehyde inclusions: none vs. 3.25 kg per tonne SalCURB (Kemin Industries, Inc., Des Moines, IA) vs. 3.0 kg per tonne Termin-8 (Anitox Corp, Lawrenceville, GA) and 2 Lys levels: Adequate (1.25% SID Lys) vs. Low (1.10% SID Lys). Product concentrations were established from supplier recommendations, and diets were treated with in commercial mills utilizing supplier-specific equipment. Pens of pigs were balanced by initial BW and randomly allotted to treatments with 5 pigs per pen and 10 pens per treatment. Data were analyzed in a factorial design using the GLIMMIX procedure of SAS. Overall, there was a tendency ($P < 0.10$) for a formaldehyde source × Lys level interaction to affect ADG and G:F. Pigs fed adequate Lys levels treated with no formaldehyde or SalCURB tended to have improved ($P < 0.10$) ADG and G:F compared to pigs fed adequate Lys levels treated with Termin-8. Pigs fed diets with low Lys and treated with Termin-8 tended to have poorer ($P < 0.10$) G:F than all other treatments. Regardless of source or Lys level, the inclusion of formaldehyde in nursery pig diets tended to reduce ($P < 0.10$) ADG and resulted in poorer ($P < 0.05$) G:F. Furthermore, the main effect of formaldehyde source affected ($P < 0.05$) ADG, G:F, and tended to affect ($P < 0.10$) ADFI, with pigs fed Termin-8 performing poorer than those fed SalCURB or no formaldehyde. As expected, Lys level affected ($P < 0.05$) ADG and G:F, but did not alter ADFI ($P > 0.10$). In summary, SalCURB inclusion did not alter nursery pig growth performance compared to the untreated basal diet, regardless of Lys level. However, the inclusion of Termin-8 tended to result in poorer G:F in adequate Lys diets and poorer ADG and G:F in low Lys diets compared to an untreated control.

Key Words: formaldehyde, lysine, nursery pigs

411 Increased dietary soybean meal does not affect performance during a PRRSV-Mycoplasma hyopneumoniae challenge.
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Porcine reproductive and respiratory syndrome virus (PRRSV) and *Mycoplasma hyopneumoniae* (MHP) are 2 significant respiratory pathogens in finishing pigs, often found in tandem. Recent anecdotes have implied that increasing soybean meal content of diets can be beneficial in pathogen-challenged pigs, while other reports suggest similar benefits by increasing the use of synthetic AA, specifically Trp. The objective of this study was to determine if increased synthetic Trp replacing a portion of SBM would impact performance of late finishing pigs dual-challenged with PRRSV and MHP. Ninety-six mixed sex pigs (120 ± 1.4 kg BW), were selected and randomly assigned to a high SBM (CON; 9 pens/trt) or synthetic Trp (SYN; 9 pens/trt) diet. Both diets were formulated to contain 0.70% TID Lys and were isocaloric; only crude protein was different between CON and SYN diets (15.9 vs. 13.5%, respectively). After 96 d on test diets, all pigs were inoculated intratracheally with MHP and intramuscularly with a field strain of PRRSV. Growth performance and feed efficiency were determined until pigs reached market weight (~138 kg BW), after which, carcass data and lung lesion scores were assessed. During the 96 d pre-challenge period, no performance differences were detected between the 2 dietary treatments. As expected, antibody titers for PRRSV and MHP increased post inoculation. However, change in PRRSV antibody titers from 0 to 28 d post inoculation tended ($P = 0.09$) to be increased in SYN verses CON pigs. MHP antibody titers and lung lesion scores did not differ between treatments. For the 28 d post-challenge period, there was no difference in ADG, ADFI or G:F. There was also no difference in hot carcass weight, yield percentage or muscle depth ($P > 0.10$). However, the SYN pigs had an increase in carcass fat depth compared to the CON ($P = 0.01$). Conversely, there was a tendency ($P = 0.09$) for carcass lean percent to be increased in CON pigs (57.6 vs. 57.1%, respectively). Altogether, these data indicate that diets with increased synthetic AA or decreased SBM do not alter pig performance during a late breaking respiratory health challenge.

Key Words: PRRSV, Soybean meal

412 Concentrations of progesterone, estrogen, and insulin in serum during early pregnancy in crossbred Angus beef heifersConcentrations of progesterone, estrogen, and insulin in serum during early pregnancy in crossbred Angus beef heifers. T. L. Ellig*[1], K. J. McLean[1], C. R. Dahlen[1,2], . P. Borowicz[1,2], L. P. Reynolds[1,2], J. S. Caton[1,2], *[1]North Dakota State University, Fargo, [2]Center for Nutrition and Pregnancy, Fargo, ND.*

