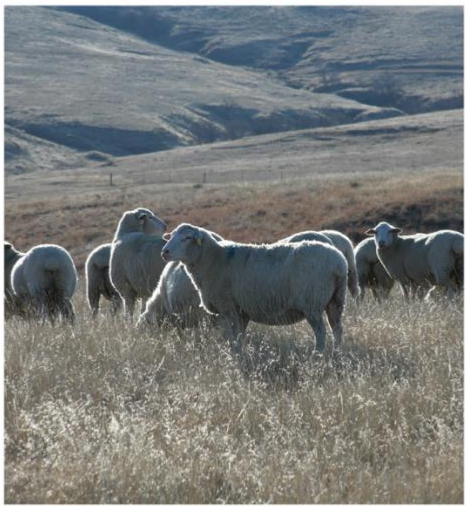
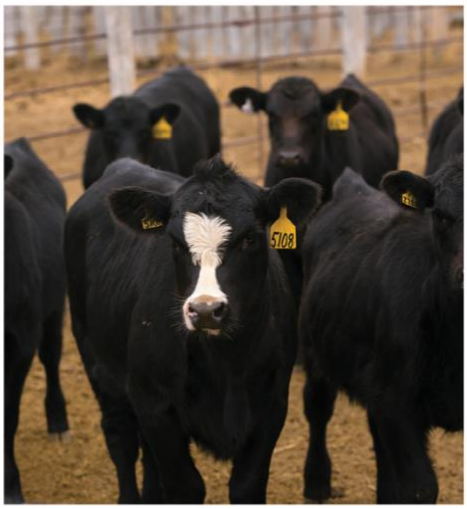
South Dakota State University

Department of Animal Science | SDSU Extension

Animal Science Research and Extension Report

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 ± 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.

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- **Chi square (χ^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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Swine

Animal Science Research Report 2026

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%; $P < 0.05$; Table1). 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.

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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, %						
	0	**0.5**	**0.75**	**1**	**1.25**	**1.5**	**SEM**
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[1]	68.9	71.3	72.8	75.3	72.3	72.6	1.41
Leu[1]	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[1]	70.7	72.6	73.9	76.2	74.3	73.9	1.30
Thr[1]	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

[1]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	**20%**		**15%**		
Diet fiber (NDF, %)	**11**	**16**	**11**	**16**	***P*-value**
Terrisporobacter mayombei (97.32%)	4.80^{bc}	2.44^{c}	16.46^{a}	7.13^{b}	0.001
C. saccharoperbutylacetonicum (97.00%)	13.81^{ab}	5.69^{c}	14.68^{a}	7.44^{bc}	0.001
Lactobacillus amylovorus (99.64%)	5.93^{ab}	12.39^{a}	4.28^{b}	9.10^{ab}	0.041
Lignipirellula cremea (81.30%)	6.06	3.38	4.74	3.76	0.054
Christensenella massiliensis (85.69%)	0.79	0.69	0.94	1.08	0.054
Culicoidibacter larvae (81.79%)	0.08^{ab}	0.17^{ab}	0.04^{b}	0.35^{a}	0.019
Maliibacterium massiliense (84.27%)	3.02	0.96	1.61	1.34	0.076
Romboutsia timonensis (98.36%)	2.32^{bc}	1.82^{c}	4.60^{a}	3.61^{b}	0.001
Clostridium baratii (96.80%)	0.09^{ab}	0.02^{bc}	0.01^{c}	0.01^{c}	0.001
Mediterranea massiliensis (89.98%)	0.11^{c}	0.11^{c}	1.27^{a}	0.23^{bc}	0.001
Duncaniella muris (86.34%)	0.92^{ab}	1.11^{a}	0.08^{c}	0.48^{bc}	0.014
Clostridium jeddahitimonense (99.00%)	0.36^{bc}	0.17^{bc}	0.54^{b}	0.92^{a}	0.001
Holdemanella porci (99.81%)	0.12^{ab}	0.46^{a}	0.06^{c}	0.16^{ab}	0.050

[abc]Within a row, values with different superscripts differ at $P < 0.05$.

