hydrolysis was conducted using a two-step assay in which pepsin and pancreatin were used to mimic gastric and small intestinal digestion. The amount of total P released by enzymatic digestion was analyzed by the ascorbic acid method. All assays were repeated 6 times. Data of *in vitro* P digestibility were analyzed using the GLM procedure in SAS. A simple linear regression analysis was conducted between *in vitro* P digestibility data and *in vivo* standardized total tract digestibility (STTD) of P, which was calculated based on apparent total tract digestibility in pigs from their respective sources from a previous experiment. Chicken meal had lower ($P < 0.01$) *in vitro* P digestibility (42.98%) compared with chicken by-product meal (62.24%), and there were no differences ($P > 0.10$) between poultry meal (33.52%) and poultry byproduct meal (32.21%). The average *in vitro* P digestibility of 3 sources of meat and bone meal was 33.21 ± 0.24%, and the average of 2 meat meal sources was 35.99 ± 1.56%. Animal protein meals with greater Ca:P tended to have a lower *in vitro* digestibility of P (*in vitro* P digestibility, % = -30.14 × Ca:P + 91.18; $R^2 = 0.89$). There was also a high correlation between *in vitro* P digestibility and *in vivo* STTD of P (STTD of P, % = 1.00 × *in vitro* P digestibility + 1.33; $R^2 = 0.91$). The mathematical model showed that when P digestibility is overestimated by 10% compared to its actual value in an ingredient, pigs fed P deficient diets may have a 30 g less average daily gain than pigs fed diets formulated with more accurate values from the *in vitro* assay. When P digestibility of ingredients is underestimated by 10% compared to its actual value, the cost of the feed may increase by $0.55/pig. These results suggest that the 2-step *in vitro* P digestibility assay can be used to reasonably predict *in vivo* P digestibility of animal protein by-products fed to swine.

Key Words: animal protein by-products, in vitro enzymatic hydrolysis, phosphorus digestibility

222 Effects of increasing chloride from potassium chloride on 7 to 12 kg nursery pig growth performance. D. J. Shawk*,[1], K. N. Nemechek[1], B. D. Goodband[1], J. C. Woodworth[1], M. D. Tokach[1], S. S. Dritz[1], K. Chitakasempornkul[1], N. M. Bello[2], J. M. DeRouchey[1], [1]*Kansas State University, Manhattan, KS,* [2]*Department of Statistics, Kansas State University, Manhattan, KS*

A total of 300 nursery pigs (DNA Line 241 × 600, initially 7 kg) were used in a 14-d trial to determine effects of increasing dietary Cl concentrations on nursery pig growth performance. Pigs were weaned at 21 d of age. Upon entry to the nursery, pigs were grouped in pens of 5 consisting of either a 2:3 or a 3:2 ratio of

	Cl, %						
Item	0.09	0.21	0.32	0.45	0.55	0.78% added salt	SEM
ADG, g[1]	273	348	372	349	356	351	0.676
ADFI, g[2,3]	436	491	507	477	504	469	0.046
G:F[1]	0.628	0.712	0.734	0.733	0.708	0.749	0.069

[1] Cl linear: $P<0.001$; quadratic: $P<0.001$; [2] Cl linear: $P<0.05$; quadratic: $P<0.05$. [3] Added salt diet vs. 0.55% Cl diet: $P<0.05$.

barrows:gilts, and fed a common starter diet (0.33% Na and 0.76% Cl) for 7 d. On d 7 after weaning, considered d 0 in the trial, pens were blocked by BW within each sex ratio and randomly assigned to treatments, with 10 pens/treatment. Experimental treatments consisted of a control diet containing 0.33% Na and 0.55% Cl provided by 0.78% added salt and 5 diets with 0.33% Na and added potassium chloride to provide 0.09, 0.21, 0.32, 0.45, or 0.55% Cl. Dietary K was not held constant across dietary treatments. Growth performance (ADG, ADFI, G:F) was recorded at the pen level and analyzed using linear mixed models that accommodated the split-plot nature of the experimental design and recognized pen as the experimental unit for treatment. Linear and quadratic orthogonal polynomials were evaluated. Additionally, the 0.78% added salt control and 0.55% Cl treatment were compared. From d 0 to 14, ADG, ADFI, and G:F improved (quadratic, $P < 0.05$) as dietary Cl concentration increased from 0.09 to 0.32% with no further benefit observed thereafter. Pigs fed the control diet (0.33% Na and 0.55% Cl from added salt) showed no evidence for a difference in ADG, lower ($P < 0.05$) ADFI and marginally increased ($P = 0.069$) G:F than those fed 0.55% Cl from KCl. In conclusion, the greatest growth performance was achieved with a dietary Cl concentration of 0.32% in pigs from 7 to 12 kg.