Objectives were to evaluate circulating progesterone, estrogen, and insulin concentrations in beef heifers during the first 50 d of gestation. We hypothesized that concentrations of progesterone would remain constant during pregnancy while estrogen and insulin would fluctuate during the establishment of pregnancy. To address our hypothesis, crossbred Angus heifers (n = 46), were synchronized, bred via AI and fed to gain 0.22 kg/d. Blood samples were taken via jugular venipuncture on d 16, 22, 28, 34, 40, and 50 of gestation. Non -bred, non-pregnant control heifers were sampled on d 16 of the estrous cycle. Concentrations of progesterone, estrogen, and insulin in serum were determined using an Immulite 1000 (Siemens, Los Angeles, CA). Statistical analyses were done within PROC MIXED of SAS with day as the variable and cow as a repeated measure. Progesterone was analyzed with a Compound Symmetry covariance structure. Estrogen and insulin were analyzed with a Toeplitz covariance structure. Concentrations of progesterone on d 0 and 50 (1.8 ± 1.8 and 3.6 ± 1.0 ng/mL; respectively) were decreased ($P < 0.01$) compared with all other days (7.4 ± 0.6 ng/mL). Concentrations of estrogen were similar ($P > 0.40$) among non-pregnant (42.4 ± 9.0 pg/mL) and pregnant heifers (44.2 ± 3.1 pg/mL). Pregnant heifers had decreased ($P < 0.05$) concentrations of estrogen on d 16 (36.5 ± 2.5 pg/mL) compared with all other days (45.7 ± 3.2 pg/mL). Concentrations of estrogen were greater ($P < 0.05$) on d 40 (50.5 ± 3.6 pg/mL), compared with d 28 and 50 (42.7 ± 2.7 and 43.9 ± 3.9 pg/mL; respectively). Concentrations of estrogen tended ($P = 0.07$) to be decreased on d 22 vs. d 40 (44.4 ± 2.7 vs. 50.5 ± 3.6 pg/mL; respectively). There was also a tendency ($P = 0.08$) for estrogen to be reduced on d 28 (42.7 ± 2.7 pg/mL) compared with d 50 (43.9 ± 3.9 pg/mL). Concentrations of insulin were not different ($P = 0.53$) among pregnancy status or days of gestation. In conclusion, concentrations of progesterone in non-pregnant heifers were less than those of pregnant heifers until d 50 post-breeding, and estrogen but not insulin was differentially observed through the early gestational period.

Key Words: beef cattle, early gestation, estrogen, progesterone

413 Calcium and magnesium absorption and retention by growing goats offered diets with different calcium sources. J. E. Long*[1], K. P. Coffey[2], J. D. Caldwell[3], D. Philipp[2], R. T. Rhein[1], A. N. Young[1], *[1]Department of Animal Science, University of Arkansas Division of Agriculture, Fayetteville, [2]University of Arkansas, Division of Agriculture, Fayetteville, [3]Purina Animal Nutrition Center LLC, Gray Summit, MO.*

Calcium addition is necessary to balance the high phosphorus concentrations in high-concentrate diets. However, calcium sources differ in their bioavailability. The objective of this study was to determine apparent Ca and Mg absorption and retention in goats offered diets containing different sources of Ca. Spanish-Boar goats (n = 16; 19.6 ± 1.88 kg) were stratified by weight and randomized to dietary treatments consisting of Purina Antlermax® 16 containing either calcium carbonate (CC), Calmin® (CM) or Milk Cal® (MC). Goats were offered their respective diets at a total of 2% of BW in equal feedings at 0830 and 1800 h while housed in 1.0 × 1.5 m pens with plastic-coated expanded metal floors. Goats were offered increasing amounts of a control corn-based high-concentrate diet on mixed bermudagrass (*Cynodon dactylon*) pasture until they were consuming the diet at 2% of BW. They were then moved to individual pens and adjusted to their respective diets along with removal of hay from the diet over a 7-d period. Goats were then offered their respective diets for an additional 14-d adaption period to diet and facilities. Total urine and feces were then collected for 7 d and analyzed for Ca and Mg by inductively coupled plasma emission spectroscopy. Data were analyzed using PROC MIXED of SAS. Calcium and Mg intake were not different ($P \geq 0.12$) among diets. Calcium apparent absorption and retention (g/d and % of Ca intake) were greatest ($P < 0.05$) in goats offered CC and did not differ ($P \geq 0.20$) between goats offered the CM and MC diets. Magnesium apparent absorption and retention (g/d and % of Mg intake) were greatest ($P < 0.05$) in goats offered CC and did not differ ($P \geq 0.69$) between goats offered the CM and MC diets. Therefore, calcium and magnesium were more available for goats from the diet containing calcium carbonate compared with diets containing Calmin and Milk Cal.

Key Words: Calcium carbonate, Calcium absorption, Goats

414 Influence of semen handling on post-thaw sperm motility. C. L. Mogck*, G. A. Perry, *Department of Animal Science, South Dakota State University, Brookings.*

Artificial insemination allows cattle producers access to the genetic-leading sires in the industry. However, correct methods of thawing frozen semen should be followed to ensure acceptable pregnancy success. Thus the objective of this project was

to determine how semen handling during the thawing process can impact different parameters of sperm motility. Semen from 14 bulls were allotted to 9 treatments: 1) Control (handled correctly; thawed at 36°C for 45 sec and placed into an warmed 36°C AI gun for 1 min), 2) thawed at 22°C, 3) thawed at 13°C, 4) thawed at 38°C, 5) thawed at 33°C, 6) thawed correctly and then placed into a 4°C AI gun, 7) thawed correctly and then placed into a 43°C AI gun, 8) thawed for on 15 sec, or 9) exposed to room temperature for 15 sec before thawing. After thawing, semen was incubated at 37°C for 20 min and 3 h and then stained with Hoechst 33342 and motility parameters were analyzed using the IVOSII Computer Assisted Sperm Analysis (CASA) system. Data were analyzed using the mixed procedure of SAS for repeated measures with bull as a random variable. There was a treatment and time effect on both total motility ($P < 0.01$) and progressive motility ($P < 0.01$), and a tendency for a treatment by time interaction ($P = 0.08$). Both total and progressive motility decreased with time ($P < 0.01$), and thawing semen at reduced temperatures (treatment 2 and 3) reduced ($P < 0.05$) total (15.9% and 12.4%) and progressive (3.9% and 4.3%) motility compared to controls (36% and 13.8%). Sperm velocity (curvilinear) was influenced by time ($P < 0.01$), but not treatment or treatment by time ($P = 0.95$ and 0.45). Straight line velocity was also influenced by time ($P < 0.01$), but there was no treatment or treatment by time interaction ($P = 0.20$ and 0.31). Both curvilinear and straight line velocity decreased from 20 min to 3 h ($P < 0.01$). In conclusion thawing semen at an incorrect temperature had negative effects on sperm motility (total and progressive). Thus improper thawing of semen could have dramatic negative effects on AI conception rates.