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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 ± 2 d; initial BW: 5.8 ± 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.

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Acknowledgements

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

References

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

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

Trt[1]	A	B	C	D	E	F	G	H	I	J	K	L
1	1[2]	1	-1[2]	-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

[1]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

[2]1 indicates inclusion in the respective treatment diet, while -1 indicates absence from the respective treatment diet.

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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 ± 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.

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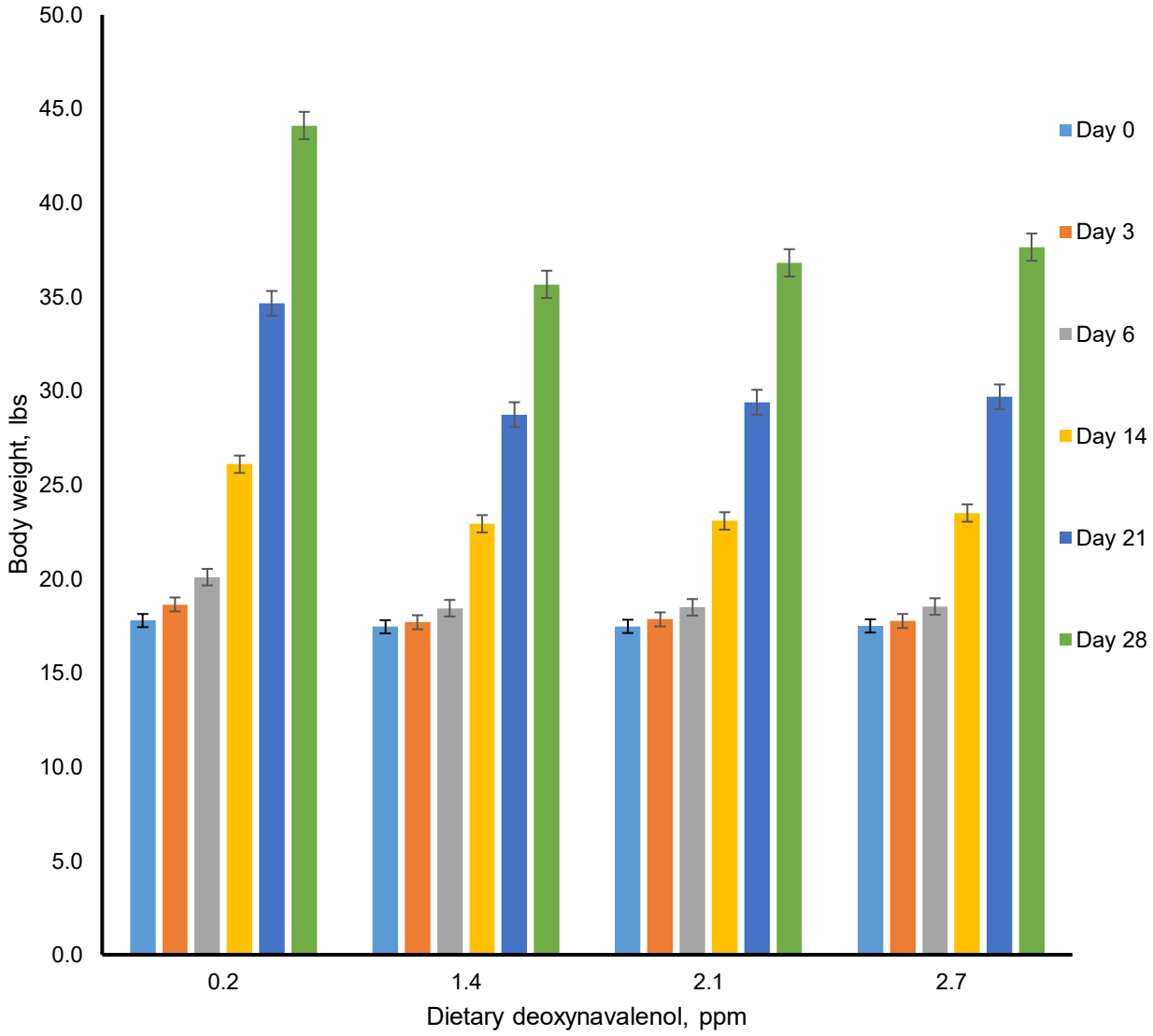
Acknowledgements

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.



