

diets is economically important for pork producers. To explore biological limits for young pigs to ingest high-fiber feedstuffs, effects of increasing inclusion of sugar beet pulp (SBP) by substituting wheat grain on diet nutrient digestibility and growth performance of young pigs were evaluated. In total, 220 pigs (initial BW = 7.5 kg) starting 1 wk after weaning at 19 d of age were fed Phase 1 diets for 2 wk (d 1 to 14) and, sequentially, Phase 2 diets for 3 wk (d 15 to 35). Five pelleted wheat-based diets including 0, 6, 12, 18, and 24% SBP in substitution of wheat were fed. The SBP contained (as-fed) 10.0% CP, 27.1% ADF, and 40.9% NDF. Phase 1 and 2 diets were formulated to provide 2.29 and 2.24 Mcal NE/kg, and 5.26 and 5.12 g standardized ileal digestible (SID) Lys/Mcal NE, respectively. Diets were balanced for NE by increasing canola oil from 0.5 to 5% for Phase 1 and 2 diets, and for AA by increasing crystalline AA. Increasing inclusion of SBP up to 24% linearly reduced ($P < 0.001$) apparent total tract digestibility (ATTD) of GE by 4.4 percentage units and of CP by 7.7 percentage units in Phase 1 diets, and linearly decreased the ATTD of GE by 1.3 percentage units ($P < 0.001$) and of CP by 6.0 percentage units ($P < 0.001$) in Phase 2 diets. Increasing inclusion of SBP up to 24% linearly reduced ($P < 0.001$) calculated diet NE values by 0.12 Mcal/kg in Phase 1, and quadratically increased ($P < 0.0001$) calculated diet NE values by 0.02 Mcal/kg in Phase 2. Increasing inclusion of SBP tended to reduce ($P < 0.06$) ADFI for d 1 to 7 and linearly reduced ADFI ($P < 0.05$) for d 8 to 14 and 22 to 28. The ADG for d 15 to 35 was linearly decreased ($P < 0.01$) from 711 to 647 g/d. The G:F was linearly increased ($P < 0.01$) for d 1 to 7, but was quadratically reduced ($P < 0.05$) for d 15 to 28. Overall (d 1 to 35), increasing dietary inclusion of SBP linearly reduced ($P < 0.01$) ADFI by 50.7 g/d and ADG by 46.1 g/d, and quadratically reduced ($P = 0.02$) G:F by 0.03. Increasing inclusion of SBP up to 24% linearly reduced ($P < 0.001$) final BW at d 35 by 1.6 kg. In conclusion, young pigs had difficulty to digest SBP and pigs fed increasing inclusion of SBP had a reduced growth performance.

Key Words: growth performance, pig, sugar beet pulp

139 Use of spectroscopy to predict nutrient digestibility in pigs and to identify in vitro digestion limits.

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Co-products are increasingly used as alternative feedstuffs for pigs, but their quality varies widely. Rapid evaluation of apparent total tract digestibility (ATTD) of energy of co-products using, for example, near-infrared spectroscopy (NIRS) is thus important; however, digestibility data are required for its calibration. In vitro digestion (IVD) models may predict ATTD of

energy, but have not been tested rigorously for co-products. In Exp. 1, we predicted ATTD of energy of canola meal, corn dried distillers grain with solubles (DDGS), soybean meal, and wheat millrun using an IVD model and chemical analyses. Unlike for cereal grains ($R^2 > 0.90$), the IVD model predicted variation in ATTD of energy among co-products not accurately ($R^2 = 0.69$) while chemical analyses had greater accuracy. The IVD model underestimated ATTD of energy in corn DDGS and wheat millrun, poorly described variation of ATTD of energy within the other co-products, and must be improved. The small quantity of IVD residues restricts using chemical analyses or NIRS to identify IVD limits. Mid-infrared spectroscopy can obtain accurate scans of 200-mg IVD residues, but has not been calibrated for ATTD of energy. In Exp. 2, a novel approach of using functional group digestibility (FGD) predicted apparent ileal digestibility (AID) of CP of wheat accurately ($R^2 = 0.99$). Absorbance in the amide I region (1,689 to 1,631 cm^{-1}) of mid-infrared spectra and ratio of inorganic indigestible marker in diet and digesta was used. In Exp. 3, the FGD predicted fat digestibility. The AID of total fatty acids ($R^2 = 0.75$) and ATTD of ether extract ($R^2 = 0.90$) of flaxseed and field pea were estimated with FGD at 2,923 cm^{-1} and 1,766 to 1,695 cm^{-1} of mid-infrared spectra, respectively. Using spectroscopic methods, evidence of poor enzymatic digestion of fat and fiber for co-products in IVD models was identified. Our findings will assist further development of IVD models to predict ATTD of energy of co-products.