Key Words: Artificial insemination, semen handling, sperm motility

UNDERGRADUATE STUDENT COMPETITION: POSTER

415 Characterizing body temperature and movement differences at the onset of estrus in replacement gilts. K. A. Shade*[1], K. R. Stewart[2], J. S. Johnson[1], *[1]USDA-ARS Livestock Behavior Research Unit, West Lafayette, IN, [2]Purdue University, West Lafayette, IN.*

Accurate estrus detection can improve sow conception rates and increase the efficiency of swine production. Unfortunately, current estrus detection practices may be inefficient due to large sow populations at commercial farms and the associated labor required. Therefore, the study objective was to characterize body temperature and movement changes in replacement gilts at the onset of estrus to develop a remote estrus detection system for commercial swine operations. Twelve replacement gilts (130.2 ± 1.9 kg BW) were fed Matrix® to synchronize estrus and data loggers (TemPlant; Data Sciences International) that detect vaginal temperature (T_V) and total movement (i.e., standing, lying, sitting, shifting position, etc.) in 5 min intervals were attached to blank CIDR's and inserted intravaginally for 7 d before expected estrus. Movement was quantified as counts per minute (cnt/min) using an internal accelerometer. During the 7 d of monitoring, gilts were checked for estrus twice daily (0800 and 1500 h) by 2 trained individuals. To standardize data, only the day of estrus detection (d_E) and the 3 d prior (d_{-3}, d_{-2}, d_{-1}, $n = 4$ total days) were used in the final analysis since gilts came into estrus on different days. Data were analyzed using the PROC MIXED procedure in SAS 9.4. Overall, T_V was reduced ($P < 0.01$; 0.26°C) on d_E compared to the previous 3 d; however, no differences were detected between d_{-3}, d_{-2}, and d_{-1}. Movement was increased ($P < 0.01$; 37.8%) on d_E compared to d_{-3} and d_{-2}, but no differences were detected between d_E and d_{-1}. Vaginal temperature decreased linearly ($P = 0.02$; 0.08°C/d) from d_{-3} to d_E and movement increased linearly ($P < 0.01$; 0.34 cnt/min/d) from d_{-3} to d_E. In summary, T_V was reduced and movement was increased at the onset of estrus, which has obvious implications for development of automated estrus detection system for use in a production setting.

Key Words: pigs, estrus detection, temperature, movement

416 The effects of nursery environmental enrichments on subsequent finishing hogs. D. J. Shawk*[1], P. L. Deeter[1], B. D. Whitaker[2], *[1]The University of Findlay, Findlay, OH, [2]University of Findlay, Findlay, OH.*

The inclusion of environmental enrichments in the nursery reduces agonistic behavior and increases average daily gain. This study evaluated the effects of exposure to environmental enrichments in the nursery on finishing hogs. Hogs ($n = 40$) that were either exposed to environmental enrichments in the nursery or not, were randomly assigned to finishing floors. All hogs were received the same diets, which met of exceeded NRC requirements. Before slaughter back fat, loin eye area, and finishing weights were recorded. Back fat and loin eye area were determined using ultrasound. Hogs exposed to environmental enrichments in the nursery had significantly thicker ($P < 0.05$) average back fat thickness (1.98 ± 0.03 cm) compared to hogs that were not exposed to environmental enrichments in the nursery (1.85 ± 0.02 cm). Similarly, hogs exposed to environmental enrichments in the nursery had significantly higher ($P < 0.05$) loin eye area (32.90 ± 1.09 cm^2) compared to hogs that were not exposed to environmental enrichments in the nursery (29.95 ± 1.03 cm^2). There was no difference between the finishing weights the 2 groups. The results of this study suggest that finishing hogs exposed to environmental enrichments in the nursery will increase higher loin eye area and back fat thickness

measurements with no adverse effects on finishing weights.

Key Words: Environmental Enrichments, Finishing, Performance

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417 Effects of PMSG dosage on reproductive performance of farm-raised whitetail deer.

W. M. Haslag*[1], B. C. Shanks[1], J. D. Caldwell[2], D. R. Hill[3], N. L. Forsythe[3], *[1]Department of Agriculture and Environmental Science, Lincoln University, Jefferson City, MO, [2]Purina Animal Nutrition Center LLC, Gray Summit, MO, [3]Oak Creek Whitetail Ranch, Bland, MO.*

Increased popularity of hunting world class whitetail deer has prompted deer breeders to widely adopt reproductive technologies such as estrus synchronization and artificial insemination. A challenge for some breeders is to produce an optimal number of fawns from each doe; as such, management issues and genetic potential oftentimes warrant reduced ovulation rates. Thus, some technicians have advocated protocols where does that tend to be more prolific receive lower doses of PMSG than single fawn-producing does. Therefore, a study was designed to examine the effects of PMSG dosage on reproductive performance of farm-raised whitetail deer (*Odocoileus virginianus*). Over 2 yr, mixed-age, farm-raised whitetail does (n = 100 total) were assigned to treatments consisting of: 1) 1.5 mL of 5,000 I.U. PMSG for historically prolific does (n = 29 total) or 2) 2.0 mL of 5,000 I.U. PMSG for less prolific does (n = 71 total). On October 24, 2012 and October 11, 2014, estrus was synchronized by intravaginal insertion of a CIDR™ 330 (Pfizer Animal Health, New York, NY, USA) containing 0.35 g progesterone. After 14 d, CIDRs were removed and does were injected intramuscularly with the appropriate dose of PMSG. Approximately 56 h later, each doe was artificially inseminated via laproscopy. Conception rates, number of fawns born per doe, and birth weights did not differ ($P \geq 0.39$) between treatments. Frequency of multiple births tended ($P = 0.07$) to be higher for does receiving 1.5 vs. 2 mL of PMSG. Male and female fawns had similar ($P \geq 0.67$) birth weights between treatments. A lower dose of PMSG for prolific does seemed to mitigate the average number of fawns born without an effect on conception rates; however, the number of multiple births still tended to be higher suggesting that a lower dose of PMSG may not be effective in achieving the optimal number of fawns from each doe.