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Animal Science Research Report 2026

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.

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References

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

Table 1. Sow reproductive performance and suckling pig growth of control and yeast carbohydrate-fed sows[1].

Item	CON	0.1 % YC	SEM	*P*-value[2]
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
Sow BW, kg				
Breeding	190.2	194.8	4.60	0.65
Weaning	225.3	229.7	7.04	0.54
Pigs per litter, n				
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
Mortality				
24h, %	5.66	2.57	1.89	0.17
Overall, %	10.63	11.55	2.29	0.76
Piglet BW, lb				
Day 1 lactation[3]	3.2	3.3	0.10	0.31
Weaning	11.3	12.3	0.66	0.11
Daily gain, lb[4]				
Week 1	0.374	0.352	0.044	0.50
Overall	0.440	0.440	0.020	0.69
Serum Ig, µg/mL[5]				
IgG	59.4	75.0	14.67	0.47
IgA	1.42	1.55	0.11	0.07
Hemoglobin concentration, g/L				
Birth	9.8	10.2	0.21	0.02
Wean	11.6	11.9	0.37	0.86

[1] 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).

[2] Values within a row with different superscripts differ.

[3] Average weight of pigs born alive.

[4] Based on litter performance after cross-fostering

[5] Blood samples for serum analysis were collected 2 days before weaning.

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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.

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References

NRC. 2012. Nutrient requirements of swine: 11th 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[a]	0.45[b]	0.003	0.08
Final BW (d 114), lb	263.4	261.1	1.7	0.34

[ab]Means within a row with different superscripts differ (0.05 ≤ 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, cm²	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 ± 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 ± 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.

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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
Exp. 1									
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
Exp. 2									
Crude protein, %	86.93^{a}	84.96^{ab}	81.28^{b}	82.76^{b}	80.78^{b}	81.08^{b}	81.50^{b}	1.32	<0.01
Arg	95.14^{a}	92.69^{ab}	91.56^{b}	93.42^{ab}	91.98^{b}	92.83^{ab}	94.89^{a}	1.17	0.02
His	92.64^{a}	91.55^{ab}	88.70^{bc}	90.49^{abc}	87.96^{c}	91.21^{abc}	93.28^{a}	0.75	<.01
Ile	88.57^{ab}	87.23^{abc}	84.58^{c}	88.12^{ab}	85.75^{bc}	87.89^{ab}	89.25^{a}	0.70	<0.01
Leu	87.65^{a}	86.74^{ab}	83.78^{b}	86.59^{ab}	83.71^{b}	86.67^{ab}	88.41^{a}	0.72	<0.01
Lys	88.01^{a}	85.68^{b}	86.40^{ab}	87.88^{ab}	85.70^{b}	87.60^{ab}	87.50^{ab}	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^{ab}	82.75^{ab}	81.44^{ab}	83.96^{ab}	80.51^{b}	81.42^{ab}	86.14^{a}	1.09	0.01
Phe	88.38^{a}	87.35^{ab}	84.42^{b}	87.31^{ab}	84.25^{b}	87.37^{ab}	88.86^{a}	0.75	<0.01
Thr	81.02^{a}	79.31^{ab}	75.37^{b}	79.12^{ab}	73.95^{b}	79.67^{ab}	82.32^{a}	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^{ab}	84.81^{abc}	81.61^{c}	85.99^{ab}	83.03^{bc}	85.68^{ab}	87.29^{a}	0.79	<0.01
Mean	89.23^{a}	87.65^{ab}	85.51^{b}	87.87^{ab}	85.12^{b}	87.95^{ab}	89.88^{a}	0.74	<0.01

^{abc} Within a row, values with different superscripts differ at $P < 0.05$.

