

0.72 kg/d greater ADFI and 6.70 kg less BW loss than parity 2 control sows ($P < 0.022$). Betaine-supplemented sows had greater ADFI in the 6- to 11-d, 12- to 16-d, and 17- to 21-d periods ($P < 0.019$). Wean-to-estrus intervals (WEI) were 0.31 d shorter ($P = 0.004$) and had different distribution ($P = 0.029$) for betaine-supplemented sows than for control sows. Greater percentages, 3.2 and 12.1% of betaine-supplemented sows, returned to estrus on d 3 and 4, respectively, than control sows. In another lactation trial, sows supplemented with 0.21% dietary betaine had 0.51 mm greater follicle diameter ($P = 0.043$) and 0.23°C lower rectal temperature ($P = 0.048$) than control sows. The second objective was to develop a cooling pad that efficiently removes excess of heat from lactating sows. Cooling pads were built with an aluminum plate surface, high-density polyethylene base, and copper pipes. Respiration rates and rectal, vaginal, and skin temperatures for 8 replicates of 10 sows were evaluated after 100 min of cooling with different constant cool water flows of 0.00 (4 sows), 0.25 (2 sows), 0.55 (2 sows), or 0.85 L/min (2 sows). The cooling was initiated 1 h after the room reached 35°C. Mean room temperature and relative humidity during the trial were 35.1 ± 0.4°C and 68.4 ± 3.2%, respectively. The 0.55 and 0.85 L/min treatments reduced respiration rates and rectal, vaginal, and skin temperatures after 80 min of cooling ($P < 0.001$). Respiration rates decreased within 20 to 40 min for sows on the 0.85 L/min treatment ($P < 0.001$). Overall, heat removal during the trial was 193, 321, and 365 W for the 0.25, 0.55, and 0.85 L/min treatments, respectively ($P < 0.001$). Betaine supplementation can alleviate some of the heat stress effects in lactating sows. Cooling pads have a greater potential than betaine to reduce heat stress in lactating sows. Initial data indicate that pulsing of cooled water results in more efficient heat transfer per liter of water.

Key Words: heat stress, lactation, sow
doi:10.2527/asasmw.2017.243

244 Validation of the extended matrix values for energy and amino acids of a new novel 6-phytase, Natuphos E, in weaned piglets. D. Torrallardona¹, P. Ader², M. Coelho^{3,*}, ¹IRTA, Monogastric Nutrition, Constanti, Spain, ²BASF SE, Lampertheim, Germany, ³BASF, Humble, TX.

The effect of using extended nutritional values for energy and AA (in addition to P and Ca nutritional values) for a novel 6-phytase (6-Phy; Natuphos E) was evaluated on the performance and bone mineralization of piglets. One hundred forty-four weaned piglets ([Large White × Landrace] × Pietrain; 26 d of age and 7.6 kg BW) were randomly distributed by initial BW into 48 pens (3 piglets per pen) according to a randomized block design with 8 blocks and 6 treatments. The experimental treatments consisted of a positive control diet (PC); a negative control diet with reduced levels of energy, AA, Ca, and P (NC); and the same NC diet supplemented with 250, 500, or 750 FTU/kg of 6-Phy or 500

FTU of a competitor's phytase (COM). Between 0 and 22 d and between 22 and 46 d (PS/ST phases, respectively), PC diets were formulated to provide 14.03/13.82 MJ ME/kg, 12.50/11.50 g SID Lys/kg, and 3.80/3.30 g digP/kg and the NC diets were formulated to provide 13.97/13.76 MJ ME/kg, 12.38/11.40 g SID Lys/kg, and 2.2/1.7 g digP/kg. Performance was measured at 22 and 46 d, and at the end of the trial, 1 piglet per pen was euthanized and the front left hoof was obtained to measure DM and ash contents in os metacarpale III. No statistically significant differences among treatments were observed for performance parameters during the PS phase (see Table 244). In conclusion, performance was maintained for all doses tested, and bone mineralization was not affected with doses of 500 FTU and over, with the use of extended nutritional values for Natuphos E.

