



**SOUTH DAKOTA  
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*Department of Animal Science | SDSU Extension*

# **Animal Science Research and Extension Report - Swine 2026**



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## Statistics in the South Dakota State University Animal Science Report

The purpose of research at SDSU is to provide reference information that represents the various populations of livestock production. Since the researcher cannot apply treatments to every member of a population, he/she must sample the population. The use of statistics allows the researcher and readers the opportunity to evaluate separation of random occurrences and real biological effects of a treatment. The following is a brief description of the major statistics used in these proceedings.

- **Mean:** Data for individual experimental units (cows, pens of cattle, steers, steaks) exposed to the same treatment are generally averaged and reported in the text, tables, and figures. The statistical term representing the average of a group of data points is mean.
- **Variability:** The inconsistency among the individual experimental units used to calculate a mean for the item measured is the variance. For example, if the ADG for all the steers used to calculate the mean for a treatment is 3.5 lb then the variance is zero. However, if ADG for individual steers is used to calculate the mean for a treatment range from 1.0 lb to 5.0 lb, then the variance is large. The variance may be reported as standard deviation (square root of the variance) or as standard error of the mean. The standard error is the standard deviation of the mean as if we had done repeated samplings of data to calculate multiple means for a given treatment. In most cases, treatment means and their measure of variability will be expressed as follows:  $3.50 \pm 0.150$ . This would be a mean of 3.5 followed by the standard error of the mean of 0.150. A helpful step combining both the mean and the variability from an experiment to conclude whether the treatment results in a real biological effect is to calculate a 95% confidence interval. This interval would be twice the standard error added to and subtracted from the mean. In the example above, this interval is 3.20 to 3.80 lb. If in an experiment, these intervals calculated for treatments of interest overlap, the experiment does not provide satisfactory evidence to conclude that treatments effects are different.
- **P-value:** Probability (*P*-value) refers to the likelihood the observed differences among treatment means are due to chance. For example, if the author reports  $P \leq 0.05$  as the significance level for a test of the differences between treatments as they affect ADG, the reader may conclude there is less than a 5% chance the differences observed between the means are a random occurrence (or 95% sure that the difference was not due to random chance). Due to this small probability of chance, there must be a difference between the treatments in their effect on ADG. Authors may discuss tendencies in data when *P* values are between 0.06 and 0.15, because they are not confident the differences among treatment means are real treatment effects. With *P*-values of 0.06 and 0.15 the chance random sampling caused the observed differences is 1 in 16.7 and 1 in 6.7, respectively.
- **Linear & Quadratic Contrasts:** Some articles contain linear (L) and quadratic (Q) responses to treatments. These parameters are used when the research involves increasing amounts of a factor as treatments. Examples are increasing amounts of a ration ingredient (corn, by-product, or feed additive) or increasing amounts of a nutrient (protein, calcium, or vitamin E). The L and Q contrasts provide information regarding the shape of the response. Linear indicates a straight-line response and quadratic indicates a curved response. *P*-values for these contrasts have the same interpretation as described above.
- **Correlation (r):** Correlation indicates amount of linear relationship of two measurements. The correlation coefficient can range from -1 to 1. Values near zero indicate a weak relationship, values near 1 indicate a strong positive relationship, and a value of -1 indicates a strong negative relationship.

- **Chi square ( $\chi^2$ ):** A statistical test used to compare observed results with expected results. The purpose of this test is to determine if a difference between observed data and expected data is due to chance, or if it is due to a relationship between the variables being studied. This is a nonparametric test used for data that do not follow the assumption of a normal distribution. The null hypothesis is that there are no differences between the variables. A  $\chi^2 \leq 0.05$  is considered statistically significant, thus, the null hypothesis should be rejected in favor of the alternative hypothesis.

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# Animal Science Research Report 2026

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## An integrated analysis to investigate the effects of dietary isoacids supplementation on digestibility, fermentation products, microbiome, and gut pH of ileal-cannulated pigs

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### Rationale and Approach

Isoacids supplementation in pig diets enhanced amino acid (AA) and fiber digestibility, particularly at the ileal level, potentially via microbiome modulation. The objective was to investigate the effects of dietary isoacids supplementation on ileal AA digestibility, fermentation products, microbiome, and gut pH of ileal-cannulated pigs, using an integrated data analysis approach of two studies. In study 1, pigs were fed normal protein low-fiber diets with or without isoacids (0.0 vs. 0.5–1.5%). In study 2, diets with or without 1% isoacids varied in protein and fiber content. Apparent ileal (AID) and total tract digestibility (ATTD) were assessed in both studies, while microbiota and gut pH were analyzed in study 2. Data from both studies were combined and analyzed using multivariate methods to identify how digestibility, fermentation products, and the gut microbiome interact, providing insights of the pathways through isoacids influence digestion across different dietary conditions.

### Results and Discussion

Isoacids primarily improved AID of isoleucine (9.2%) and leucine (7.4%) and increased fecal ammonia concentration (56%), but reduced AID of total dispensable AA (3.2%;  $P < 0.05$ ; Table 1). Isoacids also improved ATTD of total dispensable (8.6%) and indispensable AA (9.5%;  $P < 0.05$ ). Integration analysis revealed that ileal isobutyric, caproic, and isovaleric acids, and fecal valeric, isovaleric, acetic, and butyric acids were modulated by isoacids. A candidate strain, *Romboutsia timonensis*, was identified as a potential modulator of the gut responses. Integrated multivariate analysis revealed that Gross energy, dry matter, organic matter, ammonia, acetate, and *Peptostreptococcaceae* at the ileal level upregulated by isoacids, as well as Met + Cys, Leucine, and Tyrosine were downregulated ( $P < 0.05$ ; Table 2). These relationships suggest enhanced microbial activity and fermentation efficiency in pigs receiving isoacids. As responses were more pronounced in pigs fed normal-protein diets, indicate that sufficient dietary nitrogen may be required for isoacids to stimulate cellulolytic bacteria and protein-utilizing microbes effectively.

### Implications

These findings highlight isoacids as a strategy to improve feed efficiency and nutrient utilization, particularly in fiber-rich diets maintaining adequate protein levels, with important implications in pig's growth performance and farmer's profit.



## Acknowledgements

The authors thank Zinpro Corporation for their contributions and financial support of this study.

**Table 1.** Apparent ileal digestibility (%) of nutrients and amino acids at different levels of isoacid level in growing pig diet (Study 1).

	Dietary Isoacids Level, %						SEM
	0	0.5	0.75	1	1.25	1.5	
CP	79.7	80.7	82.3	81.8	79.7	80.5	0.69
Arg	81.1	80.9	82.8	85.0	82.1	81.4	1.06
His	76.2	76.3	78.2	80.7	77.3	78.5	1.16
Ile <sup>1</sup>	68.9	71.3	72.8	75.3	72.3	72.6	1.41
Leu <sup>1</sup>	71.4	73.6	74.8	76.8	75.6	75.4	1.28
Lys	68.7	70.7	70.8	75.1	72.0	71.6	1.55
Met	75.9	78.6	78.2	80.2	78.7	79.2	1.27
Met + Cys	68.0	70.2	67.9	72.3	70.1	70.7	1.44
Phe <sup>1</sup>	70.7	72.6	73.9	76.2	74.3	73.9	1.30
Thr <sup>1</sup>	56.3	58.9	61.1	66.3	60.9	60.4	1.55
Trp	71.7	72.3	71.5	74.5	72.2	72.2	1.45
Val	66.6	68.9	68.7	71.5	68.2	69.4	1.43

<sup>1</sup>Linear effect of isoacid level  $P < 0.05$ .

**Table 2.** Fecal bacterial taxon (closest known) that were influenced by isoacid level in normal or low protein diets fed to growing pigs (Study 2).