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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			*P*-value		
	No Phy	Phy	No Phy	Phy	SEM	Cu	Phy	Cu*Phy
Period, d 0-62								
BW d127, lb	276.9	277.0	272.7	273.4	1.61	0.28	0.90	0.93
ADG, lb	2.47^{ab}	2.48^{b}	2.39^{a}	2.43^{ab}	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					*P*-value		
	16.5 ppm	16.5 ppm + Phy	3 ppm	3 ppm + Phy	SEM	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^{a}	23.09^{a}	20.66^{ab}	18.94^{b}	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 ± 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 (µg/ml) and IgG concentrations (µg/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: 11th ed. National Academies Press, Washington, DC.

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

Items	CON	ZINC	SEM	*P*-value
Farrowing performance				
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
Lactation performance				
Piglets d2	13.5[a]	15.6[b]	15.7[b]	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[a]	11.9[ab]	10.8[b]	0.38
ADG suckling, g/day	248[a]	220[ab]	197[b]	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
Piglet mortality				
Mortality d1 %	6.2	4.6	4.0	3.12
Wean mortality %	0.5[a]	7.3[b]	9.8[b]	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		
Sow BW, lb				
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
Feed intake, lb/d				
Lactation	13.45	13.45	0.54	0.91

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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 brennaborense* (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,

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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: 11th ed. National Academies Press, Washington, DC.

Figure 1. Differential abundance (Log2) of the species that changes the most with each treatment.

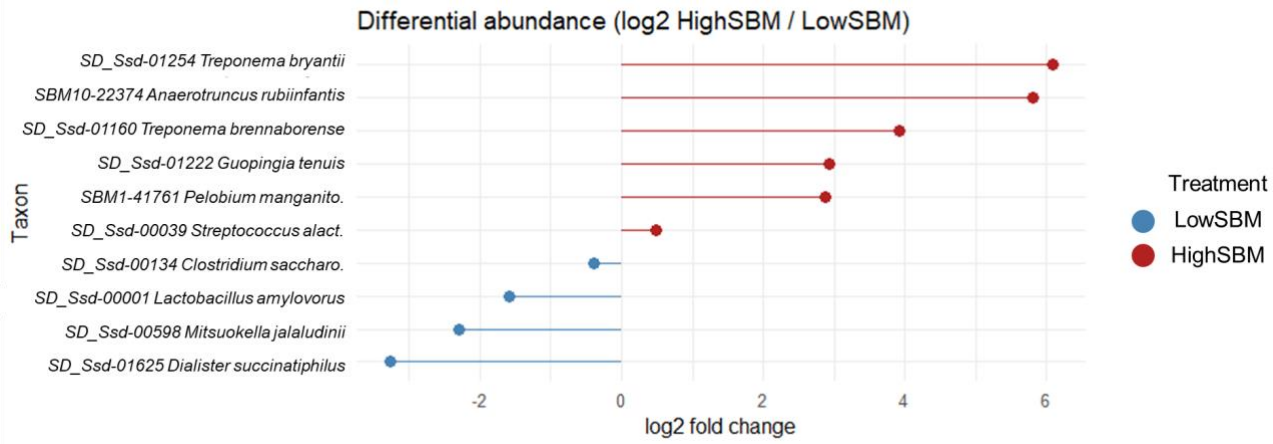
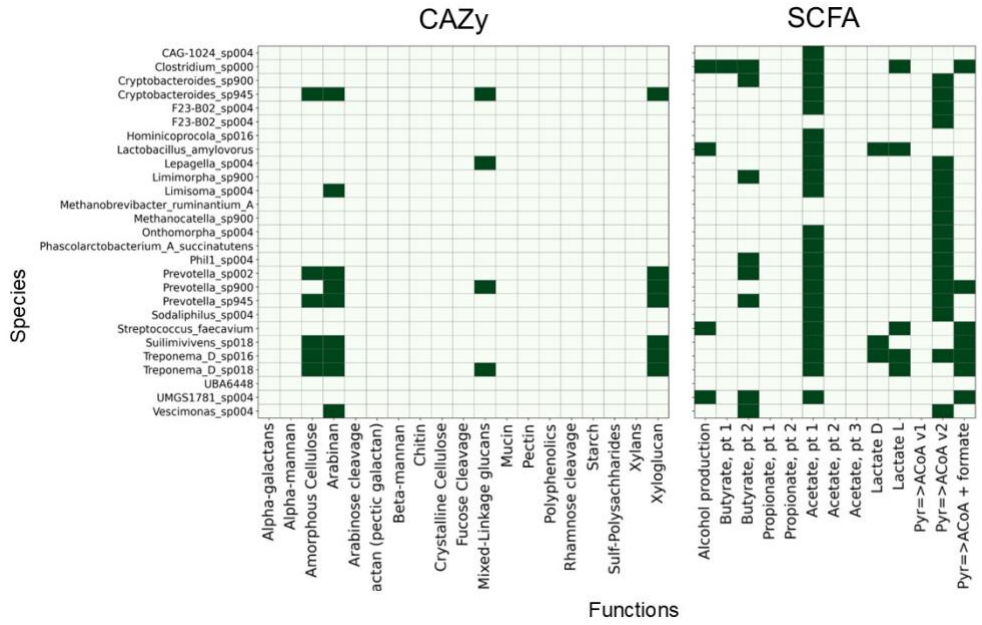


