for increased co-product usage in pig diets and reduce the reliance on traditional feed ingredients, such as corn.

Key Words: pigs, electrolyte balance, co-products

227 Protein turnover and heat production of sows varies at day 30, 45 and 105 of gestation. R. S. Samuel*[1], S. Moehn[1], P. B. Pencharz[2], and R. O. Ball[1,2], [1]*Swine Research and Technology Centre, University of Alberta, Edmonton, AB, Canada*, [2]*Research Institute, Hospital for Sick Children, Toronto, ON, Canada*.

As gestation progresses, an increasing part of the nutrients and energy consumed by sows are used for growth of the conceptus. However, sows are typically fed restrictively and inadequate allowance may be made for changing requirement during gestation. The objective of this experiment was to determine energy and leucine balance of sows in early-, mid-, and late-gestation. Gravid 2nd parity sows (n=5) were fed 2.4 ± 0.1 kg of a barley-wheat-SBM diet of 12.5 MJ ME/kg, 0.65% total lysine, and 15% crude protein twice daily throughout gestation. Heat production, by indirect calorimetry, was determined simultaneously with leucine kinetics, by primed-constant IV infusion of L-[1-^{13}C]leucine (1.0 mg•kg^{-1}•h^{-1}) over 24 h. All measurements were made at d 30, 45, and 105 of gestation. The effect of "day" was assessed using mixed model analysis (SAS 2002) with individual animals as a random variable. Significance was taken at $P < 0.05$; a tendency at $P < 0.1$. Leucine flux, appearance from breakdown, and incorporation into protein were greater ($P<0.001$) on d 45 than on d 30 or 105 of gestation. At constant feed intake, protein gain was lower ($P<0.05$) on d 45 than (137.6 g/d) than on d 30 (167.6 g/d) or 105 (164.1 g/d). Energy balance (i.e. intake over maintenance) was greater ($P<0.01$) on d 45 (6.1 MJ/d) than on d 30 (3.7 MJ/d) or d 105 (1.4 MJ/d) of gestation. This greater energy balance allowed lipid deposition only on d 45 where the respiratory quotient (RQ) was greater than 1, indicating lipogenesis. The RQ was not different than 1 on d 30 and 105. Energy intake (30.5 ± 0.9 MJ/d) was not significantly different from HP (29.1 ± 1.5 MJ/d) on day 105. Therefore, sows needed to mobilize body lipid to support fetal growth. These results indicate that after regaining body protein lost in a preceding gestation and lactation, sows deposit lipid during mid-gestation. Feeding a constant daily amount of feed does not provide sufficient energy in late gestation.

Key Words: energy, protein, gestation

228 Prediction of DE content of common ingredients in grower pigs using an in vitro digestibility technique. P. R. Regmi*[1], N. S. Ferguson[2], A. Pharazyn[2], L. F. Wang[1], and R. T. Zijlstra[1], [1]*University of Alberta, Edmonton, AB, Canada*, [2]*Nutreco Canada, Guelph, ON, Canada*.