Key Words: deer, reproduction, PMSG

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418 Corpus luteum blood flow correlation with circulating progesterone during the bovine estrous cycle.

A. Egloff*, E. Taylor, B. Funnell, K. R. Stewart, *Purdue University, West Lafayette, IN.*

The purpose of this study was to evaluate a subjective scoring system to evaluate corpus luteum (CL) function during the beef cattle estrous cycle as a means to evaluate CL function in recipient cows. Sixteen open Simmental/Angus cows ranging from ages of 2 yr to 6 yr (mean age = 3) were randomly selected from the Purdue Animal Research Education Center. Cows ranged in BCS from 4.33 to 7 (mean = 5.10) and ranged in body weight from 1025–1645 (mean = 1318.44). Blood samples were collected every day for 28 consecutive days via venous jugular puncture. The blood samples were collected in vacutainer tubes containing EDTA. It was then spun using a centrifuge and froze. Plasma progesterone concentrations were determined via Immulite 1000 progesterone kits by Siemens. The kits test on a solid phase, competitive immunoassay utilizing the enzyme labeled chemiluminescent technology. Transrectal ultrasonography was performed every other day to visualize the ovarian structures (Sonosite Micromaxx). If a CL was present, a Color-flow Doppler sonography subjective score was recorded on a scale from 0–3 based on the following criteria: 0) no Doppler color; 1) small Doppler color on periphery of CL; 2) up to 80% of CL having Doppler color; and 3) greater than 80% of CL having Doppler color. Results from compiled testing were then evaluated using Spearman Correlation Coefficients in SAS® (v9.3, SAS Inst., Cary, NC). Plasma progesterone concentration was correlated with Doppler score ($r = 0.45$, $P < 0.0001$) where increasing Doppler score correlated with higher plasma progesterone concentrations. For each cow, a peak progesterone concentration and an average progesterone concentration for the last 4 d where progesterone was elevated in the blood were calculated. Peak and average progesterone concentrations were correlated with age ($r = -0.555$, $P = 0.032$) where younger animals had higher progesterone concentrations. Peak and average progesterone concentrations were not correlated with body weight or body condition score ($P = 0.6705$ and $P = 0.4949$, respectively). Overall, the subjective Doppler scoring system used in this study is correlated with plasma progesterone concentrations and could be used in recipient cows to evaluate functionality of the CLs before embryo transfer.

Key Words: Plasma Progesterone, Corpus Luteum

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419 Effects of diets containing psyllium seed husks on carcass composition, fatty acid profile, and cholesterol of rabbits.

K. M. Jones*[1], B. C. Shanks[1], J. D. Caldwell[2], J. A. Apple[3], B. R. Wiegand[4], L. S. Wilbers[1], T. M. Johnson[3], A. L. Bax[1], C. L. Thomas[1], K. L. Basinger[1,3], J. W. S. Yancey[3], *[1]Department of Agriculture and Environmental Science, Lincoln University, Jefferson City, MO, [2]Purina Animal Nutrition Center LLC, Gray Summit, MO, [3]Department of Animal Science, University of Arkansas, Fayetteville, [4]University of Missouri, Columbia.*

Interest in low-fat diets coupled with attention for novel and locally-produced foods has led to a resurgence in rabbit meat

consumption in the United States. Psyllium seed husks (PSH) from the *Plantago ovata* plant have been touted as a livestock nutritional enhancement designed to clean digestive tracts, improve performance and feed efficiency, and lower production costs; however, PSH has not been fully investigated in rabbit diets. Therefore, intact male and female New Zealand fryers (n = 44) were used to examine effects of diets with PSH or without (C) on carcass composition, fatty acid profile, and cholesterol of rabbits. Rabbit fryers (2.3 ± 0.54 kg BW) were sourced from 2 producers, and transported from southwest Missouri to the University of Arkansas abattoir, where they were humanely harvested. After harvest, carcass measurements were collected and LM samples were obtained for fatty acid analysis and cholesterol determination. Rabbits fed PSH had greater ($P < 0.01$) final BW, HCW, cold CW, and DP than rabbits fed C. Even though LM color and cooking losses did not differ ($P \geq 0.34$) between treatments, LM from PSH-fed rabbits had greater ($P < 0.01$) shear force values than that from C-fed rabbits. Cholesterol content tended to be greater ($P \leq 0.07$) in the LM of C than PSH rabbits. Among the various SFA, mg of C10:0 was higher ($P \leq 0.01$) in the LM of C-fed rabbits, whereas, LM concentrations of C14:0 was greater ($P \leq 0.04$) in PSH-fed rabbits. All other SFA examined did not differ ($P \geq 0.26$) between treatments. For MUFA, only C18:1t was found to be greater ($P \leq 0.03$) in PSH-fed than C-fed rabbits; all other MUFA were similar ($P \geq 0.26$) between treatments. Polyunsaturated fatty acids, C20:4n-6, C22:5, and C22:6 were greater ($P \leq 0.03$) in PSH than C rabbits. Fatty acid C20:2 tended ($P \leq 0.07$) to be higher in C vs. PSH. All other PUFA were similar ($P \geq 0.12$) between dietary treatments. Total mg of FA found in LM of PSH- and C-fed rabbits did not differ ($P \geq 0.65$). Weights and dressing percentages of rabbit fryers fed psyllium seed husks were improved relative to control rabbits sourced and harvested at the same time; however, shear force values were lower in control rabbits in this trial. Cholesterol tended to be lower and various differences were observed in the fatty acid profile of rabbits fed psyllium seed husks.

