696 Nutrient profile and in vitro vs. in vivo energy digestibility of wheat co-products from flour milling in growing pigs. R. Jha*[1,2], P. R. Regmi[1], L. F. Wang[1], A. Pharazyn[3], and R. T. Zijlstra[1], [1]*University of Alberta, Edmonton, AB, Canada,* [2]*University of Hawaii at Manoa, Honolulu,* [3]*Nutreco Canada, Guelph, ON, Canada.*

Wheat flour milling generates co-products (WFM) such as wheat shorts, millrun, middlings, and bran that are classified based on fiber content. These WFM can serve as alternative feedstuffs for conventional energy sources in swine diets to reduce feed cost, a major challenge of swine industry; however, information is scarce about their digestible nutrient content that limits their use in swine diets. Nutrients of 9 WFM (2 shorts, Shorts A and B; 5 millrun, Millrun A, B, C, D, and E; Middlings; and Bran) were profiled. In vitro energy digestibility was determined using 3-step assay. In a 30-d digestibility study (a 10-d acclimation to a standard pre-grower diet, followed by 2 consecutive 10-d experimental periods), 20 growing pigs (BW, 37.5 kg) were fed at 3 × maintenance requirement with 1 of 10 diets (9 WFM added at 40% to corn; and corn as control). Feces were collected by grab sampling and apparent total tract digestibility (ATTD) of wheat co-products was calculated using the indicator method. The CP content of WFM ranged from 15.9 (Bran) to 27.8% (Shorts A) and crude fiber from 5.2 (Shorts B) to 12.0% (Bran). Diet DE content was highest ($P < 0.05$) for Shorts B and lowest for Bran (3.56 vs. 3.21 Mcal/kg DM), corn had 3.46 Mcal DE/kg. The ATTD of energy of WFM diets ranged from 74.4 in Bran to 82.5 in Shorts A, and was 82.9% in the corn diet. The in vivo energy digestibility was highest ($P < 0.01$) in Short B (81.9) and lowest in Bran (62.6%). In vitro energy digestibility was highest ($P < 0.05$) in Short B (69.1) and Middlings (68.0) and lowest in Millrun B (51.6%). In vitro energy digestibility was strongly related ($R^2 = 0.80$) with ATTD of energy of the WFM. Among nutrients, NDF was the best predictor for in vitro ($R^2 = 0.74$) and in vivo DE ($R^2 = 0.81$). In conclusion, nutrient profiles and digestibility of WFM vary widely but some WFM (Short A and B; Millrun A, B and D; and Middlings) have a DE content comparable to corn. Thus, type and composition of wheat co-products should be considered for swine feed formulation. Finally, the existing in vitro technique predicts ATTD of energy in WFM accurately.

Key Words: energy, pig, wheat co-product

697 Nutrient profile and in vitro vs. in vivo energy digestibility of grain legumes in growing pigs. R. Jha*[1,2], L. F. Wang[1], P. R. Regmi[1], A. Pharazyn[3], and R. T. Zijlstra[1], [1]*University of Alberta, Edmonton, AB, Canada,* [2]*University of Hawaii at Manoa, Honolulu,* [3]*Nutreco Canada, Guelph, ON, Canada.*

Grain legumes contain protein and energy and can serve as alternative feedstuffs to mitigate rising swine feed cost. However, their nutrient content and digestibility are poorly understood. Nutrients of 8 grain legumes and fractions (3 field pea, Pea A, B, C; Lentil; Maple bean; Roasted bean; Pea protein; and Pea starch) were profiled. In vitro digestibility of samples was determined following 3-step assay. In a 30-d digestibility study (10-d acclimation to standard pre-grower diet followed by 2 consecutive 10-d experiments), 18 growing pigs (BW 43.5 kg) were fed 1 of 9 diets (8 legumes and corn as control) at 3 × maintenance requirement for 4 observations per diet. Feces were collected by grab sampling. Apparent total tract digestibility (ATTD) of energy was measured with the indicator method. The CP content ranged from 6.4 (Pea starch) to 55.3% (Pea protein) and crude fiber from 1.8 (Pea starch) to 6.9% (Roasted bean). The GE content was higher in Pea protein (4.78) and Lentil (4.54) than Corn (4.45 Mcal/kg DM). Diet DE content was highest ($P < 0.05$) for Pea protein and lowest for Maple bean (3.30 vs. 3.07 Mcal/kg DM, respectively), DE of corn diet was 3.18 Mcal/kg. The ATTD of energy of diet was highest in Pea starch (91.0) and lowest in Roasted bean (76.4%) while Corn diet was 84.4%. In vitro energy digestibility was highest ($P < 0.05$) in Pea protein (88.8) and lowest for Maple and Roasted bean (79.0 and 79.8%, respectively). In vitro energy digestibility was moderately related to ATTD of energy for legume samples ($R^2 = 0.44$; linear) although in vitro DE and in vivo DE were related tighter ($R^2 = 0.57$). Among nutrients, ADF was the best predictor ($R^2 = 0.67$) for in vivo DE. In conclusion, some grain legumes provide more DE with higher ATTD of energy than corn; thus, can serve as alternative feed ingredient for growing pigs. However, variation due to type and composition of grain legume should be considered for swine pig diet formulation. Finally, the current in vitro digestibility technique needs improvements to better predict the ATTD of energy in grain legumes in swine.