Energy value of feed ingredients can vary widely due to changes in energy digestibility. Prediction of variation in DE value among and within ingredients is important to determine the energy value of ingredients and to balance feed formulations. Previously, a 2-d in vitro digestibility technique, involving subsequent digestion of ground samples in pepsin (2 h), pancreatin (6 h), and Viscozyme, a fiber-digesting enzyme complex (18 h), was used to predict DE content of feed samples in swine. The objective of this study was to test the accuracy of the in vitro technique to predict the variation in DE content across common ingredients (corn, wheat, barley, field pea, soybean meal, corn DDGS, canola meal, and wheat millrun) and within ingredients (wheat and canola meal) in swine. The range of ADF and CP contents (in DM) were, respectively, 3.0 to 16.9 and 9.6 to 52.1% among ingredients, 3.3 to 6.2 and 11.2 to 20.8% among batches of wheat, and 15.2 to 18.1 and 36.2 to 41.3% among batches of canola meal. In vivo DE value was determined using barrows (n = 48) in complete randomized design and ranged among ingredients, within wheat, and within canola meal from 1.82 to 3.18, 3.36 to 3.81, and 3.01 to 3.18 Mcal/kg of DM, respectively. Similarly, in vitro DE value among ingredients, within wheat, and within canola meal ranged from 2.71 to 4.08, 3.50 to 3.94, and 2.96 to 3.33 Mcal/kg of DM, respectively. The relationship of in vitro and in vivo DE values was strong across ingredients ($R^2 = 0.86$, $Y = 1.02 X — 0.13$) and within wheat ($R^2 = 0.78$, $Y = 0.92 X + 0.20$), but was poor within canola meal ($R^2 = 0.05$). Higher ADF and ash (6.7 to 8.6%) contents possibly caused discrepancies between in vivo and vitro digestion, and a narrow range of DE content might have contributed to the poor relationship between in vivo and vitro DE values in canola meal. The in vitro technique can be used to estimate the variation in DE content among common ingredients and within wheat; however, the technique needs to be improved to predict DE content within canola meal.

Key Words: digestible energy, pig, in vitro digestibility

Meat Science and Muscle Biology: Symposium: Balancing Live Cattle Performance and Beef Quality

229 Growth technologies: Performance benefits and quality considerations. J. D. Tatum*, *Colorado State University, Fort Collins*.

Growth enhancement is unquestionably one of the most effective management tools currently available to beef producers for adding value to cattle. Growth-enhancement technologies have been used for more than 50 yr in US beef production systems to improve cattle performance and reduce per-unit cost of beef. In today's commercial cattle feeding industry, most cattle produced in conventional finishing systems receive 1 or 2 growth-promoting (estrogenic, androgenic, or combination) implants. Moreover, growing numbers of implanted feedlot cattle also are fed 1 of 2 recently approved beta adrenergic agonists (BAA) during the final few wk of finishing. Growth enhancement in successive stages of finishing using implants and BAA produces additive, beneficial effects on rate and efficiency of gain and substantially increases pay-weight, thereby improving economic returns to the feeding enterprise. In a 2007 analysis conducted by Iowa State University economists, estimates of value added to feedlot cattle by a) implanting and b) supplementing implanted cattle with BAA were $71 and $15/animal, respectively. Within the past 2 decades, however, development and subsequent adoption of growth-enhancement products with ever-increasing potency have intensified concerns in the packing, retail, and foodservice sectors of the beef industry about potential adverse effects of growth enhancement on beef quality characteristics. Growth-enhancement programs designed to maximize cattle performance have been shown to reduce deposition of intramuscular fat, increase beef toughness, and decrease consumer acceptability. In addition, aggressive growth enhancement can increase frequencies of heavyweight carcasses and over-sized beef cuts. When growth-enhancement programs, cattle types, and marketing targets are properly matched, use of growth technologies can facilitate efficient production of beef without substantially reducing product quality.

Key Words: growth technologies, beef, quality

230 Production systems to optimize growth and beef quality. I. Rush*, *University of Nebraska, Lincoln*.

Cattle producers have many options in utilizing available resources for economical production of high quality beef. Cattle performance must be optimized to assure the economical production of the animal to harvest, however ultimately the industry must produce a high quality product that is readily acceptable to the consumer with high market value. Economic analysis of various production systems consider input costs such as grazed forages, harvested feeds (grain, by-product feeds and forages) and non-feed costs. Efficiency of production, which is often associated with high performance, is one of the most important parameters in determining the most profitable or the least cost production system. Many data sets show that production parameters post weaning are 2-3 times more important than the value of the carcass when sold on an average grid basis. Often carcass weight was a large factor in determining the lowest breakeven. This may have sent the wrong market signal and has often overlooked the importance of the quality of the product. We know that when considering the entire production system many factors may affect the quality of the ultimate beef product. These include genetic traits, nutrient flow to the fetus in the uterus, level of antibodies received from colostrum in early life, level of nutrition of the calf in early life, age of calf when harvested, temperament of animal, lifetime health of the calf, level and timing of growth promotants, feeding management and conditions plus other factors. Three areas of the production systems that affect a large range of the use of these resources are: 1) early weaning and placing the calf on a high concentrate diet (2) normal weaning and then placing on finishing diets and (3) normal weaning however growing the calf on forages (often grazed) and placing them on a finishing diet at a heavier weight. All segments of the industry must work together to assure the production of the highest quality economical product. In order for the industry to stay competitive in the animal protein market, low cost systems must be evaluated however high quality beef must be a part of the overall decision process in any beef production system.