Key Words: Rabbit, Psyllium Seed Husks, Fatty Acid

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420 Electrical impedance correlations to pork quality.

S. B. Schauunaman*, J. M. Young, X. Sun, J. H. Liu, L. A. Bachmeier, R. Somers, D. J. Newman, *North Dakota State University, Fargo.*

The objective of this study was to identify the relationships between electrical impedance values and pork quality characteristics of boneless loin chops. Sections of boneless loins were collected weekly from 2 separate pork processing plants (20 samples from plant A and 10 samples from plant B over 6 wk), vacuum packaged, and sent to North Dakota State University for analysis. Samples were cut into 2.54-cm slices and allowed to bloom for 10 min before subjective color and marbling (NPB, 2010) were evaluated. Instrumental color was evaluated using a Minolta Colorimeter (CR-410, 50 mm diameter orifice, 2° observer; Minolta Company, Ramsey, NJ) using both C and D_{65} illuminants. The pH was recorded using a Hach H160 m (Loveland, CO). Electrical impedance measurements were taken using an EFRESH Analyzer (CellMet Rx Corporation, Harrisville, MI) that sent a sinusoidal wave form of 425 μA ± 25 μA at 50 kHz through probes into the sample. Drip loss and cook loss characteristics were also measured by weighing the samples before and after being stored at 4°C for 24 h or being cooked to 65°C, respectively. After being cooked, samples were evaluated for Warner-Bratzler Shear Force (WBSF; G-R Manufacturing, Manhattan, KS). Residual correlations were estimated using PROC CORR in SAS (SAS Institute, Inc., Cary, NC). Resistance was significantly correlated ($P < 0.05$) with C illuminant L* ($r = -0.19$) and a* ($r = 0.18$) and D_{65} illuminant L* ($r = -0.19$) and a* ($r = 0.15$). Reactance was significantly correlated ($P < 0.05$) with subjective color score ($r = 0.23$), C illuminant L* ($r = -0.29$) and b* ($r = -0.28$), D_{65} illuminant L* ($r = -0.29$) and b* ($r = -0.30$), and WBSF ($r = 0.23$). Impedance was significantly correlated ($P < 0.05$) with C illuminant L* ($r = -0.20$) and a* ($r = 0.15$) and D_{65} illuminant L*($r = -0.20$). Impedance also tended to be correlated ($0.05 < P < 0.10$) with subjective marbling score ($r = 0.14$) and D_{65} illuminant a* ($r = 0.13$) and b* ($r = -0.13$). Phase angle was significantly correlated ($P < 0.05$) with pH ($r = 0.25$), C illuminant L* ($r = -0.36$) and b* ($r = -0.35$), subjective color score ($r = 0.25$), WBSF ($r = 0.28$), and D_{65} illuminant L* ($r = -0.35$) and b* ($r = -0.37$). In summary, electrical impedance measurements on individual pork loin chops are a poor indicator of pork quality because they are weakly correlated with pork quality measurements.

Key Words: electrical impedance, pork quality, pork

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421 Development of an imaging technique using clinical CT-scans to detect osteochondritic-like lesions in femoral growth plates of growing pigs.

N. Gross*, S. Oldenburg, J. Lawinger, M. Grez, T. D. Crenshaw, *University of Wisconsin-Madison, Madison.*

Lesions of terminal cartilage canals in growth plates, diagnosed as osteochondrosis (OC) are presumed to be induced by diet, but evidence to support dietary induction is limited in controlled trials. The energy source and density of diets in this experiment were altered to simulate formulations presumed to induce OC lesions in commercial pigs. The primary objectives were to assess dietary induction of OC lesions and to develop an imaging technique which allowed a rapid assessment of OC lesions with potential for use in live animals. Thirty crossbred (1/4 Landrace × 1/4 Large White × 1/2 PIC Line 19) gilts (initial BW = 16.4+0.35 kg) were fed 1 of 3 diets designed to induce differences in the incidence of OC lesions. Diets included a corn-SBM, 1% fat control (Ctl) diet, the Ctl plus 20% glucose with 4% fat (Glc), or the Ctl plus 20% starch with 4% fat (Str). Adjustments in amino acids, Ca, and P were made for

differences in energy density. After a 30-d trial, femurs were collected for assessments of OC. Joint surfaces of femurs were visually examined and entire femurs were scanned by dual energy X-ray absorptiometry (DXA) and computed-tomography (CT). Images from CT scans of excised femurs were reconstructed using Mimics (Marterialize software 17.0). Suspected lesions on the distal growth plates were analyzed digitally for volume and surface area. Two observers analyzed each femur. No differences were detected between observers in lesion traits ($P > 0.15$) or within individual observers ($P > 0.10$). The CV for within observer error for lesion volume was 10.5% and for lesion number was 1.4%. Lesions > 10 mm^3 tended ($P < 0.10$) to have an increased volume (39.8, 21.8 and 29.7 mm^3) in Ctl vs. Glc and Str groups. Lesion volumes were larger ($P < 0.05$) on the medial vs. lateral condyle (15.2 vs. 3.8 mm^3). Detection of lesions in the scanned images were validated by physical sectioning of bones to reveal defects in the growth plate at locations visualized in the scanned images. In conclusion, CT scan techniques provide a non-invasive, rapid procedure to investigate OC in growing pigs. Additional benefits of image analysis may be realized by histologists as a mean to target specific lesion locations for sectioning and preparation of slides.