Key Words: enzyme matrix, novel 6-phytase, piglets
doi:10.2527/asasmw.2017.244

245 Evaluating the effect of superdosing Natuphos E 5000 G phytase on nursery pig performance.

K. M. Gourley*, J. C. Woodworth, J. M. DeRouchev, M. D. Tokach, S. S. Dritz, R. D. Goodband, *Kansas State University, Manhattan.*

A total of 360 pigs (DNA 200 × 400; initially 5.9 kg) were used in a 42-d growth trial to determine the effect of superdosing a novel phytase source (Natuphos E 5000 G; BASF Corporation, Florham Park, NJ) on nursery pig growth and bone ash. Pigs were randomly allotted to pens at weaning in a randomized complete block design, and pens were allotted to 1 of 8 dietary treatments. There were 5 pigs per pen and 9 pens per treatment. Diets were fed in 3 phases (d 0–7, d 7–21, and d 21–42) with formulated total Ca:P ratios of 1.07, 1.05, and 0.93, respectively. Treatments included a negative control (NC) with 0.40, 0.30, or 0.25% aP from monocalcium P for Phases 1, 2, and 3, respectively, and NC with either 500, 1,000, 2,000, 3,000, or 4,000 FTU/kg phytase. There was also a positive control (PC) with 0.55, 0.45, or 0.40% aP from monocalcium P for Phases 1, 2, and 3 respectively, or PC with 2,000 FTU/kg phytase. On d 42, 1 pig/pen was euthanized and the right fibula was removed for bone ash analysis. From d 0 to 42, pigs fed increasing phytase in NC tended to have increased (quadratic, $P = 0.064$) ADG and (linear, $P = 0.082$) ending BW and had improved (quadratic, $P = 0.008$) G:F. Adding 2,000 FTU/kg phytase to PC did not influence ADG or ADFI but tended to improve ($P = 0.060$) G:F. Additionally, percentage bone ash increased as phytase increased in NC (linear, $P < 0.001$) and PC diets ($P < 0.001$). The NC diet with 500 FTU/kg and PC (no added phytase) were formulated to be equivalent in available Ca and P. When comparing the 2 diets, pigs fed PC had increased ($P = 0.007$) ADFI and tended to have greater ($P = 0.099$) percentage bone ash; however, pigs fed NC + 500 FTU/kg phytase had improved ($P = 0.032$) G:F. In summary,

Table 244. Average daily growth, G:F, and bone ash content and weight

	PC	NC	250 FTU	500 FTU	750 FTU	COM	Root MSE	P-value
ADG 0 to 22, g	261	252	240	287	257	280	52	0.50
GFR 0 to 22	0.70	0.74	0.71	0.75	0.71	0.75	0.11	0.90
ADG 22 to 46, g	514 ^b	445 ^c	522 ^b	531 ^{ab}	573 ^a	581 ^a	49	<0.01
GFR 22 to 46	0.58 ^b	0.57 ^b	0.61 ^{ab}	0.58 ^b	0.62 ^{ab}	0.64 ^a	0.05	0.03
ADG 0 to 46, g	393 ^b	352 ^c	387 ^{bc}	414 ^{ab}	422 ^{ab}	437 ^a	37	<0.01
GFR 0 to 46	0.61	0.61	0.64	0.63	0.65	0.67	0.05	0.11
Bone ash, g	1.74 ^a	1.24 ^c	1.47 ^b	1.69 ^a	1.68 ^a	1.68 ^a	0.19	<0.01
Bone dry wt, g	4.76	4.09	4.46	4.85	4.50	4.82	0.54	0.06

Table 245.

Item	Negative control						Positive control		SEM
	0	500	1,000	2,000	3,000	4,000	0	2,000	
d 0 to 42									
ADG, g	369	380	396	387	395	381	400	398	10.2
ADFI, g	540	529	562	551	559	555	580	561	13.5
G:F, g/kg	684	713	705	702	707	686	689	709	7.8
Bone ash, %	44.2	45.2	47.1	48.0	48.4	49.1	47.0	51.3	0.77

increasing dietary phytase in NC linearly increased percentage bone ash whereas G:F was maximized at 1,000 FTU/kg. Adding phytase to PC with P and Ca formulated at NRC (2012) recommendations tended to improve feed efficiency.