Diet Crude Protein Diet fiber (NDF, %)	20%		15%		P-value
	11	16	11	16	
<i>Terrisporobacter mayombe</i> (97.32%)	4.80 <sup>bc</sup>	2.44 <sup>c</sup>	16.46 <sup>a</sup>	7.13 <sup>b</sup>	0.001
<i>C. saccharoperbutylacetonicum</i> (97.00%)	13.81 <sup>ab</sup>	5.69 <sup>c</sup>	14.68 <sup>a</sup>	7.44 <sup>bc</sup>	0.001
<i>Lactobacillus amylovorus</i> (99.64%)	5.93 <sup>ab</sup>	12.39 <sup>a</sup>	4.28 <sup>b</sup>	9.10 <sup>ab</sup>	0.041
<i>Lignipirellula cremea</i> (81.30%)	6.06	3.38	4.74	3.76	0.054
<i>Christensenella massiliensis</i> (85.69%)	0.79	0.69	0.94	1.08	0.054
<i>Culicoidibacter larvae</i> (81.79%)	0.08 <sup>ab</sup>	0.17 <sup>ab</sup>	0.04 <sup>b</sup>	0.35 <sup>a</sup>	0.019
<i>Maliibacterium massiliense</i> (84.27%)	3.02	0.96	1.61	1.34	0.076
<i>Romboutsia timonensis</i> (98.36%)	2.32 <sup>bc</sup>	1.82 <sup>c</sup>	4.60 <sup>a</sup>	3.61 <sup>b</sup>	0.001
<i>Clostridium baratii</i> (96.80%)	0.09 <sup>ab</sup>	0.02 <sup>bc</sup>	0.01 <sup>c</sup>	0.01 <sup>c</sup>	0.001
<i>Mediterranea massiliensis</i> (89.98%)	0.11 <sup>c</sup>	0.11 <sup>c</sup>	1.27 <sup>a</sup>	0.23 <sup>bc</sup>	0.001
<i>Duncaniella muris</i> (86.34%)	0.92 <sup>ab</sup>	1.11 <sup>a</sup>	0.08 <sup>c</sup>	0.48 <sup>bc</sup>	0.014
<i>Clostridium jeddahitimonense</i> (99.00%)	0.36 <sup>bc</sup>	0.17 <sup>bc</sup>	0.54 <sup>b</sup>	0.92 <sup>a</sup>	0.001
<i>Holdemanella porci</i> (99.81%)	0.12 <sup>ab</sup>	0.46 <sup>a</sup>	0.06 <sup>c</sup>	0.16 <sup>ab</sup>	0.050

<sup>abc</sup>Within a row, values with different superscripts differ at  $P < 0.05$ .

# Animal Science Research Report

## 2026

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### Using a screening tool is effective in choosing costly nursery ingredients

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#### Rationale and Approach

Identifying effective nutritional strategies that promote early feed intake and support post-weaning adaptation remains a key priority for the swine industry. Nursery diets often contain a wide range of specialty proteins, carbohydrate sources, and mineral additives intended to improve feed intake and promote growth; however, the relative efficacy of these ingredients when combined in complex diets is not well established. A Plackett–Burman experimental design provides an efficient approach to screen multiple dietary factors simultaneously. Therefore, this study utilized a Plackett–Burman design to evaluate the effects of various nursery diet ingredients and housing environments on growth and adaptation of pigs during the first week of post-weaning. A total of 312 weaned pigs from 24 litters (weaning age:  $19 \pm 2$  d; initial BW:  $5.8 \pm 1.5$  kg) were used. Twelve litters remained in farrowing stalls (STALLS) and twelve were moved to nursery pens (PENS). Pigs were weaned by litter and assigned to treatment by litter weight to 1 of 12 dietary treatments arranged in a Plackett–Burman design, where each diet contained a combination of ingredients at high (present) or low (absent) levels (Table 1). Factors tested were; fermented soybean meal (FS, HP300), whey, whey permeate, fishmeal, spray-dried animal plasma (SDAP), steam-rolled oats, dextrose, cornstarch, zinc oxide, copper chloride, soybean oil, and reduced dietary acid-binding capacity. Diets met or exceeded NRC (2012) requirement estimates. Individual pig body weights were recorded on days 0, 4 and 7 post-weaning to calculate ADG.

#### Results and Discussion

Pigs fed diets containing SDAP had greater ADG than those without SDAP from day 0 to 4 (122.8 vs. 56.5 g/d;  $P = 0.01$ ), day 4 to 7 (17.5 vs. -42.4 g/d;  $P = 0.01$ ), and overall from day 0 to 7 (77.7 vs. 14.1 g/d;  $P < 0.01$ ). From day 4 to 7, addition of whey tended to increase ADG (26.2 vs. -40.4 g/d;  $P = 0.10$ ), whereas FS and whey permeate addition reduced ADG over the same period (-33.7 vs. 33.7 g/d,  $P = 0.02$ ; -29.3 vs. -3.4 g/d, respectively). Housing also affected growth, with pigs in STALLS showing higher ADG from day 4 to 7 (8.5 vs. -33.3 g/d) and a numeric tendency for greater overall ADG from day 0 to 7 (58.9 vs. 33.0 g/d) than pigs in PENS.

#### Implications

Addition of spray-dried animal plasma to diets improves early post-weaning growth, likely by supporting gut health and immune function. Weaning pigs in their farrowing stalls also enhances growth, likely by reducing stress and promoting early eating behavior. The experimental design is an effective method to assess numerous ingredient options or management options in promoting early weaned pig feed intake.



## Acknowledgements

The authors thank the SDSU swine group for their contributions and support for this study.

## References

NRC. 2012. Nutrient requirements of swine: 11<sup>th</sup> ed. National Academies Press, Washington, DC.

**Table 1.** Plackett-Burman design matrix for dietary ingredients contribution to growth performance one-week post-weaning.

Trt <sup>1</sup>	A	B	C	D	E	F	G	H	I	J	K	L
1	1 <sup>2</sup>	1	-1 <sup>2</sup>	-1	-1	-1	-1	-1	1	1	1	-1
2	-1	1	1	-1	1	-1	-1	-1	-1	-1	1	1
3	-1	1	-1	1	-1	-1	-1	-1	1	1	-1	-1
4	1	1	1	-1	-1	-1	-1	-1	-1	-1	1	1
5	-1	-1	1	1	-1	-1	1	-1	-1	1	-1	-1
6	-1	-1	1	1	1	-1	1	-1	1	1	1	1
7	1	-1	-1	1	-1	-1	-1	-1	1	-1	-1	-1
8	1	-1	1	-1	-1	-1	-1	-1	-1	1	1	-1
9	1	-1	-1	1	-1	1	1	-1	1	-1	1	-1
10	1	-1	1	-1	1	-1	1	-1	1	1	-1	1
11	1	-1	-1	-1	-1	-1	1	1	1	1	-1	-1
12	1	-1	1	1	-1	1	-1	-1	1	-1	-1	1

<sup>1</sup>A, Fermented soybean meal; B, Whey permeate; C, Fishmeal; D, Spray-dried animal plasma; E, Steam-rolled oats; F, Dextrose; G, Dairy Lactose; H, Cornstarch; I, Zinc oxide; J, Copper Chloride; K, Soybean Oil; L, Calcium carbonate

<sup>2</sup>1 indicates inclusion in the respective treatment diet, while -1 indicates absence from the respective treatment diet.

# Animal Science Research Report

## 2026

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### Effects of corn DDGS contaminated with varying levels of deoxynivalenol (DON) on growth performance and health of nursery pigs

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#### Rationale and Approach

Corn dried distillers grains with solubles (DDGS) are widely used in swine diets as an economical protein and energy source. However, DDGS are susceptible to *Fusarium* contamination, particularly with deoxynivalenol (DON), a mycotoxin that depresses feed intake and growth in pigs. Current regulations state pigs can reasonably tolerate 1 ppm DON in the diet with minimal impact on intake, but this value is more than 20 years old. This study evaluated the effects of corn DDGS contaminated with DON levels up to 3-fold higher than current regulations on the growth performance and health of nursery pigs. A total of 542 weaned pigs (14–19 pigs per pen, initial BW  $14.7 \pm 0.4$  lb) were allocated to 32 pens and assigned to one of four dietary treatments for 28 days: control (CON; 0.2 ppm DON), DON-Low (1.4 ppm), DON-Mid (2.1 ppm), and DON-High (2.7 ppm). All diets contained 20% DDGS and were formulated to meet or exceed NRC (2012) nutrient requirements based on expected growth. Growth performance was measured by body weight (BW), average daily gain (ADG), average daily feed intake (ADFI), and feed-to-gain ratio (F:G) on study days 3, 6, 14, 21, and 28. Vomit incidence and fecal scores were recorded daily for 7 days, and DON levels were confirmed in diet samples. Data were analyzed for linear and quadratic effects within day; diarrhea was tested using a nonparametric method.

#### Results and Discussion

There were linear ( $P < 0.01$ ) and quadratic ( $P < 0.01$ ) effects of DON level where average daily gain and feed intake were reduced at all DON levels compared to CON with no difference in F:G. As a result, CON pigs were 6.5 lbs heavier on day 28. The linear and quadratic effects ( $P < 0.01$ ) on growth were detected at day 6, 14, 21, and 28 (Figure 1). The lack of differences in performance were observed among the DON groups, indicating that once dietary DON exceeded 1.4 ppm, further increases did not exacerbate performance losses. Incidence of diarrhea was higher ( $\chi^2 < 0.05$ ) in DON-Mid and DON-High pigs. A common response to DON in pigs is vomiting. In this case, the incidence of vomiting was low in DON-fed groups and absent in CON pigs. This indicates that DON contamination of feed, even at levels above 2 ppm, can influence performance without clear visual evidence of contamination.