Key Words: systems, beef, quality

231 Cellular differentiation: Muscle growth and marbling. B. J. Johnson*, K. Y. Chung, and S. L. Parr, *Texas Tech University, Lubbock*.

Exogenous growth-enhancing compounds have been used to improve growth rate and efficiency in meat animals for over a half century. In cattle, these compounds enhance efficiency of growth by preferentially stimulating skeletal muscle growth at the expense of adipose tissue accretion. Consequently, these growth-enhancing compounds have been shown to reduce intramuscular fat (marbling) in beef cattle compared to nonimplanted cattle. Concurrent administration of trenbolone acetate (TBA) and estradiol-17β (E2) has shown to increase carcass protein accumulation 8 to 10% in yearling steers. Muscle satellite cells isolated from steers implanted with TBA/E2 had a shorter lag phase in culture compared to satellite cells isolated from nonimplanted steers. Collectively, these data indicate that activation, increased proliferation, and subsequent fusion of satellite cells in the muscle of implanted cattle may be an important mechanism by which anabolic steroids enhance skeletal muscle hypertrophy. These cellular events may in part be responsible for the negative effects observed with the use of these compounds in terms of marbling development in beef cattle. Markers of adipogenic differentiation are also affected by TBA/E2. Specifically, PPARγ and SCD mRNA levels, were lower in biopsy samples ($P < 0.06$) of TBA/E2 implanted steers compared to nonimplanted steers. In adipose tissue, an enzyme important for energy balance, AMPKα, may also be affected by anabolic steroids. These data indicate that in adipose tissue compared to skeletal muscle, anabolic steroids may have opposite effects on cellular growth and differentiation. This inverse relationship may contribute to changes in beef quality.

Key Words: adipose tissue, anabolic steroids, skeletal muscle

232 Managing genetic antagonisms between economically important beef production traits and marbling. R. L. Weaber[1] and R. M. Enns*[2], [1]*University of Missouri, Columbia*, [2]*Colorado State University, Fort Collins*.

As the beef complex has become more consumer focused with more cattle individually priced through value-based marketing systems, seedstock and commercial producers have been motivated to place more selection pressure on carcass traits by downstream industry partners. A number of grid pricing systems exist that substantially reward cattle that grade average Choice or better and meet other production specifications for branded beef programs. Economic incentives and the publicity surrounding branded programs have raised industry awareness of the value of carcass merit. Additional motivation for selection to improve end-product quality and consistency comes from the 2000 National Beef Quality Audit which identified insufficient marbling and inappropriate USDA Quality Grade mix as beef attributes that needed improvement. A wide range of carcass traits have been shown to be moderately to highly heritable and lowly to moderately correlated with production traits such as cow body condition score, direct and maternal weaning weight. Many breed association sponsored genetic evaluation systems now include carcass traits and several breed organizations utilize ultrasound indicator traits of carcass merit in a multiple trait genetic evaluation. Considerably more selection pressure is placed on carcass traits today, by a wider range of seedstock and commercial producers, than ever before. Genetic regression and a selection index architecture was used to investigate the potential correlated responses and economic consequences to selection for increased marbling. Predicted genetic changes in correlated traits were small in magnitude for all traits included in the breeding objective and for their indicator traits even when considerable selection pressure was placed on marbling score. Changes in net merit value for an integrated production system that retains ownership through harvest and produces its own replacement females were also small in magnitude. These small changes in net merit may be reflective of the lower economic importance of changes in marbling relative to other traits in the index including cow longevity and fertility.