Key Words: dietary energy, lameness, non-invasive imaging

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422 Evaluation of perennial switchgrass as a replacement for cornstalks in high sulfur beef cattle diets. *A. K. Reis*[*1], *R. Ostrem*[1], *K. J. Heiderscheit*[1], *O. N. Genther-Schroeder*[1], *C. A. Clark*[2], *D. D. Loy*[1], *S. L. Hansen*[1], *[1]Iowa State University, Ames, [2]Armstrong Memorial Research and Demonstration Farm, Iowa State University, Lewis.*

Perennial switchgrass is a bio-renewable energy resource, and may serve as a roughage source in feedlot diets. Mature switchgrass is a very low quality feedstuff, but alkali treatments have been shown to increase its digestibility. This study determined the effects of untreated and alkali treated switchgrass on cattle growth performance, ruminal pH and hydrogen sulfide concentrations when used as a replacement for cornstalks in diets calculated to contain 0.5% S. Thirty-six Angus-cross steers (430.6 ± 30.55 kg, SD) were blocked by BW to pens with feed bunks capable of recording individual intake (12 steers per treatment). Pens (6 steers per pen) were assigned to one of the following high-S, corn-based diets, where roughage was provided by: 1) chopped corn stalks (11.5% of diet DM; providing 10% NDF from roughage), 2) chopped untreated switchgrass (11.8% of DM; 10% roughage NDF), or 3) chopped switchgrass treated with calcium hydroxide (added at 7% of DM) for 1 wk before feeding (11.8% of DM; matching untreated switchgrass inclusion). Weights were recorded on 2 consecutive days at the start and end of the 88 d trial. Data were analyzed using Proc Mixed in SAS, with steer as the experimental unit and the fixed effect of diet and block. Analyzed as repeated measures, ruminal pH and hydrogen sulfide concentrations collected on d 14, 21, 35, and 42 at 6 h postfeed delivery were not affected by the treatment × time interaction ($P \geq 0.11$). Steers fed untreated switchgrass had greater ($P = 0.02$) ruminal pH than steers fed cornstalks, but pH was not different ($P \geq 0.29$) between any other treatments. Ruminal hydrogen sulfide concentrations were unaffected by diet ($P = 0.57$). Final BW was not affected by treatment ($P = 0.84$). Overall ADG was consistent between treatments ($P = 0.66$), as was DMI ($P = 0.92$) and G:F ($P = 0.61$). There were no differences between treatments ($P \geq 0.43$) for HCW, backfat thickness, ribeye area, marbling score, or calculated yield grade. Based on these results there is no apparent benefit to alkali treatment of switchgrass when used at low inclusions in concentrate-based diets, and mature switchgrass may replace cornstalks under these conditions.

Key Words: cattle, sulfur, switchgrass

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423 College student perceptions of animal welfare and production agriculture practices at a small Historical Black University. J. D. Rippeto[*1], K. A. Cash[1], B. C. Shanks[1], J. D. Caldwell[2], M. S. Aruguete[1], *[1]Lincoln University, Jefferson City, MO, [2]Purina Animal Nutrition Center, Grays Summit, MO.*

With young adults today being further removed from the farm and exposed to negative press associated with a myriad of agriculture-related issues, it has become increasingly important for the animal agriculture industry to educate tomorrow's consumer today. Therefore, the objective of this study was to measure perceptions of college students on animal welfare and production agriculture topics. College students ($n = 163$) from Lincoln University, a small Historically Black University, representing a wide-array of majors and ranging academically from freshman to graduate level, were surveyed to determine their perceptions of animal welfare and production agriculture practices. A 5-point Likert-type response format scale was utilized, with "strongly agree" scored as 5 and "strongly disagree" scored as one. Cronbach's α tests discerned reliability of each scale and "Animal Welfare", "Genetically Modified Organisms", and "Agriculture" were sufficient ($\alpha \geq 0.70$) for further analysis with independent-samples *t*-tests. Students that participated were 44% female, 37% male (19% not indicated), and 89% stated they were between the ages of 18–23. Percentage of students that were raised in an urban or suburban area was 61%. Students reported being 43% African American, 33% Caucasian, 6% other ethnicities and 18% did not indicate their ethnicity. Collectively there were 38% freshman, 29% sophomores, 18% juniors, 9% seniors, 1% graduate students, and 5% did not indicate their year of school. Male and female attitudes differed only for the "Genetically Modified Organisms" scale. Females indicated significantly ($P = 0.03$) more negative attitudes toward "Genetically Modified

Organisms" than males did. African American and Caucasian participants differed only in their attitudes toward "Agriculture" with Caucasian participants signifying more ($P < 0.01$) positive attitudes than African American participants. Rural students expressed more ($P < 0.03$) positive attitudes toward "Agriculture" and "Genetically Modified Organisms" than urban students. Overall student's attitudes were close to neutral on topics of "Animal Welfare", "Genetically Modified Organisms", and "Agriculture", but perceptions did differ by gender, ethnicity, and size of hometown with Caucasian men from rural areas exhibiting the most positive perceptions. Unquestionably, male and female students of any ethnicity, from urban, suburban, or rural settings, should be educated on all aspects of agriculture including focus on animal welfare and agriculture production practices.