#### Implications

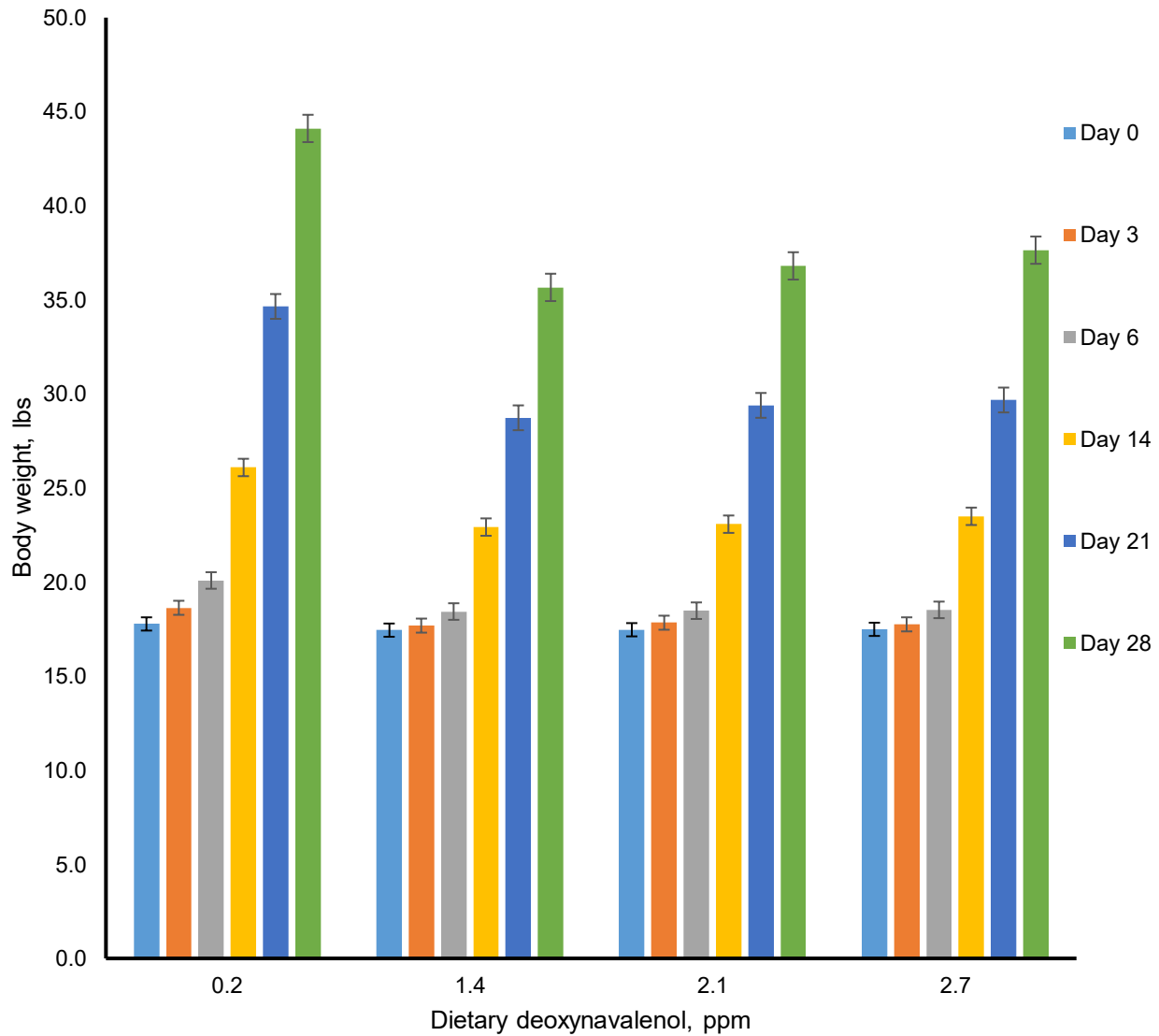
Dietary DON contamination at or above 1.4 ppm significantly reduced growth and feed intake in nursery pigs, with effects evident within 3 days and persisting through the 28-day trial. Higher DON levels did not further impair growth but tended to worsen digestive disturbances. The regulation for the upper limit of dietary DON levels in pigs may need to be re-evaluated.



## Acknowledgements

The Authors thank POET for providing the DDGS.

**Figure 1.** Body weight of pigs fed deoxynivalenol-contaminated feed provided over a period of 28 days starting at 14 lbs.



# Animal Science Research Report

## 2026

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### Effects of yeast carbohydrate (YC) products fed to gestating and lactating sows on sow and suckling pig immunological responses and performance

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#### Rationale and Approach

Supplementation of yeast carbohydrates (YC) derived from lysed yeast cell walls in sow diets has been linked to the modulation of immune responses for both sows and their offspring. The objective of this study was to assess the impact of YC supplementation in sow gestation and lactation diets on the immunological responses and performance of sows as well as suckling piglet performance to weaning. Sixty-three multiparous sows (PIC Camborough 1050; Parity 0 to 5; 541 ± 68 lb) and their litters were used in a randomized complete block design in three farrowing groups and assigned to a control diet (CON) or YC supplementation (0.1% of diet) from breeding through lactation. Concentrations of immunoglobulins were assessed in colostrum, milk, and serum, as well as the comprehensive performance outcomes of sows and their suckling offspring. Diets were formulated to meet or exceed the nutrient requirements of the sow (NRC, 2012) based on expected litter characteristics.

#### Results and Discussion

Sow reproductive performance (litter size and weight at birth, lactation feed intake, stillborns and mummies) and lactation length (18 ± 1 day) were not different between CON and YC sows (Table 1). No differences were observed ( $P > 0.05$ ) in the number of weaned pigs between groups (13.8 ± 0.4 piglets) as well as in sow hemoglobin concentration, either pre-farrowing (10.3 ± 0.4 g/L) or at weaning (10 ± 0.3 g/L). However, piglets from YC sows tended to have greater ( $P < 0.1$ ) hemoglobin concentration at birth than piglets from CON sows (10.2 vs 9.8 ± 0.2 g/L). Colostral immunocrit ratio tended to be greater ( $P < 0.1$ ) in YC sows compared with CON sows (0.8 vs. 0.6 ± 0.07). Suckling pigs from YC sows tended to have greater ( $P < 0.1$ ) concentrations of serum IgA at weaning than piglets from CON sows (1.55 vs 1.42 ± 0.1 µg/mL). Although not statistically significant, sows supplemented with YC weaned a higher percentage of piglets in the Average (5.0 – 6.4 kg) (50.5% vs 48.7%) and Heavy (>6.65 kg) (8.5% vs. 7.7%) categories compared to the control.

#### Implications

The 0.1% YC supplementation in the sow diet enhanced markers of suckling piglet resilience, as indicated by Hb level at birth, colostral immunocrit ratio, and offspring IgA concentrations at weaning, which increased the capacity to wean more average- and heavy-born piglets.

#### Acknowledgements

The authors thank CBS Bio-Platforms for their contributions and support for this study.



## References

NRC. 2012. Nutrient requirements of swine: 11<sup>th</sup> ed. National Academies Press, Washington, DC.

**Table 1.** Sow reproductive performance and suckling pig growth of control and yeast carbohydrate-fed sows<sup>1</sup>.

Item	CON	0.1 % YC	SEM	P-value <sup>2</sup>
Sows, n	32	31		
Lactation daily feed intake, lb	15.6	16.4	3.30	0.40
Standing estrus, d	5.2	4.8	0.35	0.28
<b>Sow BW, kg</b>				
Breeding	190.2	194.8	4.60	0.65
Weaning	225.3	229.7	7.04	0.54
<b>Pigs per litter, n</b>				
Born Alive	15.6	15.1	0.65	0.38
Stillborn	1.6	1.6	0.46	0.99
Mummified	0.16	0.32	0.13	0.23
Weaned	13.9	13.6	0.36	0.42
<b>Mortality</b>				
24h, %	5.66	2.57	1.89	0.17
Overall, %	10.63	11.55	2.29	0.76
<b>Piglet BW, lb</b>				
Day 1 lactation <sup>3</sup>	3.2	3.3	0.10	0.31
Weaning	11.3	12.3	0.66	0.11
<b>Daily gain, lb<sup>4</sup></b>				
Week 1	0.374	0.352	0.044	0.50
Overall	0.440	0.440	0.020	0.69
<b>Serum Ig, µg/mL<sup>5</sup></b>				
IgG	59.4	75.0	14.67	0.47
IgA	1.42	1.55	0.11	0.07
<b>Hemoglobin concentration, g/L</b>				
Birth	9.8	10.2	0.21	0.02
Wean	11.6	11.9	0.37	0.86

<sup>1</sup> A corn/soybean meal-based diet formulated to meet sow requirements based on expected litter size and birth weight, considering parity distribution (NRC, 2012). CON diet with supplementation of Yeast Carbohydrate at 0.1% from gestation to weaning (Canadian Bio-Systems Inc, 4389 112 Ave SE, Calgary, AB T2C 0J7).