Key Words: beef cattle, marbling, selection

233 Maternal obesity affects adipogenesis and myogenesis in fetal sheep muscle at late gestation. X. Yan*, W. Xu, J. F. Tong, J. X. Zhao, M. J. Zhu, S. P. Ford, and M. Du, *University of Wyoming, Laramie*.

During fetal development, both muscle cells and adipocytes are derived from mesenchymal stem cells. Enhancing adipogenesis in fetal muscle increases intramuscular adipocytes which enhances marbling in offspring animals. Using pregnant sheep as a model, the objective of this study was to investigate the impact of maternal overnutrition on adipogenesis in fetal skeletal muscle at late gestation when skeletal muscle matures in sheep. Non pregnant ewes were randomly assigned to a control (Con, 100% of NRC recommendations, n=5) or obesogenic (OB, 150% of NRC, n=5) diet from 60 days before to 135 days after conception, when fetal Lateral and Medial Gastrocnemius, Soleus and semitendinosus (St) muscle were collected and weighed. The St muscle was used for

histochemical and biochemical analyses. At the end of the treatment, both maternal body weight (90.4 ± 7.7 kg vs. 107.6 ± 7.1 kg, $p < 0.05$) and body condition score (6.1 ± 0.4 vs. 8.5 ± 0.4, $p < 0.05$) were higher in OB than Con groups. Intriguingly, there was no significant difference in fetal body weight (5205.7 ± 282.9 g vs. 5113.4 ± 283.2 g) as well as St muscle weight (8.7 ± 0.3 g vs. 8.2 ± 0.5 g) between these two groups. Fetal St muscle from OB mothers contained more large adipocytes, with the total relative area of fat cells increased by 26.3 ± 3.4% ($P < 0.05$). Corresponding to that, the number of muscle cells in a certain area was decreased by 11.6 ± 1.7% ($P < 0.05$) in OB fetal St muscle, as well as a decreased average diameter by 11.1 ± 3.7% ($p<0.05$). OB enhanced the expression of peroxisome proliferator-activated receptor γ (PPARγ) and Preadipocyte factor-1 (Pref-1) in fetal muscle by 23.8 ± 3.9% ($P < 0.05$) and 14.0 ± 5.7% ($P=0.09$), indicating enhanced adipogenesis. The protein content of Glut 1 and Glut 4 was decreased by 22.1 ± 4.8% and 13.9 ± 1.3% in OB fetal muscle respectively ($P < 0.05$). In conclusion, maternal over-nutrition during fetal stage dramatically increases the number and size of intramuscular adipocytes, which will provide sites for intramuscular fat accumulation in offspring, and could effectively improve marbling and quality grade of the resulting carcasses.

Key Words: adipogenesis, fetus, marbling

Nonruminant Nutrition: Improving the Nutritional Value of Alternative Feed Ingredients

234 Carbohydrates in alternative feed ingredients. B. M. Vester Boler and G. C. Fahey Jr.*, *University of Illinois, Urbana*.

With the fluctuating prices of commodity ingredients fed to livestock, poultry, and companion animals, alternative feed ingredients are of interest as partial substitutes for more traditional ingredients used in animal diets. Many of these alternative ingredients have carbohydrate concentrations and profiles different from those of traditional ingredients. Indeed, greater proportions of fermentable carbohydrates (i.e., dietary fibers) often are found. Popular alternative ingredients include corn co-products (e.g., distillers dried grains, distillers dried grains with solubles, corn germ, corn germ meal, corn gluten feed, corn gluten meal, corn bran), legumes (e.g., peas, soybean hulls), wheat middlings, canola meal, sunflower meal, and even grains other than corn (e.g., barley, oats, rice, sorghum, wheat) and co-products from the bakery industry (e.g., bakery by-product meal). Good analytical techniques exist for the measurement of all categories of carbohydrates, but for these values to be meaningful, further characterization of carbohydrates is needed that emphasizes their nutritional/physiological relevance for a particular animal species. Starch, hydrolyzable carbohydrates, rapidly and slowly fermentable carbohydrates, non-starch polysaccharides, total dietary fiber, and detergent fibers are carbohydrate fractions affecting select aspects of animal metabolism such as nutrient intake and digestion, glycemic response, immune response, and gut microbiota modulation. Most contain multiple carbohydrate moieties, and various analytical techniques exist for their quantification. To fully appreciate the importance of carbohydrates in alternative feed ingredients, integration of information related to chemical composition, analytical methodology, and nutritional/physiological outcomes must occur.