Key Words: agriculture, animal welfare, student survey

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424 Effects of level of soybean meal and Yucca *schidigera* addition to diets on growth performance of nursery pigs. C. V. Cooper*, S. D. Carter, S. Schaaf, S. L. Becker, *Oklahoma State University, Stillwater.*

A total of 180 crossbred pigs (average BW = 6.1 kg) were used to determine the effects of addition of Yucca *schidigera* (Micro-Aid; Porterville, CA) to a soybean meal-based diet on growth performance of nursery pigs in a 43-d experiment. Pigs were weaned at 20 d of age and allotted to 1 of 3 treatments in a completely randomized design (5 barrows, 5 gilts/pen; 6 pens/trt). The 3 dietary treatments consisted of: 1) control diet (CNT) containing animal protein sources (plasma, fish meal), 2) a high soybean meal-based diet without animal protein sources (HSBM), and 3) the HSBM-based diet plus 125 ppm of Micro-Aid (MA). Pigs were fed in 4 dietary phases. During d 0–21, animal plasma and fish meal were replaced in the CNT diet with soybean meal. Soybean meal was included at 30% in phases 1 (d 0–7), 2 (d 7–14), and 3 (d 14–21) for the HSBM and MA diets. Soy protein concentrate, soybean oil, L-lysine HCl, DL-methionine, L-threonine, dicalcium phosphate, and limestone were added to the HSBM and MA diets to equalize ME, amino acid, Ca, and P concentrations. During phase 4 (d 21–43), due to decreasing use of animal protein sources, the concentration of soybean meal was similar across the 3 dietary treatments. Feed disappearance and BW were recorded to calculate ADG, ADFI, and G:F for d 0–14, 0–21, 21–43, and 0–43. For d 0–14, pigs fed CNT had greater ($P < 0.02$) ADG (222 vs. 186 g/d), ADFI (281 vs. 254 g/d), and G:F (0.79 vs. 0.73) compared with pigs fed the HSBM diet. There was no difference ($P > 0.10$) in growth performance between pigs fed CNT and MA diets during d 0–14. Pigs fed MA tended to have greater ($P < 0.10$) ADG (209 vs. 186 g/d) and greater ($P < 0.04$) G:F (0.78 vs. 0.73) compared with pigs fed the HSBM diet during d 0–14. However, for d 0–21, 21–43, and 0–43, there were no differences ($P > 0.10$) among treatments. These results suggest pigs fed the HSBM diet from d 0–14 have decreased performance, but recover in the following phases, such that no differences in performance were noted at the end of the nursery phase. Addition of Micro-Aid tended to partially alleviate the negative effects of high soybean meal on growth performance during d 0–14 in the nursery. This work was partially supported by NPB SREE.

Key Words: pigs, soybean meal, Yucca *schidigera*

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425 Effects of foliar fungicide application on the growing corn plant. K. Robinson*[1], C. Kalebich[1], G. M. Fellows[2], F. C. Cardoso[1], *[1]University of Illinois, Urbana, [2]BASF Corporation, Research Triangle Park, NC.*

The presence of disease and fungus threaten corn health. Foliar fungicide applications to corn (*Zea mays*) may reduce disease and provide developmental benefits to the crop. The objective of this study was to evaluate the effect of various applications of foliar fungicide on the health and growth of the corn plant. Eight 1-acre plots of corn were planted in 2015. Treatments were replicated once and randomly assigned to one of the plots. Treatments were: CON, no foliar fungicide application; V5, 1 application of pyraclotrobin (Priaxor; BASF Corp.) foliar fungicide at corn vegetative growth stage V5; R1, 1 application of pyraclostrobin and metconazole (Headline AMP; BASF Corp.) foliar fungicide at corn reproductive growth stage R1; and V5+R1, 1 application of pyraclotrobin foliar fungicide at V5 and 1 application of pyraclostrobin and metconazole foliar fungicide at R1. Total yield for treatments CON, V5, R1, and V5+R1 were 31.6, 33.6, 32.9, and 33.5 tons/acre. Measurements of height and weight were recorded at 2 time points: R1- the silking stage and R3- the kernel milk stage, for 6 individual corn plants and cobs per row from 2 locations within each replicate at both time points. The same plant's leaves, corncobs, and stalks were assessed and collected at R1 and R3. Foliar disease evaluation and scoring of 10 random plants within each plot was conducted at R1 and R3. At R3, a 24.7% of disease incidence in plants evaluated showed symptoms of Gray Leaf Spot. Treatment V5 at R3 was most effected by Gray Leaf Spot (15%). Northern Leaf Blight was also found in the field, the highest percentage of disease incidence being in CON (10%) and least disease incidence in V5+R1 (1.63%). Statistical analysis was conducted using the MIXED procedure in SAS. There was no difference ($P = 0.52$) for the weight of the plants among treatments. Applications of foliar fungicide increased ($P < 0.0001$) the average heights for CON, V5, R1, V5+R1 (251 ± 6.9, 297 ± 7.1, 305.28 ± 6.9, 286.46 ± 7.1 cm, respectively). Furthermore, applications of foliar fungicide in V5, R1, V5+R1 (1.44 ± 0.18, 0.83 ± 0.18, 0.88 ± 0.18, respectively) decreased ($P = 0.0018$) the average number of yellow leaves compared with CON (1.71 ± 0.18). In conclusion, applications of foliar fungicides increased plant

health, which may contribute to a higher quality feedstuff.