<sup>2</sup> Values within a row with different superscripts differ.

<sup>3</sup> Average weight of pigs born alive.

<sup>4</sup> Based on litter performance after cross-fostering

<sup>5</sup> Blood samples for serum analysis were collected 2 days before weaning.

# Animal Science Research Report

## 2026

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### An evaluation of high and low soybean meal levels in pelleted diets fed to pigs from wean to finish

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#### Rationale and Approach

A push for new soybean crushing plants could lead to a decreased cost of soybean meal (SBM), making SBM a more available and economically viable feed ingredient. High and low levels of dietary SBM may have different effects on performance, carcass traits, nutrient output in feces, energy use in pelleting, and economic profitability in wean-to-finish pigs. This project aims to provide industry with a better understanding of the potential effects of feeding high and low SBM to growing pigs. A total of 275 pigs (PIC × Terminal Duroc, 25.6 lb., 7 weeks of age) were housed in a fully slatted floor, environmentally controlled room. The treatments consisted of formulations designed to evaluate SBM at different dietary levels: high (50%) and low (20%). All diets were formulated to meet or exceed NRC (2012) recommendations; SID lysine and net energy (NE) levels were kept consistent across the two diets. NE estimates for SBM were 1,135 Kcal/lb and for corn 1,212 Kcal/lb. The two diets were allotted to 46 pens (23 pens/diet), with six pigs per pen in a randomized complete block design (RCBD). Performance data was subject to analysis as a RCBD with pens as the experimental unit, dietary treatment as a fixed effect. Carcass, digestibility, and fecal nutrient data was analyzed as a RCBD with individual pig as the experimental unit and dietary treatment as a fixed effect.

#### Results and Discussion

Performance variables, including average daily gain (ADG), ADFI, and feed-to-gain ratio, did not differ significantly ( $P > 0.10$ ; Table 1) between pigs fed high and low SBM diets. Similarly, carcass characteristics such as primal and trimmed primal cutouts, hot carcass weight, percent recovery, carcass traits, meat color, pork belly quality, cook loss, and Warner-Bratzler shear force showed no statistical differences between dietary treatments ( $P > 0.10$ ; Table 2). Pellet durability and energy consumption exhibited numerical differences that may favor the high SBM diets. Fecal N content was significantly greater in pigs fed the high SBM diet during both the growing and finishing phases. Based on income over feed cost (IOFC), a diet containing 50% SBM appears profitable from day 0 to 28 at the current SBM price of \$260/ton. However, for the overall wean-to-finish period, the profitability of a 50% SBM diet will depend on price relationships.

#### Implications

Increasing SBM level in swine diets can be a viable strategy without compromising growth performance, carcass characteristics, or potentially pellet durability.

#### Acknowledgements

Appreciation is expressed to the United Soybean Board and South Dakota Soybean Research and Promotion Council for their generous funding and support of this project.



## References

NRC. 2012. Nutrient requirements of swine: 11<sup>th</sup> ed. National Academies Press, Washington, DC.

**Table 1.** Overall growth performance (0–14 wk) of pigs fed high or low soybean meal (SBM) diets.

Item	High	Low	SEM	P-value
ADG, lb/d	2.07	2.07	0.022	0.86
ADFI, lb/d	4.54	4.65	0.06	0.20
G:F	0.46 <sup>a</sup>	0.45 <sup>b</sup>	0.003	0.08
Final BW (d 114), lb	263.4	261.1	1.7	0.34

<sup>ab</sup>Means within a row with different superscripts differ ( $0.05 \leq P < 0.10$ ).

SEM = standard error of the mean.

**Table 2.** Carcass and pork quality characteristics of pigs fed high or low soybean meal (SBM) diets.

Item	High	Low	SEM	P-value
Loin eye area, cm <sup>2</sup>	18.92	17.78	0.19	0.63
Fat thickness, cm	2.13	2.00	0.04	0.43
Subjective color	1.98	1.99	0.17	0.98
Marbling score	1.04	1.06	0.03	0.77
Firmness	1.54	1.68	0.17	0.56

SEM = standard error of the mean.

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### Differentiating nutritional value (energy and amino acids) of soybean meal (SBM) from various origins fed to swine

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#### Rationale and Approach

Soybean meal (SBM) is widely recognized as the primary protein source in swine diets due to its favorable amino acid (AA) profile and nutrient availability but the nutritional value can vary depending on its origin, influencing feed value in pigs. This study differentiated the energy and AA nutritional value of SBM from various origins in growing pigs. Two experiments determined the energy (Exp. 1) and AA (Exp. 2) value of SBM from U.S.: Northwest (NW), Northeast (NE), South (S), and East (E); Brazil (BRZ); Argentina (ARG); and reimported U.S. (Re-US)]. In Exp. 1, a corn-based basal diet and seven corn-based diets containing one SBM source were provided to twenty-four barrows ( $77 \pm 4$  lb) in a crossover design with three collection periods resulting in 9 observations/diet. Each period lasted 14 days (7 days of diet adaptation, 7 days of total fecal and urine collection). Feces, urine, and diets were analyzed for gross energy (GE). Digestible (DE) and metabolizable energy (ME) values were calculated. In Exp. 2, eleven ileal-cannulated barrows ( $64 \pm 7$  lb) were provided one of seven diets in a crossover design with six 7-day experimental periods (5 days of adaptation, 12 hours of ileal digesta collection on days 6 and 7). Digesta samples were analyzed for crude protein (CP), AA, and titanium to calculate standardized ileal digestibility (SID) values.

#### Results and Discussion

In Exp. 1, DE and ME values did not differ ( $P > 0.05$ ) among SBM sources (Table 1). In Exp. 2, SBM from ARG had the highest ( $P < 0.05$ ) SID of CP, similar to BRZ, and greater than all US sources and Re-US. The SID of Lys and Thr ( $P < 0.05$ ) were similar in ARG, Re-US, NW, S, and E which were all higher than BRZ and NE. The SID values for total AAs was greater ( $P < 0.05$ ) in U.S. E than Re-US and U.S E was similar to the other US sources, ARG, and BRZ. The SBM samples from ARG and the U.S. E had the lowest KOH solubility values, (ARG: 76.7; BRZ: 76.4; Re-US: 81.0 NW: 84.1; NE: 82.2; S: 81.6; E: 76.3%) and trypsin inhibitor concentrations (ARG: 22,360; BRZ: 25,380; Re-US: 26,947 NW: 33,040; NE: 40,673; S: 44,347; E: 20,520 TIU/g); lower KOH solubility and trypsin inhibitor concentration are associated with greater protein digestibility. The critical AA value (sum of SID Lys, Thr, Trp, Met, Cys content) was greatest in Re-US SBM (ARG: 0.141; BRZ: 0.137; Re-US: 0.143 NW: 0.142; NE: 0.139; S: 0.141; E: 0.141).

#### Implications

Overall, all sources evaluated had high nutritional value and differences in protein value based on digestibility can in part be explained by markers of processing conditions; however, concentration of critical amino acids may be more important for practical diet formulation.



## Acknowledgements

The authors thank Northern Soy Marketing for financial assistance with this study.

**Table 1.** Digestible and metabolizable energy content and standardized ileal digestibility in soybean sources fed to growing pigs.