Key Words: energy digestibility, in vitro, spectroscopy

140 Formation of fines during the pelleted feed manufacturing process and the resulting differences in nutrient composition of fines and pellets.

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A 3-wk study was conducted at a commercial feed mill to determine where the formation of fines occurred during pelleted feed manufacturing and if differences in nutrient composition exist between fines and pellets. During the study, 1,781 pelleted feed samples representing 4,203 metric tonnes were collected from 4 swine and 2 turkey diet formulations. Progression of fines formation during the manufacturing process was determined by collecting samples immediately after the pellet mill, pellet cooler, fat coater, and at load-out. Samples were taken on 7 to 10 different runs of feed for each diet. Pellet durability index (PDI) and percentage fines were determined for all samples, and nutrient analysis was determined on a pooled sample from each run within diet. Overall, PDI was different ($P < 0.05$; SEM = 0.82) between mill sampling locations. Pellet durability index was similar between the pellet mill (77.0%) and pellet cooler exit (78.3%). From the pellet cooler exit, PDI increased ($P < 0.05$) to the fat coater exit

Table 140.

Item, % ¹	Fines	Pellets	SEM	<i>P</i> <
DM	88.83	88.32	0.16	0.031
CP	13.58	15.24	0.48	0.021
ADF	4.09	3.59	0.20	0.087
Ca	0.74	0.74	0.07	0.975
P	0.50	0.53	0.02	0.354
Fat	9.00	7.71	0.42	0.039

¹Values represent the mean of 32 samples.

(84.6%) but then decreased between the fat coater exit and load-out (84.6 vs. 81.9%). The largest increase in PDI was observed between the pellet cooler exit and fat coater exit (78.3 vs. 84.6%). Percentage fines decreased ($P < 0.05$; SEM = 0.76) from the pellet mill to cooler exit (9.44 vs. 8.54%), but then increased ($P < 0.05$; SEM = 0.77) after the fat coater and from the fat coater to load-out (14.20 vs. 20.46%). The largest increase in fines was observed between pellet cooler and fat coater exits and between the fat coater exit and load out (5.6 and 6.5%). For nutrient composition, DM and fat were greater ($P < 0.05$) and ADF tended to be greater ($P < 0.08$) in fines than in pellets. However, CP was lower ($P < 0.05$) in fines than in pellets. In conclusion, fines increased from the pellet mill to load-out and PDI improved from the pellet mill to the fat coater but then was poorer at load-out. Fines were higher in fiber and fat, but lower in CP when compared with pellets.

Key Words: feed mill, fines, pellet durability index, pellets

- 141 Impact of particle size and grinding method (roller or hammermill) on apparent total tract digestibility of energy in growing pigs.** J. A. Acosta Camargo^{1,*}, S. A. Gould¹, C. K. Jones², C. R. Stark², J. F. Patience¹, ¹Iowa State University, Ames, ²Kansas State University, Manhattan.