Key Words: corn silage, foliar fungicide, ruminant nutrition

426 Determine nutritional and anti-parasitic benefits of *Cleome gynandra* for goats. J. Kirk*[1], R. Lawrence[2], O. Gekara[2], J. Onyilagha[2], U. Adamu[2], [1]*University of Arkansas At Pine Bluff, Pine Bluff,* [2]*University of Arkansas at Pine Bluff, Pine Bluff.*

Goat meat inventory in the United States has been declining since 2009 and remains low in grocery stores across the Country due to limited and inconsistent local supply. Consumer perception that goat meat is healthier than traditional red meats (beef, pork and lamb) is driving increased demand. Key factors limiting goat production in the United States include lack of suitable year-round browse and nematode parasitism, mainly *Haemonchus contortus.* Goat producers in the United States are seeking browse plants that can meet the nutritional needs of animals while providing effective natural remedies against parasites. This study evaluated one such plant, *Cleome gynandra* (African spider plant), known for its nutritional and anti-parasitic activities beneficial to humans. Consequently, the objective of this study was to determine the nutritional and anti-parasitic benefits derivable from *Cleome gynandra* (CG) plant by goats. Twenty four female goats (2 to 3 yr old) of Savannah breeding (BW = 34.7 ± 3.7 kg) were randomly assigned to 4 treatments, replicated 3 times. The treatments were: (i) no CG (Control; CO*N* = 0.00 kg DM CG.goat^{-1}.d^{-1}), (ii) low CG (LCG = 0.08 kg DM CG.goat^{-1}.d^{-1}), (iii) medium CG (MCG = 0.10 kg DM CG.goat^{-1}.d^{-1}), and (iv) high CG (HCG = 0.12 kg DM CG.goat^{-1}.d^{-1}). Each animal was also fed a supplemental diet containing 16% CP at the rate of 0.63 kg DM.d^{-1} and offered good quality hay *ad lib*. The study lasted for 28 d; September 25 through October 23, 2015. The animals were weighed, scored for body condition (BCS) and sampled for blood for hematocrit count (packed cell volume = PCV) on Day 1 and 28, and sampled for feces to determine parasite eggs per gram of feces (EPG) on Day 1, 7, 14, 21, and 28. The data was subjected to ANOVA of SAS; pen with 2 goats was the experimental unit. Treatment had no effect ($P > 0.10$) on ADG (0.11 vs. 0.12 kg. d^{-1}), BCS change (0.75 vs. 0.36), PCV change (−2.5% vs. −1.1%) or EPG change (242 vs. 561). *Cleome gynandra* can be a suitable browse plant for goats, however, further parasitology work is required to establish the phytochemicals present in CG and their efficacy against *Haemonchus contortus*, related parasites and other pathogens of significance to goats.

Key Words: *Cleome gynandra*, Nutritional, Anti-parasitic, *Haemonchus contortus*, Goats

427 Relationship of frame size and body measurements with feed efficiency traits in heifers. C. R. Kuehl*, A. B. P. Fontoura, F. E. Keomanivong, C. R. Dahlen, K. Ringwall, K. A. Vonnahme, L. L. L. H. Hanna, K. C. Swanson, *North Dakota State University, Fargo.*

The objective was to examine the relationship between heifer size and feed efficiency. This project is a part of a multi-year study examining the effects of frame size on feed efficiency and longevity in cattle fed forage-based diets. Eighty-nine crossbred heifers (BW = 342 ± 3.4 kg) were sorted into groups based on frame score (small to moderate < 5.5, average frame size = 4.27 ± 0.132, average BW = 317 ± 6.1 kg, $n = 49$; moderate to large ≥ 5.5, average frame score = 6.45 ± 0.191, average BW = 371 ± 11.8, $n = 40$). The heifers contained Angus, Red Angus, Gelbvieh, Hereford, Lowline, Shorthorn, and Simmental breeding. Heifers were fed over a 106-d feeding period. Feed intake was measured using the Insentec feeding system, which allows for the measurement of individual feed intake and feeding behavior in a group-fed situation. Body length, hip height, hip width, and heart, mid-, and flank girth were measured on the first and last d of the experiment. Body weight was measured on 2 consecutive days at the beginning and end and every 14 d of the experiment. Average daily gain, DMI, G:F, and residual feed intake (RFI) were analyzed using the Mixed procedure of SAS with fixed effects of frame score group ($n = 2$), sire breed group ($n = 8$), and age (350–406 d of age). Pearson correlation analysis was used to examine relationships between body measurements and growth performance traits. Average daily gain, G:F, and RFI were not influenced by frame score group ($P =$ 0.28, 0.71, and 0.85, respectively). Dry matter intake (% of BW) was greater ($P < 0.001$) in small to moderate heifers vs. moderate to large heifers (2.29 vs. 1.92%, respectively). Average daily gain was negatively correlated ($P = 0.01$; $r = -0.26$) with final hip height. Dry matter intake (% of BW) was negatively correlated ($P \leq 0.007$) with initial frame score ($r = -0.65$), and initial and final BW ($r = -0.74$ and -0.74),body length ($r = -0.33$ and -0.29) hip height ($r = -0.65$ and -0.61), hip width ($r = -0.52$ and -0.52), and heart ($r = -0.69$ and -0.65), mid- ($r = -0.68$ and -0.51), and flank girth ($r = -0.58$ and -0.46). Gain:feed and RFI were not correlated with body measurements. These data indicate that for this group of growing heifers fed a forage-based diet, heifers in the small to moderate frame size group had greater feed intake relative to BW which agreed with the correlation analysis suggesting a negative relationship between body size and relative DMI with less of an effect on ADG, G:F, and RFI. These findings will be validated in heifers from future years of the project.

Key Words: body size, feed efficiency, heifer

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