Item	Arg	Bra	Re-US	US NW	US NE	US South	US East	SEM	P-value
<b>Exp. 1</b>									
Digestibility of GE, %	88.3	87.5	88.5	88.0	87.7	88.0	89.7	0.72	0.52
Metabolizability of GE, %	84.8	84.7	84.7	84.5	84.2	84.4	86.2	0.68	0.55
DE, kcal/kg	1600	1601	1651	1530	1535	1576	1611	34.6	0.22
ME, kcal/kg	1512	1500	1540	1443	1445	1478	1522	36.3	0.48
<b>Exp. 2</b>									
Crude protein, %	86.93 <sup>a</sup>	84.96 <sup>ab</sup>	81.28 <sup>b</sup>	82.76 <sup>b</sup>	80.78 <sup>b</sup>	81.08 <sup>b</sup>	81.50 <sup>b</sup>	1.32	<0.01
Arg	95.14 <sup>a</sup>	92.69 <sup>ab</sup>	91.56 <sup>b</sup>	93.42 <sup>ab</sup>	91.98 <sup>b</sup>	92.83 <sup>ab</sup>	94.89 <sup>a</sup>	1.17	0.02
His	92.64 <sup>a</sup>	91.55 <sup>ab</sup>	88.70 <sup>bc</sup>	90.49 <sup>abc</sup>	87.96 <sup>c</sup>	91.21 <sup>abc</sup>	93.28 <sup>a</sup>	0.75	<.01
Ile	88.57 <sup>ab</sup>	87.23 <sup>abc</sup>	84.58 <sup>c</sup>	88.12 <sup>ab</sup>	85.75 <sup>bc</sup>	87.89 <sup>ab</sup>	89.25 <sup>a</sup>	0.70	<0.01
Leu	87.65 <sup>a</sup>	86.74 <sup>ab</sup>	83.78 <sup>b</sup>	86.59 <sup>ab</sup>	83.71 <sup>b</sup>	86.67 <sup>ab</sup>	88.41 <sup>a</sup>	0.72	<0.01
Lys	88.01 <sup>a</sup>	85.68 <sup>b</sup>	86.40 <sup>ab</sup>	87.88 <sup>ab</sup>	85.70 <sup>b</sup>	87.60 <sup>ab</sup>	87.50 <sup>ab</sup>	1.08	<0.01
Met	90.75	89.77	88.24	91.04	87.53	89.61	91.15	1.00	0.12
Met + Cys	84.60 <sup>ab</sup>	82.75 <sup>ab</sup>	81.44 <sup>ab</sup>	83.96 <sup>ab</sup>	80.51 <sup>b</sup>	81.42 <sup>ab</sup>	86.14 <sup>a</sup>	1.09	0.01
Phe	88.38 <sup>a</sup>	87.35 <sup>ab</sup>	84.42 <sup>b</sup>	87.31 <sup>ab</sup>	84.25 <sup>b</sup>	87.37 <sup>ab</sup>	88.86 <sup>a</sup>	0.75	<0.01
Thr	81.02 <sup>a</sup>	79.31 <sup>ab</sup>	75.37 <sup>b</sup>	79.12 <sup>ab</sup>	73.95 <sup>b</sup>	79.67 <sup>ab</sup>	82.32 <sup>a</sup>	1.25	<0.01
Trp	95.17	95.18	94.31	92.75	94.28	95.60	96.77	0.93	0.16
Val	86.48 <sup>ab</sup>	84.81 <sup>abc</sup>	81.61 <sup>c</sup>	85.99 <sup>ab</sup>	83.03 <sup>bc</sup>	85.68 <sup>ab</sup>	87.29 <sup>a</sup>	0.79	<0.01
Mean	89.23 <sup>a</sup>	87.65 <sup>ab</sup>	85.51 <sup>b</sup>	87.87 <sup>ab</sup>	85.12 <sup>b</sup>	87.95 <sup>ab</sup>	89.88 <sup>a</sup>	0.74	<0.01

<sup>abc</sup> Within a row, values with different superscripts differ at  $P < 0.05$ .

# Animal Science Research Report 2026

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## Strategic use of growth promotant levels of dietary zinc and copper during nursery periods and its effects on pig growth performance until market

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### Rationale and Approach

Feeding pharmacological levels of copper (Cu) in pig production improve growth. Due to concerns of soil mineral accumulation, some countries have regulated the levels of certain minerals in swine diets. Alternative approaches are needed to minimize use. The industry commonly feeds trace minerals above NRC (2012) recommendations. This study evaluated the impact of feeding two levels of added copper, industry (16.5 ppm) and NRC (3.0 ppm), with and without phytase on growth performance, carcass traits, and blood parameters of growing–finishing phase pigs previously fed diets containing 150 ppm copper. A total of 437 pigs (PIC 1050 × Compart Duroc; 102.7 ± 1.34 lb) were housed in fully-slatted pens with ad libitum access to feed and water. Pigs were individually weighed and assigned by BW and sex to one of four dietary treatments in a 2 × 2 factorial arrangement: two Cu levels (3 or 16.5 ppm) and phytase (0 or 0.3% of the diet). Each treatment had 19 replications with 6 pigs per pen. Carcass traits were measured on 212 pigs (53 per treatment) at slaughter.

### Results and Discussion

From d 0-15, a significant Cu x Phytase interaction was observed for ADG ( $P < 0.01$ ; Table 1) and feed efficiency ( $P < 0.01$ ), where pigs fed 16.5 ppm Cu without phytase and pigs fed 3 ppm Cu with Phytase had higher ADG. No significant interactions were observed in the latter phases or overall. From d 15-28 Cu improved ADG ( $P = 0.01$ ), while from d 28-43 and 43-62 Cu improved feed efficiency ( $P = 0.03$ ,  $P = 0.01$ ). Between days d 43-62, pigs receiving phytase tended to have lower feed intake ( $P = 0.06$ ). Overall, pigs fed 3 ppm Cu had reduced weight gain ( $P < 0.01$ ), while phytase improved feed conversion ( $P = 0.02$ ). Pigs fed 16.5 ppm Cu had increased BW and BF by ultrasound ( $P < 0.01$ , Table 2). Plasma Cu status did not differ among treatments.

### Implications

While the industry level of copper improved growth, pigs can be fed 3 ppm Cu in the latter phases with minimal impact on performance, as feed conversion was unaffected and ADG decreased only slightly. Phytase supplementation improved feed efficiency.

### Acknowledgements

The authors thank the SDSU swine group for their contributions and support for this study. This work is supported in part by Hatch funds from the USDA National Institute of Food and Agriculture (SD00H753-22).



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**Table 1.** Performance of grow-finish pigs fed different Cu levels with or without phytase.

Item	16.5 ppm Cu		3ppm Cu		SEM	P-value		
	No Phy	Phy	No Phy	Phy		Cu	Phy	Cu*Phy
<b>Period, d 0-62</b>								
BW d127, lb	276.9	277.0	272.7	273.4	1.61	0.28	0.90	0.93
ADG, lb	2.47 <sup>ab</sup>	2.48 <sup>b</sup>	2.39 <sup>a</sup>	2.43 <sup>ab</sup>	0.01	0.01	0.35	0.56
ADFI, lb	6.94	6.73	6.78	6.60	0.05	0.19	0.08	0.90
F:G	2.81	2.72	2.83	2.73	0.04	0.69	0.02	0.88

**Table 2.** Carcass traits of grow-finish pigs fed different Cu levels with or without phytase.

Item	Dietary treatments				SEM	P-value		
	16.5 ppm	16.5 ppm + Phy	3 ppm	3 ppm + Phy		Cu	Phy	Cu*Phy
HCW	190.7	185.3	182.2	185.1	4.07	0.29	0.75	0.31
BF, mm	18.3	18.9	17.9	16.8	0.85	0.16	0.77	0.29
Ultrasound backfat, mm	23.39 <sup>a</sup>	23.09 <sup>a</sup>	20.66 <sup>ab</sup>	18.94 <sup>b</sup>	1.16	0.01	0.39	0.54
Loin depth, mm	59.1	58.4	59.7	58.8	1.09	0.64	0.45	0.93
Lean, %	54.81	54.30	54.85	55.67	0.58	0.23	0.78	0.26

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## Influence of zinc and fostering on sow and piglet immune states

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### Rationale and Approach

Zinc plays a key role in immune function and the passive transfer of immunity from sows to piglets through colostrum. This study evaluated the effects of high dietary zinc supplementation during late gestation and lactation, combined with differing fostering loading, on serum zinc concentration and immunoglobulin G (IgG) levels in sows and piglets. A total of 43 PIC (1050) sows ( $555.6 \pm 4.74$  lb) in two groups were used and allocated into two dietary treatments from d 100 of gestation until weaning. Dietary treatments consisted of a standard gestation and lactation diet formulated to meet or exceed NRC (2012) recommendations fortified with 198 ppm of zinc in the form of zinc sulfate (CON) or 650 ppm of supplemental zinc (HZ diet), using zinc sulfate as the zinc source. Cross-fostering (FOSTER) occurred on d 2 post-farrowing within maternal treatment groups and litter size was standardized considering the number of teats: (1) one piglet less than teats capacity; (2) the same number of piglets with the teats; (3) one more piglet than the number of teats. Blood samples were collected from sows and piglets at birth and weaning to determine serum Zn ( $\mu\text{g/ml}$ ) and IgG concentrations ( $\mu\text{g/ml}$ ); colostrum IgG was also analyzed. Data were analyzed (SAS) with fixed effects of Zinc, Fostering, and their interaction. Significant differences were reported at  $P < 0.05$  and tendencies for differences at  $P < 0.10$ .

### Results and Discussion

Serum Zn concentration was not affected by dietary Zn level but tended to differ by fostering category at birth and sows (Trt, Fost;  $P = 0.09$  and  $0.07$ , respectively; Table 1), with numerically lower serum Zn observed in the fostering category (3). IgG concentrations in piglets at birth and weaning were not influenced by Zn supplementation ( $P = 0.61$ ), but piglet IgG at weaning varied widely among fostering categories, with numerically greater IgG in piglets from category foster (1) under both Zn levels. Colostrum IgG concentration was unaffected by Zn level ( $P = 0.54$ ) and fostering category ( $P = 0.92$ ).

### Implications

Pig immune status, assessed by IgG, tended to improve at weaning in pigs placed to 1 less than the teat number. While serum zinc in pigs placed at 1 more pig per teat number tended to be lower in pigs, dietary supplementation of 650 ppm Zinc as zinc sulfate in late gestation did not enhance serum zinc nor IgG concentrations in sows or piglets vs typical industry levels.