Key Words: energy, legume, pig

698 Digestible and metabolizable energy concentration in canola meal, 00-rapeseed meal, and 00-rapeseed expellers fed to growing pigs. T. Maison* and H. H. Stein, *University of Illinois at Urbana-Champaign, Urbana.*

This experiment was conducted to measure DE and ME in canola meal, 00-rapeseed meal, and 00-rapeseed expellers fed to growing pigs. Twenty 3 barrows (initial BW: 27.7 ± 2.92 kg) were allotted to an 8 × 23 Youden square design with 8 periods and 23 animals. Twenty-three diets were prepared. One diet was a corn based basal diet; 6 diets were based on corn and each of 6 samples of canola meal from solvent-extraction crushing plants in North America (average of 4,218 kcal GE/kg, 38.0% CP, and 3.82% crude fat); 11 diets were based on corn and each of 11 samples of 00-rapeseed meal from solvent-extraction crushing plants in Europe (average of 4,210 kcal GE/kg, 36.2% CP, and 3.87% crude fat); and 5 diets were based on corn and each of 5 samples of 00-rapeseed expellers from mechanical-press crushing plants in Europe (average of 4,721 kcal GE/kg, 35.6% CP, and 11.5% crude fat). Pigs were fed at 3 times their estimated energy requirement for maintenance, and were placed in metabolism cages that allowed for the total, but separate, collection of feces and urine. The concentration of DE and ME in corn was calculated from the basal diet and the contribution of DE and ME from corn to the remaining diets was then calculated, and the DE and ME of each source of canola meal, 00-rapeseed meal, and 00-rapeseed expellers were calculated by difference. Results of the experiment indicate that the apparent total tract digestibility in 00-rapeseed expellers (78.32%) was greater ($P < 0.01$) than in 00-rapeseed meal (70.63%), but no difference between 00-rapeseed meal and canola meal (69.82%) was observed. The concentration of DE and ME in canola meal (3,378 and 3,127 kcal/kg DM) were not different from DE and ME in 00-rapeseed meal (3,461 and 3,168 kcal/kg DM), but 00-rapeseed expellers had greater ($P < 0.01$) DE and ME (4,005 and 3,691 kcal/kg DM) than 00-rapeseed meal. In conclusion, the concentration of DE and ME is not different between canola meal and 00-rapeseed meal, but 00-rapeseed expellers contain more DE and ME than 00-rapeseed meal.

Key Words: canola meal, rapeseed product, pig

699 Determination of true phosphorus digestibility in *Brassica napus* black and *Brassica juncea* yellow fed to growing pigs using regression analysis. P. A. Adhikari*, J. M. Heo, and C. M. Nyachoti, *University of Manitoba, Winnipeg, MB, Canada.*

Diet formulation on the basis of apparent phosphorus (P) digestibility values can vary within a single feed ingredient that leads to P over-feeding and excessive P excretion in pigs. The determination of true digestibility values in feed ingredients helps to address this issue. The objectives of this study were to determine the apparent (ATTD) and true (TTTD) total tract digestibility of P in canola meals (CM) from *Brassica napus* black and *Brassica juncea* yellow fed to growing pigs using the regression analysis technique. Forty-eight barrows (initial BW = 19.9 ± 0.22 kg mean ± SD) housed individually in metabolic crates were allotted to 8 dietary treatments in a completely randomized design to give 6 observations per treatment. Eight isocaloric cornstarch-based diets (4 diets per cultivar) were formulated to contain 0.8, 1.6, 2.4 and 3.3 g/kg DM from either *B. napus* black or *B. juncea* yellow. Canola meal (*B. napus* black or *B. juncea* yellow) was the sole source of P and limestone was added to maintain Ca:total P ratio of 1.2:1. The daily quantity of feed provided per pig was calculated as 2.6 times the maintenance energy requirement of the pigs and divided into 2 equal meals at 0800 and 1600 h. Pigs were adapted to dietary treatments for 9 d followed by the total collection of feces for 5 d. The ATTD values of P increased from 17.9 to 29.4% for *B. napus* black and from 16.6 to 27.2% for *B. juncea* yellow as the dietary P content increased from 0.8 to 3.3 g/kg DM. The endogenous fecal outputs of P were not different between the CM cultivars and averaged 0.667 g/kg DMI. There was no difference ($P > 0.05$) in TTTD of P (33.3 vs. 31.9%) in *B. napus* black and *B. juncea* yellow when determined with the regression method. In this study, estimates of endogenous P loss were higher than previous studies which can be due to various factors including diet type, age or metabolic state of animal.