The objective of this study was to determine the impact of mean particle size (PS) of corn and wheat with 2 different grinding technologies on the apparent total tract digestibility (ATTD) of GE in growing pigs (GP) and in finishing pigs (FP). Ninety-six growing barrows (BW = 54.6 ± 0.4 kg) and 96 finishing barrows (BW = 110.2 ± 0.8; PIC 337 sires × C22 or C29), providing 8 observations per dietary treatment, were housed in individual pens and randomly assigned to 1 of 12 treatments. Corn and wheat were ground to 3 different PS (300, 500, and 700 microns), using either a roller mill (RM) or a hammermill (HM). Fecal samples were collected for the last 3 d of an 11 d feeding period. Titanium dioxide was used as an indigestible marker. Data were analyzed using the MIXED procedure of SAS. Particle size interacted with growth stage ($P < 0.01$); ATTD of GE increased in GP by lowering PS (81.4, 84.7, and 85.6% for 700, 500, and 300 microns respectively; $P < 0.05$); in FP, ATTD of GE increased from 700 to 500 microns ($P < 0.05$) and remained constant at 300 microns (83.65, 86.50, and 86.20% respectively). Particle size interact-

Table 142.

Item	Mash	45 s Pellet	90 s Pellet	Extruded	SEM	<i>P</i> =
ADG, kg	0.95	0.99	1.01	0.98	0.012	<0.001
ADFI, kg	2.78	2.73	2.78	2.68	0.038	0.140
G:F	0.341	0.362	0.363	0.368	0.003	<0.001
HCW, kg	91.5	95.1	95.5	94.9	1.20	0.046
Yield, %	72.1	72.7	72.4	72.6	0.19	0.092
Backfat, mm	20.5	19.7	20.9	20.6	0.56	0.524
Loin depth, mm	60.9	62.7	62.5	62.7	0.83	0.353
Jowl iodine value	75.7	77.0	77.1	77.5	0.40	0.008

ed with ingredient ($P < 0.01$); ATTD of GE improved in pigs fed corn by lowering PS (81.55, 84.44, and 85.94% for 700, 500, and 300 microns, respectively); in pigs fed wheat, ATTD of GE increased from 700 to 500 microns, but was similar at 300 microns (83.49, 86.75, and 85.87%, respectively). Particle size interacted with grinding technique ($P < 0.01$); ATTD of GE increased by lowering PS with RM (82.42, 85.40, and 86.68% for 700, 500, and 300 microns, respectively; $P < 0.05$); for HM, ATTD of GE increased ($P < 0.05$) from 700 to 500 microns but was similar ($P > 0.05$) at 300 microns (82.62, 85.79, and 85.14%, respectively). In conclusion, lowering PS improved ATTD of GE. This improvement was accentuated more in growing pigs than finishing pigs, in corn more than in wheat and when using the RM than the HM.

Key Words: hammermill, particle size, roller mill

- 142 Using extreme thermal processing to improve nutrient utilization of diets for finishing pigs.** G. E. Bokelman^{1,*}, K. F. Coble², C. R. Stark¹, J. C. Woodworth¹, M. D. Tokach¹, S. Alavi¹, C. K. Jones¹, ¹Kansas State University, Manhattan, ²New Fashion Pork, Jackson, MN.

A total of 270 pigs (PIC 337 × 1050; initially 52.2 kg BW) were utilized in a 79-d experiment to determine the effects of feed processing methods (long-term conditioning or extrusion) on finishing pig growth performance and carcass characteristics. There were 7 or 8 pigs per pen and 9 pens per treatment. Treatments included 1) negative control: nonprocessed mash, 2) positive control: pelleted with 45 s conditioner retention time, 3) pelleted with 95 s conditioner retention time, and 4) extruded. Diets were fed in 3 phases with the same low energy formulation across treatments containing 30% corn dried distillers grains with solubles and 19% wheat middlings. Thermal processing, regardless of length or type, affected ADG and G:F ($P < 0.05$), but not ADFI ($P > 0.10$). Extruded diets tended to improve G:F compared with pelleted diets ($P < 0.10$). Interestingly, HCW was greater when pigs were fed pelleted diets compared with extruded diets, regardless of conditioning time ($P < 0.05$). However, pigs fed any thermally-processed treatment had greater HCW compared with those fed the negative control mash ($P < 0.05$). Thermal processing did not influence percentage yield, backfat, or loin depth when HCW was used as a covariate ($P > 0.10$).