### Acknowledgements

The authors thank the SDSU swine group for their contributions and support for this study.

### References

NRC. 2012. Nutrient requirements of swine: 11<sup>th</sup> ed. National Academies Press, Washington, DC.



**Table 1.** Effect of dietary zinc sulfate in late gestation and lactation on offspring performance.

Items	CON	ZINC	SEM	P-value
<b>Farrowing performance</b>				
Total born	17.5	16.4	0.70	0.31
Born alive	16.3	14.7	0.57	0.06
Stillborn	1.2	1.7	0.35	0.28
Stillborn, %	6.2	9.9	1.84	0.18
Mummies	0.5	0.2	0.20	0.39
<b>Lactation performance</b>				
Piglets d2	13.5 <sup>a</sup>	15.6 <sup>b</sup>	15.7 <sup>b</sup>	0.34
BW d1, lb	3.3	3.3	1.4	0.08
Piglets weaned	13.4	14.5	14.1	0.43
Wean age	17.1	17.9	17.6	0.37
BW weaning, lb	13.2 <sup>a</sup>	11.9 <sup>ab</sup>	10.8 <sup>b</sup>	0.38
ADG suckling, g/day	248 <sup>a</sup>	220 <sup>ab</sup>	197 <sup>b</sup>	0.01
Milk production, lb	25.0	24.8	22.1	0.66
Litter weaning weight, lb	162.4	167.8	150.1	4.14
Days to estrus	5.66	8.80	4.80	1.51
<b>Piglet mortality</b>				
Mortality d1 %	6.2	4.6	4.0	3.12
Wean mortality %	0.5 <sup>a</sup>	7.3 <sup>b</sup>	9.8 <sup>b</sup>	2.08
Piglet low viability 1 %	0.2	0.6	0.2	0.42
Piglets laid on %	0.9	4.2	6.2	1.78
Piglets <1kg survival, %	24.4	42.6	44.3	13.58

**Table 2.** Effect of dietary zinc sulfate in late gestation and lactation on sow performance.

Items	CON	ZINC	SEM	P-value
Sow per treatment	21	22		
<b>Sow BW, lb</b>				
d 100	515.21	500.45	4.74	0.35
d 1 post farrowing	499.34	496.7	6.68	0.87
Weaning	491.85	496.48	6.04	0.82
Change, d1 to Wean (lb)	-3.97	0.88	2.90	0.61
<b>Feed intake, lb/d</b>				
Lactation	13.45	13.45	0.54	0.91

# Animal Science Research Report

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### Effects of high dietary soybean meal on the gut microbiome of finishing pigs

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#### Rationale and Approach

Soybean meal (SBM) is the primary protein source in swine diets across the U.S. Midwest, and it is typically supplemented with synthetic amino acids to optimize growth. Variation in dietary SBM level can influence pig performance and gut health due to non-protein components, such as polysaccharides and oligosaccharides; as these can affect microbial metabolism, further investigations are needed to increase our understanding of the effects of SBM on the swine gut environment. As new processing facilities expand SBM availability and lower costs, understanding how dietary SBM level impacts the gut microbiome is increasingly important. In this context, this study aimed at characterizing the effect of dietary SBM levels on swine gut bacterial communities. 546 mixed-sex pigs were used in a 111-day trial to evaluate the effects of diets with 1) low dietary SBM supplemented with synthetic amino acids (5%; LowSBM) vs 2) high dietary SBM (28%; HighSBM). All diets met or exceeded NRC (2012) requirement estimates, with standardized ileal digestible (SID) lysine and net energy (NE) levels kept constant. To determine fecal bacterial composition and identify candidate gut microbial species, 14 fecal samples per treatment were collected for DNA extraction and 16S rRNA sequencing via PCR amplification of the V1–V3 regions. To further explore how a HighSBM diet shaped gut microbiome function, we performed shotgun metagenomic sequencing on select fecal samples for genome assembly; this allowed us to predict the metabolic potential of the most abundant gut bacterial species.

#### Results and Discussion

A 16S rRNA gene-based analysis of dissimilarity indicated significant differences in bacterial composition between the two treatments ( $P < 0.05$ ). Notably, we found specific OTUs that were in higher abundance in the HighSBM samples compared to the LowSBM samples ( $P < 0.05$ ; Figure 1). These included Ssd-39, closely related to *Streptococcus alactolyticus* (99.5% identity match; 15% vs. 10%); Ssd-1160, related to *Treponema brennaborensense* (88.0% identity match; 2% vs. 0.1%); and Ssd-1254, similar to *Treponema bryantii* (97.0% identity match; 2% vs. 0.03%). Using metagenome-assembled genomes (MAGs; quality: >70% completeness, <10% contamination; Figure 2), functional annotation revealed metabolic capabilities such as oligosaccharide degradation and butyrate production. Interestingly, MAGs affiliated with the genus *Treponema* suggest a role in fiber degradation, utilization and lactate production.

#### Implications

As SBM becomes more affordable, this study offers insight into optimizing its use as a protein source in swine. Results support the hypothesis that HighSBM diets alter gut microbiome composition,



influencing short-chain fatty acid and metabolite production driven by the oligosaccharides and amino acids present in SBM.

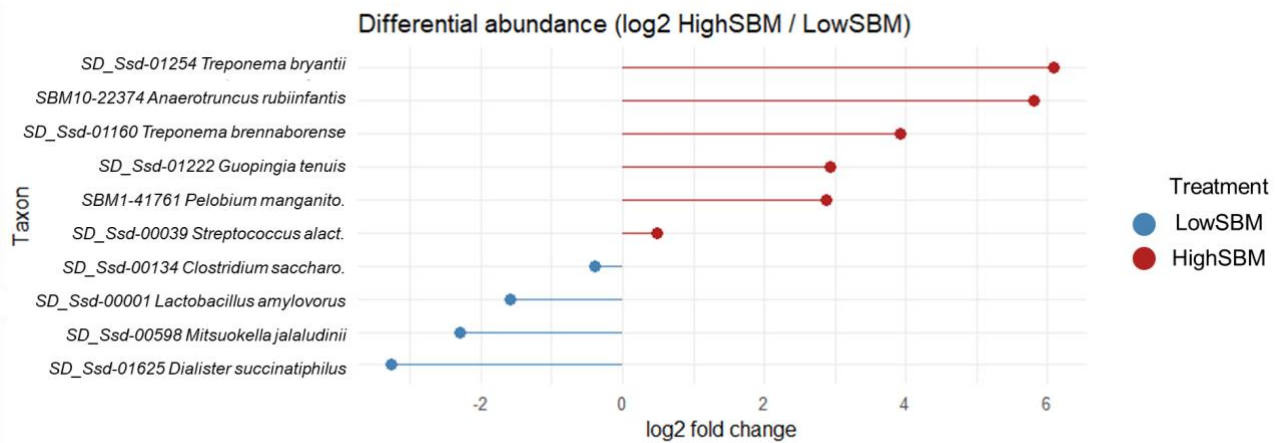
## Acknowledgements

This study was supported by the SDSU Agricultural Experiment Station Hatch funds, and the United Soybean Board.

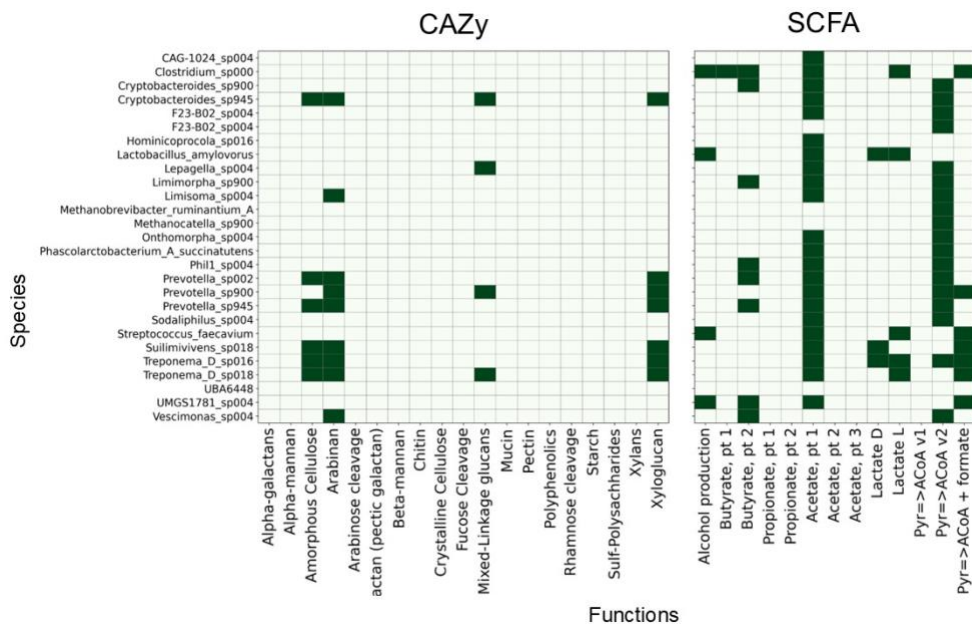
## References

NRC. 2012. Nutrient requirements of swine: 11<sup>th</sup> ed. National Academies Press, Washington, DC.