Key Words: digestibility, endogenous loss, phosphorus

700 Physiological effects of L-methionine compared with DLDL-methionine fed to nursery pigs. Y. B. Shen* and S. W. Kim, *North Carolina State University, Raleigh.*

D-Methionine is slowly transported to intestinal cell and need to be converted to L-Met (LM) in the liver for biological functions. Thus, we hypothesized dietary LM as a direct source of Met will have beneficial effects on gut development and growth of pigs compared with the use of DL-Met (DLM). Twenty individually housed crossbred pigs (8.40 ± 0.25 kg BW) were randomly allotted to 2 treatments at 26 d of age: (1) basal diet (0.16% endogenous Met) + 0.145% DLM; or (2) basal diet + 0.145% LM. Both diets had Met meeting 95% the NRC requirement. Pigs were fed assigned diets for 20 d. During the entire period, pigs fed a diet supplemented with LM tended to have 7.4% greater gain:feed ratio (0.62 vs. 0.58; $P = 0.064$) compared with pigs fed a diet supplemented with DLM. On d 20, pigs fed a diet supplemented with LM had 15.4% and 7.4% greater villus height (709 vs. 614, μm; $P = 0.047$) and width (159 vs. 148 μm; $P = 0.036$) in duodenum compared with pigs with DLM. Pigs fed a diet supplemented with LM tended to have 17.5% greater villus height:crypt depth ratio (1.54 vs. 1.31; $P = 0.075$) in duodenum compared with pigs with DLM. Pigs fed a diet supplemented with LM tended to have 19.9% lower concentration of malonedialdehyde (MDA) in plasma (7.45 vs. 9.30 μM; $P = 0.069$) and 52.6% lower concentration of MDA in ileum mucosa (0.55 vs. 1.16, umol/g protein; $P = 0.081$) compared with pigs with DLM. Concentrations of protein carbonyl in duodenum mucosa of pigs fed a diet supplemented with LM was 12.0% lower (3.00 vs. 3.41, umol/g protein; $P = 0.023$) than pigs with DLM. However, concentrations of glutathione in duodenum and liver were not affected by dietary treatments ($P = 0.123$). Collectively, compared with DLM, use of LM as a source of dietary Met supplementation in nursery pig diets improved gut development by enhancing villus development associated with reducing oxidative stress in nursery pigs.

Key Words: DL-methionine, gut development, L-methionine

701 Predicting digestible energy (DE) and net energy (NE) of dried distillers grains with solubles from its oil content. S. Nitikanchana*, A. B. Graham, R. D. Goodband, M. D. Tokach, S. S. Dritz, and J. M. DeRouchey, *Kansas State University, Manhattan.*

The energy content of dried distillers grains with solubles (DDGS) is a concern as more oil content is being extracted during the ethanol production process. The objective of this study was to determine the DE and NE value of DDGS varying in oil content. To determine the DE of DDGS, a total of 12 pigs in metabolism cages were fed a corn-based diet and corn-50% DDGS diets from 5 sources of DDGS that had various oil contents (5.35, 7.63, 9.38, 9.57, and 12.10%; as-fed basis).The same 5 sources of DDGS were also used in 3 growth studies to determine the NE of the DDGS sources from the G:F responses. Four of the DDGS sources were tested at 20 and 40% of the diet. One DDGS source was tested at 15, 30, and 45%. The net energy efficiency (calories of NE intake (kcal) per kg of gain; NEE) of pigs fed the respective DDGS diet in each study was solved to equal the NEE of pigs fed the corn-soybean meal diet in the same study by adjusting the dietary NE of the DDGS diet. Corn and soybean meal were assumed to have a NE content of 2,672 and 2,087 kcal/kg, respectively. The dietary NE content that resulted in equal NEE was then used to calculate NE of DDGS according to the percentage of DDGS in that diet. From this method, NE of 5 sources of DDGS were determined. Then, DE from the digestibility study and NE from the growth studies for the 5 DDGS sources were used in a stepwise regression to establish the DE and NE prediction equations. The linear and quadratic term of oil (ether extract), crude protein, crude fiber, acid detergent fiber, neutral detergent fiber, particle size, bulk density, including the interaction terms were the variables in the regression analysis. Of these measures, oil content was the only significant variable. The equations to predict DE and NE as a function of oil content were: [DE (kcal/kg) = 62.347 × oil (%) + 3058.13 (n = 5, Adjusted $R^2 = 0.41$); NE (kcal/kg) = 115.011 × oil (%) + 1501.01 (n = 5, Adjusted $R^2 = 0.86$)]. These equations indicate changing the oil content 1% in DDGS will change the DE by 62 kcal/kg and NE by 115 kcal/kg.

Key Words: DE, dried distillers grains with solubles, NE