Key Words: carbohydrates, alternative feeds, nutrition

235 Mycotoxins in alternative ingredients. T. K. Smith*, *University of Guelph, Guelph, ON, Canada*.

Mycotoxins are metabolites produced by fungi (molds) that can infest crops pre-harvest and can continue to flourish under sub-optimal storage conditions. Grains with a high moisture content are particularly unstable and prone to mold proliferation and possible mycotoxin production. Excess rainfall at harvest and at key periods during the growing season can be a major promoter of mycotoxin contamination of feedstuffs. The most significant species of mycotoxin-producing fungi that have an impact on livestock production would include *Aspergillus* and *Fusarium*. The most significant mycotoxin produced by *Aspergillus* fungi are the aflatoxins and these are most commonly found in tropical and semi-tropical climates. The *Fusarium* mycotoxins include the trichothecenes such as deoxynivalenol (DON, vomitoxin), zearalenone and the fumonisins. The major economic cost of feed-borne mycotoxins is immunosuppression. This results in lingering herd health problems, animals that do not respond to medication and failure of vaccination programs. Other more specific symptoms of mycotoxicoses include behavioral changes arising from altered brain neurochemistry including loss of appetite, loss of muscle coordination and lethargy; impaired reproduction and gastrointestinal tract pathology resulting in reduced efficiency of nutrient absorption. Recent increases in fuel ethanol production have diverted feed grains away from the animal industries. This has increased the price and reduced availability of traditional feedstuffs while alternative feed ingredients such as distillers dried grains and corn and wheat gluten by-products have become more attractively priced and more available. Such products, however, have an increased likelihood of mycotoxin contamination. The use of alternataive feed ingredients, therefore, requires increased monitoring for mycotoxin contamination.

Key Words: alternative ingredients, mycotoxins, immunosuppression

236 Anti-nutritional compounds and other limitations to the use of alternative feed ingredients. H. H. Stein*, *University of Illinois, Urbana*.

Alternative feed ingredients that are used in the swine industry may be categorized in 4 groups: 1) Intact ingredients such as field peas, canola seeds, barley, wheat, and oats; 2) Processed ingredients that are by-products from other industries such as distillers dried grains with solubles (DDGS), high protein distillers dried grains, corn gluten meal, hominy feed, corn gluten meal, corn germ, wheat middlings, soybean hulls, alfalfa meal, canola meal, de-hulled sunflower meal, cotton seed meal, glycerol, and liquid whey; 3) Off-spec products from other industries such as pet food, cookies, bread, etc, and 4) Left-overs from other industries such as outdated bread, out dated milk, left-over chocolate, etc. Anti nutritional compounds may be present in some of these ingredients such as gossypol in cottonseed products, glycosinolates in canola products, tannins in field peas, alkaloids in lupins, and mycotoxins in many cereal grains and by-products of grains. However, these anti-nutritional compounds can usually be managed and in most cases, they do not represent major limitations to the use of alternative feed ingredients, although there are exceptions to this rule. Many alternative feed ingredients, especially from the group of processed ingredients, contain relatively large concentrations of dietary fiber, which on many occasions limits the inclusion rate of these ingredients in diets fed to swine. This is true in particular for ingredients such as alfalfa meal and soybean hulls. Undesirable characteristics of the carcass of pigs fed alternative ingredients may also limit the inclusion rate of ingredients such as DDGS with high concentrations of unsaturated fatty acids.