**Figure 1.** Differential abundance (Log<sub>2</sub>) of the species that changes the most with each treatment.



**Figure 2.** Heatmap showing metabolic capabilities predicted from 26 metagenome-assembled genomes (MAG's) that were analyzed from select fecal samples collected from pigs fed a high SBM diet. The panel 'CAZy' shows the predicted enzymatic activities associated with digestion of carbohydrates, while the panel 'SCFA' shows predicted microbial end products that could be produced for use as nutrients by the pig host. CAZy: carbohydrate-active enzyme(s); SCFA: short-chain fatty acid(s).



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### Feeding the prolific sow for success: late gestation phase feeding improves farrowing duration, micronutrient status, and reproductive performance

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#### Rationale and Approach

Genetic selection has increased sow prolificacy, with a U.S. average of 16 total born per litter. Conventional gestation feeding may not meet late-gestation nutrient demands when fetal growth peaks. This study evaluated a nutrient-enriched late-gestation diet on farrowing duration, maternal nutrient biomarkers, and reproductive performance across consecutive cycles. Seventy sows (parity 0–5) at 70 ± 2 days gestation were assigned to a control diet (CON; n = 35; 11% CP, 0.52% SID lysine, industry-standard organic trace minerals, and vitamins) or LGPHASE (n = 35; 16% CP, 0.87% SID lysine, 2× CON industry-standard organic trace minerals and vitamins except selenium, plus 500 mg/kg vitamin C). Sows received a common lactation diet. Gestation diets were repeated in the subsequent cycle. Blood samples were collected, and body weight, backfat, and body condition were assessed for each sow at days 70 and 110 of gestation, day 2 of lactation, and at weaning (lactation day 19 ± 3).

#### Results and Discussion

Farrowing duration was shorter in LGPHASE sows than CON sows (290.4 vs. 359.9 min;  $P = 0.03$ ; Table 1). Total pigs born (CON: 16.5; LGPHASE: 16.5), live born (CON: 15.2; LGPHASE: 14.5) and birth rates were similar, but stillbirth rate tended to be lower in LGPHASE sows (3.4% vs. 6.8%;  $P = 0.10$ ). LGPHASE sows tended to wean more pigs per litter (13.4 vs. 12.3;  $P = 0.06$ ), with higher piglet survivability (90.5% vs. 84.8%;  $P = 0.02$ ) than CON sows. Blood Hb was higher in LGPHASE sows at day 110 gestation (11.2 vs. 10.7 g/dL;  $P = 0.09$ ) and weaning (10.7 vs. 9.9 g/dL;  $P < 0.01$ ). Ferritin tended to be higher in LGPHASE sows (38.5 vs. 28.3 ng/mL;  $P = 0.07$ ). Serum 25(OH)D<sub>3</sub> was greater at day 110 (54.8 vs. 35.5 ng/mL;  $P < 0.01$ ).

#### Implications

Late-gestation nutrient requirements in prolific sows exceed conventional, commercial levels; phase feeding improves farrowing duration, sow micronutrient status, piglet survival, and subsequent prolificacy.

#### Acknowledgements

This project was partially funded by Novus International, dsm-firmenich, Pig Improvement Company, and the National Pork Checkoff.



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**Table 1.** Effects of late gestation phase feeding on sow reproductive performance in cycle I

Item	Dietary treatment		SEM	P-value
	CON	LGPHASE		
Sows, n	35	35	-	-
Average parity, n	1.61	1.61	-	-
Farrowing duration, min <sup>1</sup>	360	290	22.24	0.03
Total born, n	16.47	16.50	0.87	0.98
Liveborn, n	14.67	15.17	0.73	0.59
Stillborn, n	1.18	0.60	0.31	0.09
Stillborn, %	6.79	3.36	1.89	0.10
Piglet birth wt., kg	1.50	1.51	0.05	0.86
Total litter birth wt., kg	23.12	23.00	0.94	0.88
Pigs weaned, n	12.31	13.39	0.49	0.06
Piglet wean wt., kg <sup>2</sup>	6.16	5.70	0.22	0.09
Total litter wean wt., kg <sup>2</sup>	74.96	72.89	2.58	0.57
Pigs weaned, % <sup>3</sup>	84.80	90.46	1.67	0.02
Pre weaning mortality, %	14.87	10.03	1.98	0.05
Wean age, days	19.19	18.90	0.30	0.49

<sup>1</sup>Farrowing duration adjusted for total born as a covariate

<sup>2</sup>Piglet wean weight and total litter wean weight adjusted for number of pigs weaned as a covariate

<sup>3</sup>Pigs weaned, % = (Live piglets post-fostering ÷ Liveborn piglets) × 100.

# Animal Science Research Report

## 2026

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### Blood hemoglobin as a predictor of removal risk and reproductive performance in prolific sows

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#### Rationale and Approach

Modern swine production increasingly relies on highly prolific maternal lines to maximize piglet output, which in turn elevates nutrient and metabolic demands in sows. This raises concerns about maternal robustness and longevity. In this context, anemia, commonly defined in swine as hemoglobin (Hb) < 10 g/dL, is highly prevalent in commercial herds and may compromise sow survival and life-time productivity. This study evaluated the association between late-gestation Hb and subsequent sow removal risk and reproductive performance under commercial conditions. A total of 1,945 sows (parities 0–8; DNA Line 241) across four U.S farms were enrolled at 100 ± 12 days of gestation. Blood was collected via ear vein prick and analyzed on-farm using the HemoCue Hb 201+ device. Sows were classified as non-anemic (Hb ≥ 10 g/dL; n = 792) or anemic (Hb < 10 g/dL; n = 1,153), and perineal score and body condition (Knauer Sow Caliper v2; KSC) were recorded. Sow removal data—including death, euthanasia, or other non-age-related reasons—were tracked for 70 days post-sampling, with all events classified as removals.

#### Results and Discussion

Anemia prevalence varied by farm (52–65%) and averaged 59.3% across all four farms. Anemia prevalence increased with parity ( $P < 0.01$ ), occurring in 40.6% of parity 0 females, rising to 82.7% by parity 3. Anemic sows had lower body condition than non-anemic sows (12.5 vs. 13.1 KSC,  $P < 0.01$ ; Table 1), with a weak positive correlation found between Hb and body condition ( $r = 0.21$ ;  $P < 0.01$ ). Anemic sows had more total piglets born than non-anemic sows (16.4 vs. 15.7;  $P < 0.01$ ; Table 2). However, anemic sows had a higher stillborn rate (5.3 % vs. 4.2%;  $P = 0.01$ ), with no differences found in the number of piglets weaned (anemic: 11.9; non-anemic: 12.1). Sow removal rates were more than two-fold greater in anemic sows than in non-anemic sows (8.4% vs. 3.5%;  $P < 0.01$ ), with each 1 g/dL increase in Hb reducing removal risk by 43% (HR = 0.57;  $P < 0.01$ ). Sow removal rates were higher in anemic sows within most parities; parity 0 (anemic: 15.4%; non-anemic: 6.9%), parity 1 (anemic: 8.3%; non-anemic: 2.8%), parity 2 (anemic: 13.5%; non-anemic: 6.7%), and parity 3 (anemic: 11.3%; non-anemic: 4.2%) ( $P < 0.05$ ). Sow removal rates in parity 4+ sows were similar (anemic: 12.1%; non-anemic: 10.3%).

## Implications

Anemia in sows is common and consequential; anemic sows are more prolific but have higher stillbirth rates and increased removal risk, highlighting trade-offs between litter size and sow longevity.

## Acknowledgements

This study was facilitated by Pillen Family Farms and Passel Farms, with partial funding provided by Pharmacosmos Inc. and the National Pork Checkoff.

**Table 1.** Sow measurements by hemoglobin (Hb) status

Item	Non-anemic Hb $\geq$ 10 g/dL	Anemic Hb < 10 g/dL	SEM	P-value
Total females, No.	792	1153	NA	NA
Mean parity, No.	2.6	3.5	0.12	< 0.001
Hemoglobin, g/dL	10.7	9.1	0.03	< 0.001
Caliper score, mm	13.1	12.5	0.09	< 0.001

**Table 2.** Reproductive outcome by hemoglobin (Hb) status

Item	Non-anemic Hb $\geq$ 10 g/dL	Anemic Hb < 10 g/dL	SEM	P-value
Total females, No.	792	1153	NA	NA
Total born, No.	15.7	16.4	0.15	< 0.001
Live born, No.	14.3	14.7	0.32	< 0.001
Stillborn, No.	0.7	0.9	0.16	0.03
Stillborn, %	4.2	5.3	0.97	0.01
Pigs weaned, No.	12.1	11.9	0.13	0.39
Sow removal*, %	3.5	8.4	2.97	< 0.001

\* Sow removals include females that died, were euthanized, or were culled for non-age-related reasons. Values represent the number of removals divided by the total number of females within each Hb status category.