Key Words: salt, chloride, nursery pig

223 Impact of Added Copper and Chlortetracycline on Growth Performance of Nursery Pigs. M. B. Menegat*, J. C. Woodworth, S. S. Dritz, R. G. Amachawadi, T. G. Nagaraja, K. Capps, M. D. Tokach, J. M. DeRouchey, R. D. Goodband, *Kansas State University, Manhattan, KS*

A study was conducted to determine the impact of Cu and chlortetracycline (CTC), fed alone or in combination, on prevalence and quantification of Cu-associated antimicrobial resistance in fecal enterococci of weaned piglets. Only the effects on growth performance are reported herein. A total of 320 nursery pigs (DNA 200 × 400, initially 7.4 ± 0.06 kg) were used in a 28-d trial. A common non-medicated diet was

	Cu, ppm			CTC, ppm			
	0	200	P<	0	440	P<	SEM
d 0 to 14							
ADG, g	271	294	0.025	262	303	0.001	7.9
ADFI, g	362	388	0.011	360	390	0.004	7.0
G:F	0.750	0.756	0.546	0.728	0.778	0.001	0.009
d 14 to 28							
ADG, g	596	600	0.693	574	622	0.001	7.6
ADFI, g	884	895	0.386	857	922	0.001	11.8
G:F	0.674	0.671	0.518	0.671	0.675	0.486	0.004

fed for 7 d after weaning. Pens were allotted to dietary treatments based on BW and location in a randomized complete block design with 5 pigs per pen and 8 replications per treatment (each replication as a pair of adjoining pens). Treatments were a 2 × 2 factorial with added Cu (0 vs. 200 ppm Cu sulfate) and CTC (0 vs. 440 ppm). Data were analyzed using a linear mixed model (PROC GLIMMIX, SAS®). There was no evidence for interactive effects of Cu and CTC on growth performance. From d 0-14, added Cu increased ($P<0.05$) ADG and ADFI and added CTC improved ($P<0.01$) ADG, ADFI, and G:F. From d 14-28, addition of CTC to the diet improved ($P<0.01$) ADG and ADFI, but there was no evidence for Cu effect. Overall, d 0-28, pigs fed diets with CTC had improved ($P<0.05$) ADG, ADFI, and G:F, but there was no evidence for Cu effect. The inclusion of Cu or CTC increased ($P<0.05$) BW on d 14 (11.2 vs. 11.5 kg, for Cu; 11.1 vs. 11.6 kg, for CTC) and d 28 (19.5 vs. 20.0 kg, for Cu; 19.2 vs. 20.3 kg, for CTC). In conclusion, these findings characterize a beneficial effect of feeding Cu for 14 d on growth performance of young pigs (7-12 kg BW) and a growth promoting effect of therapeutic levels of CTC in nursery diets. The lack of interactive effects between Cu and CTC suggests the responses on growth performance of nursery pigs are similar when fed alone or in combination.

Key Words: chlortetracycline, weanling pig, copper

224 Evaluation of Elarom SES with or without Tribasic Copper Chloride on Nursery Pig Growth Performance. H. E. Williams*, J. C. Woodworth, J. M. DeRouchey, S. S. Dritz, M. D. Tokach, R. D. Goodband, *Kansas State University, Manhattan, KS*

Weanling pigs (n=360, initially 6.0 ± 0.13 kg BW) were used in a 42-d study evaluating the effects of feeding Elarom SES in combination with increasing tribasic copper chloride on growth performance and fecal consistency. Elarom SES (Trouw Nutrition USA, Highland, IL) is a proprietary blend of functional ingredients designed to enhance growth performance and gut health. Tribasic copper chloride (TBCC, Intellibond C, Micronutrients USA, LLC., Indianapolis, IN) is a form of Cu that has the potential for improved bioavailability and enhanced growth performance. Pigs were weaned at approximately 21 d and allotted to pens based on initial BW in a completely randomized block design with 5 pigs per pen and 12 replications per treatment. Experimental diets were fed in 3 phases (Phase 1, d 0 to 7; Phase 2, d 7 to 21; and Phase 3, d 21 to 42 post-weaning) in meal form. Treatments were arranged as a 2 × 3 factorial with main effects of Elarom SES (none vs. 0.2% in all phases) and TBCC (none, 108, or 183 ppm of Cu in Phase 3 only). Pen fecal consistency score was determined on d 0, 4, 7, 14, 21, 28, 35, and 42 on a scale from 1 to 5. A score of 1 indicated hard, pellet type feces and a score of 5 indicated watery, liquid feces. All diets contained 17 mg/kg of Cu from the trace mineral premix. Overall, there was no evidence for treatment differences observed for ADG, ADFI, or fecal consistency; however, a marginal effect for an Elarom SES×TBCC interaction was observed for G:F (quadratic, P=0.058). This was the result of G:F improving at the intermediate level of TBCC without Elarom SES, yet G:F was improved at the highest level of TBCC when Elarom SES was present. Overall, no consistent benefit was observed from feeding Elarom SES or different levels of TBCC on growth performance or fecal consistency of weaned pigs.

	-Elarom SES			+Elarom SES			
	TBCC, ppm			TBCC, ppm			
	0	108	183	0	108	183	SEM
d 0 to 21							
ADG, g	241	262	256	245	253	248	12.26
G:F	0.773	0.810	0.793	0.799	0.780	0.802	0.015
d 21 to 42							
ADG, g	610	621	612	604	631	638	13.29
G:F	0.667	0.67	0.655	0.667	0.673	0.680	0.008
d 0 to 42							
ADG, g	425	441	433	424	440	443	10.69
G:F[a]	0.694	0.706	0.691	0.700	0.701	0.710	0.006

[a]Elarom SES×TBCC (quadratic; $P=0.058$)

Key Words: feed additive, growth performance, nursery

225 Effects of Zinc Oxide, Zinc Hydroxychloride, and Tribasic Copper Chloride on Nursery Pig Performance. H. S. Cemin*[,1], J. C. Woodworth[1], M. D. Tokach[1], S. S. Dritz[1], J. M. DeRouchey[1], R. D. Goodband[1], J. L. Usry[2], [1]*Kansas State*