Key Words: nursery pig, phytase, superdose
doi:10.2527/asasmw.2017.245

246 Super dosing effects of corn-expressed phytase on bone characteristics and nutrient digestibility in nursery pigs fed diets sufficient in phosphorus and calcium. J. K. Lee*, H. Chen, I. Park, S. W. Kim, North Carolina State University, Raleigh.

This study was conducted to investigate the super dosing effects of phytase from corn-expressed phytase (CEP; 3,962 FTU/g CEP; Agrivida, Inc., Medford, MA) on metacarpal bone characteristics, apparent ileal digestibility (AID) of nutrients, and gut health of nursery pigs fed corn-soybean meal diets sufficient in P and Ca (0.44 and 0.36% STTD P and 0.83 and 0.74% Ca for Phase 1 and 2, respectively, meeting nutrient requirements suggested by the NRC [2012]). Pigs (16 barrows and 16 gilts at 21 d of age with 6.2 ± 0.7 kg BW) were allotted to 4 dietary treatments ($n = 8$) based on a randomized complete block design with initial BW and sex blocks. Pigs were fed a basal diet supplemented with ground CEP to have phytase activities at 0, 500, 1,500, or 3,000 FTU/kg based on 2 phases (Phase 1: 10 d and Phase 2: 20 d). Analyzed phytase activities were 96, 320, 1,190, and 2,210 FTU/kg in Phase 1 diets and 60, 541, 898, and 2,150 FTU/kg in Phase 2 diets, respectively. Plasma samples (d 25), metacarpal bones (d 30), ileal digesta (d 30), and tissues from the jejunum (d 30) were collected. Characteristics of metacarpal bones were evaluated by determining the composition and strength. Phase 2 diets contained titanium oxide (0.25%) as an indigestible external

marker to calculate AID of nutrients. Numbers of proliferating enterocytes in crypts were counted in the jejunum using immunohistochemistry of Ki-67. Data were analyzed using polynomial contrasts in the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC). Increasing phytase levels increased (linear, $P < 0.05$) fat-free dry weight (2.02 to 2.72 g) and the amounts of P (0.17 to 0.25 g), Ca (0.36 to 0.52 g), and ash (0.15 to 18 g) and tended to increase (quadratic, $P = 0.058$) breaking strength (323 to 401 N at 1,500 FTU/kg) of metacarpal bones. Increasing phytase levels increased AID of CP (linear, $P < 0.05$; 69.1 to 77.4%) and tended to increase AID of ether extract (linear, $P = 0.088$; 54.9 to 65.7%) and AID of Ca (0 vs. others, $P = 0.081$; 66.6 to 72.4%). Increasing phytase levels did not affect the numbers of proliferating enterocytes in crypts of the jejunum. In conclusion, super dosing corn-expressed phytase up to 3,000 FTU/kg enhanced bone characteristics and nutrient digestibility of pigs fed diets with sufficient P and Ca meeting NRC requirements.

Key Words: corn-expressed phytase, digestibility, nursery pigs
doi:10.2527/asasmw.2017.246

247 Effects of feeding corn-expressed phytase on the live performance, bone characteristics, and phosphorus digestibility of nursery pigs. J. N. Broomhead^{1,*}, P. A. Lessard¹, R. M. Raab¹, M. B. Lanahan¹, J. J. Chewning², ¹Agrivida, Medford, MA, ²Swine Research Services, Inc., Springdale, AR.

A 41-d feeding trial was conducted to determine the efficacy of a corn-expressed phytase (CEP; Grainzyme; Agrivida) on the live performance, bone characteristics, and P digestibility of nursery pigs fed a reduced-P diet. Weaned piglets (21 ± 3 d; $n = 360$) were acclimated on a common diet (phase 1) for 7 d before