# Animal Science Research Report

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### Weaning acclimation impacts feeding behavior, thermoregulation, and growth performance of piglets

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#### Rationale and Approach

Post-weaning feed intake is closely linked to weaned pig mortality. Newly weaned pigs often show reduced appetite due to environmental and microbial changes, new feed and water sources, social stress, and the challenges of transport and relocation. Delayed weaning may enhance piglet robustness, yet it increases non-productive sow days and offers limited benefit to piglets with poor milk access, potentially raising late-lactation mortality. Stall weaning offers a simplified transition: the sow is removed while piglets remain in the familiar farrowing stall, where water and heat are already in place and only a feeder is added. This study evaluated the effects of housing stability during weaning on piglet growth, thermoregulation, and feeding behavior when kept in farrowing stalls versus conventional nursery pens. A total of 293 piglets from 21 litters (weaning age:  $18 \pm 3$  days; BW:  $12.46 \pm 1.21$  lbs) were enrolled. Eleven litters remained in their farrowing stalls post-weaning (STALLS), while ten litters were moved to conventional nursery pens (PENS). All pigs were fed a common, complex nursery diet formulated to meet or exceed NRC requirements. Individual body weights (BW) were recorded on days 0, 3, and 7 post-weaning. Feed disappearance was measured by PEN or STALL to estimate average daily feed intake (ADFI) from days 0 to 7. Body temperatures (BT) were recorded every 24 hours for the first 72 hours post-weaning from a representative small, medium, and large pig in each PEN and STALL (STALL;  $n = 33$ ; PEN;  $n = 30$ ). Feeding behavior was monitored for 6 PENS and 6 STALLS via video analysis to determine average eating time during the first 72 hours post-weaning.

#### Results and Discussion

Individual BW did not differ between groups at any time point. Pigs housed in STALLS tended to have less BW loss from day 0 to 3 ( $-6.7$  vs.  $-22.1$  g/d;  $P = 0.10$ ; Table 1) and greater ADG from day 3 to 7 ( $191.5$  vs.  $163.4$  g/d;  $P = 0.08$ ) compared to PEN pigs. Overall ADG from day 0 to 7 was greater in STALLS ( $106$  vs.  $83$  g/d;  $P = 0.03$ ). During the first 24 hours post-weaning, STALL pigs tended to spend more time eating ( $17.9$  vs.  $1.9$  min;  $P = 0.07$ ; Figure 1), which corresponded with higher ADFI from day 0 to 7 ( $209.9$  vs.  $133.8$  g/d;  $P < 0.05$ ). STALL pigs also maintained higher BT in the first 24 hours ( $102.6$  vs.  $101.9^\circ\text{F}$ ;  $P < 0.01$ ).

#### Implications

Stall weaning maintains a familiar environment and supports faster feed adaptation, increasing eating behavior during the post-weaning period.

#### Acknowledgements

The authors thank the SDSU swine group for their contributions and support for this study.



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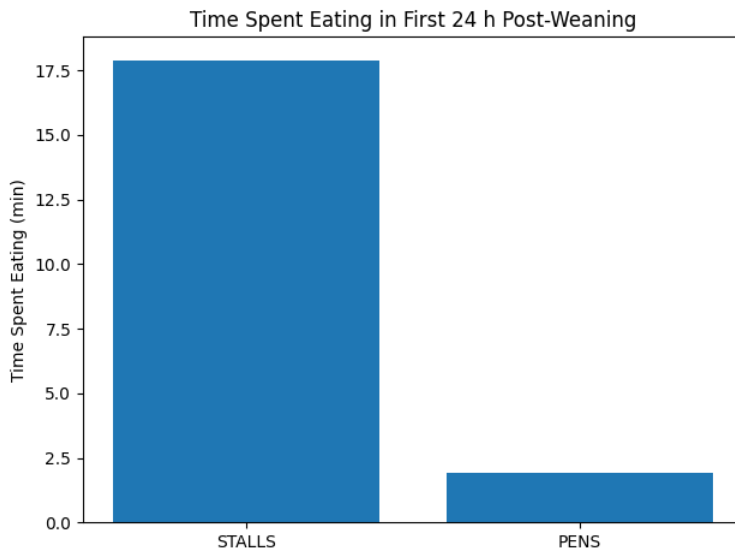
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**Table 1.** Effects of housing environment at weaning on piglet performance.

Item	STALLS	PENS	P-value
Body weight, lb (d 0)	12.46	12.46	NS
ADG, g/d (d 0–3)	-6.7	-22.1	0.10
ADG, g/d (d 3–7)	191.5	163.4	0.08
ADG, g/d (d 0–7)	106	83	0.03
ADFI, g/d (d 0–7)	209.9	133.8	<0.05
Body temperature, °F (first 24 h)	102.6	101.9	<0.01
Time eating, min (first 24 h)	17.9	1.9	0.07

NS = not significant ( $P > 0.10$ ). SEM values available upon request.

**Figure 1.** Time spent eating during the first 24 h post-weaning.



Piglets housed in STALLS tended to spend more time eating during the first 24 h post-weaning (17.9 vs. 1.9 min;  $P = 0.071$ ).

# Animal Science Research Report

## 2026

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### Effects of dietary tribasic copper chloride level and duration in growing-finishing pigs

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#### Rationale and Approach

Copper (Cu) is an essential mineral for swine involved in maintaining physiological processes such as maintenance, growth and reproduction (Espinosa, et al, 2021). A variety of inorganic sources can be included in diets to meet Cu requirements including Tribasic Copper Chloride (TBCC). TBCC can be utilized in swine diets as a nutritional and pharmacological supplement that supports growth performance. Increasing Cu above NRC (2012) requirements has been shown to improve growth performance and gut health. Evaluating the timing of feeding pharmacological Cu provides insight into whether dietary addition throughout marketing improves growth performance or feed efficiency. A total of 1,112 mixed sex pigs (DNA 600 × 241, 47.6 ± 1.8lb) were used in a 122-d grow-finish study. Pigs were placed in 44 pens at the South Dakota State University commercial wean-to-finish research facility to investigate the effect of TBCC level and feeding duration on growth performance. Pens were stocked with 25 ± 1 pigs, with similar distribution of barrows and gilts. Dietary treatments were randomly allotted to pens within block by body weight (BW) and dietary treatments were replicated 11 times. Treatments included: negative control at or above NRC Cu requirements, pharmacological Cu until approximately 120lb, pharmacological Cu until approximately 200lb, and pharmacological Cu fed until market.

#### Results and Discussion

Feeding Cu at pharmacological levels to pigs improved ADG and G:F from d 0-14 ( $P < 0.05$ ) and tended ( $P = 0.07$ ) to increase feed intake. However, throughout the remainder of the trial, no significant differences in growth performance were observed ( $P > 0.10$ ). No significant differences in BW were observed d 0-107 ( $P > 0.10$ ; Table 1). Overall, no treatment differences were observed for ADG, ADFI, or G:F ( $P > 0.10$ ). No significant differences were observed among treatments in total removals ( $P > 0.10$ ).

#### Implications

Adding pharmacological Cu to the diet had no overall effects on ADG, ADFI, G:F, or body weight. Feeding Cu above NRC (2012) requirements improved ADG and G:F during d 0-14. However, this response was not observed throughout the remainder of the trial.

#### Acknowledgements

The authors thank the SDSU swine group for their contributions and support for this study.



## References

Espinosa, C. D., and H. H. Stein. 2021. Digestibility and metabolism of copper in diets for pigs and influence of dietary copper on growth performance, intestinal health, and overall immune status: a review. *J. Animal Sci. Biotechnol.* 12:13. doi.org.10.1186.s40104-020-00533-3.

**Table 1.** Duration of Pharmacological Supplementation of Copper (TBCC\*) on G-F Performance

Item	Negative Control	Cu to ~120 lb	Cu to ~200 lb	Cu to Market	SEM	P-value
<b>BW, lb</b>						
d 0	47.6	47.8	46.7	47.4	1.23	0.64
d 107	278.0	283.3	279.8	281.3	5.12	0.30
<b>Overall (d 0–107)</b>						
ADG, lb/d	2.16	2.20	2.18	2.20	0.04	0.38
ADFI, lb/d	5.42	5.49	5.47	5.56	0.13	0.08
G:F	0.40	0.40	0.40	0.39	0.01	0.54

\*Pharmacological level of copper provided as tri-basic copper chloride (TBCC).



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