Figure 2. Heatmap showing metabolic capabilities predicted from 26 metagenome-assembled genomes (MAG's) that were analyzed from select fecal samples collected from pigs fed a high SBM diet. The panel 'CAZy' shows the predicted enzymatic activities associated with digestion of carbohydrates, while the 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_3 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

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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[1]	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[2]	6.16	5.70	0.22	0.09
Total litter wean wt., kg[2]	74.96	72.89	2.58	0.57
Pigs weaned, %[3]	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

[1]Farrowing duration adjusted for total born as a covariate
[2]Piglet wean weight and total litter wean weight adjusted for number of pigs weaned as a covariate
[3]Pigs weaned, % = (Live piglets post-fostering ÷ Liveborn piglets) × 100.

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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%).

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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 ≥ 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 ≥ 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.

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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 ± 3 days; BW: 12.46 ± 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°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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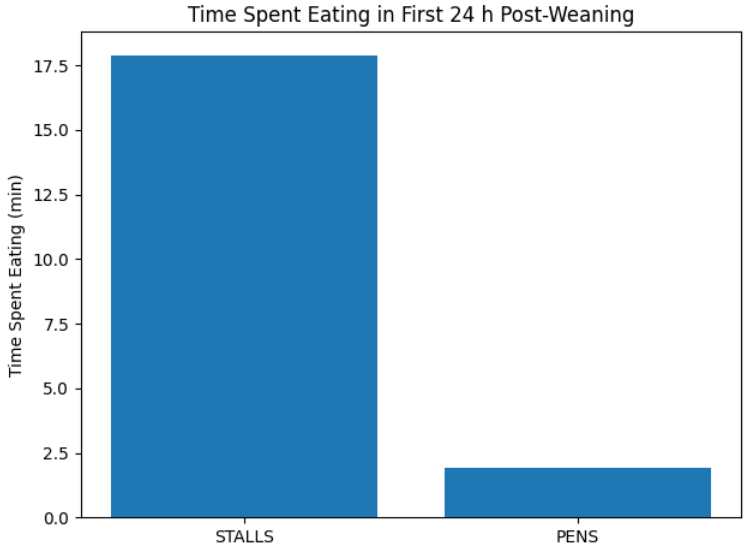
Table 1. Effects of housing environment at weaning on piglet performance.

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; $P = 0.071$).

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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 approximaly 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.

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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
BW, lb						
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
Overall (d 0–107)						
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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Bison

Observing pH of grass-fed bison heifer gastrointestinal tracts *postmortem*

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Rationale and Approach

Gastrointestinal (GI) pH is a critical indicator of metabolic health and ruminal fermentation efficiency in ruminants. While well-characterized in other ruminant species, baseline postmortem GI pH values for bison (*Bison bison*) remain largely unreported. As bison management diversifies (conservation and commercial production herds), dietary differences may significantly influence GI physiology. Establishing these baseline pH values is therefore essential for developing nutritional and health benchmarks for the species. This study aimed to characterize the pH within the rumen, omasum, and abomasum of grass-fed bison. Five approximately 36-month-old bison were humanely euthanized under USDA inspection in August 2025. Carcasses were processed in a mobile abattoir unit. The entire GI tract was removed within 24 hours postmortem. The rumen, omasum, and abomasum were identified. Digesta was collected manually by introducing a gloved arm into the lumen of each compartment. Fluid was strained through cheesecloth, and a 20 mL sample was collected for analysis. Ruminal fluid was obtained from all five animals. However, due to practical constraints during field sampling, omasal and abomasal fluids were successfully collected from a subset of two animals each (2 animals per compartment). pH was measured immediately using an Orion Star A221 Portable pH Meter (Thermo Fisher Scientific, Waltham, MA, USA), which was calibrated according to manufacturer specifications prior to use. All study animals were maintained on a grass-fed diet prior to harvest.

Results and Discussion

Given the observational nature of this trial, the results are presented using descriptive statistics. Gastrointestinal contents were harvested and analyzed at an average of 87.7 minutes postmortem. The interval between death and sample collection represents a potential limitation, as protozoal activity and autolysis occurring postmortem may have affected the measured values (Lee at al. 2010 and Wilemann et al. 2008). However, the extended sampling period was designed to capture biological variability, consistent with observations reported in other ruminant species, which may help offset this limitation. Rumen content samples were successfully collected from all five heifers. The average ruminal pH across all animals and timepoints was 5.81 (Table 1). Figure 1 illustrates the pH profiles within the rumen, omasum, and abomasum for each individual animal. The observed average ruminal pH of 5.81 falls within the range reported for pasture-fed dairy cattle (pH 5.8–6.2) (Kolver and de Veth, 2002) and is consistent with values for grain-fed beef cattle (pH 5.8–6.5) (Nagaraja and Titgemeyer, 2007). This relatively low pH suggests the consumption of highly fermentable forage. However, as a forage analysis was not conducted, any direct link between dietary composition and fermentability remains speculative. The pH values recorded in the omasum and abomasum align with established physiological

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benchmarks for cattle. The abomasal pH (4.59) is conducive to proteolytic enzymatic activity, while the higher omasal pH (6.11) is typical for this compartment (Pérez et al., 2023). These values support normal digestive function, indicating that nutrient absorption and enzymatic processes were likely proceeding typically in these animals at the time of sampling.

Implications

The findings from this observational study underscore the need to establish baseline GI pH values for bison. Specifically, these preliminary data enable more informed investigations into how divergent diets (such as grain supplementation versus native forage) affect ruminal fermentation, nutrient absorption, and overall animal health and productivity in this species. The observed similarity between bison pH values and those reported in domestic cattle suggests that certain physiological principles of ruminant digestion are conserved. However, species-specific variations likely exist, reinforcing the necessity of direct research on bison rather than relying solely on bovine models. Ultimately, establishing species-specific benchmarks is essential for developing science-based nutritional strategies that optimize bison welfare and production outcomes across diverse management systems.

Acknowledgements

We acknowledge the Bad River Ranch with Turner Enterprises in Ft. Pierre, South Dakota for access to these animals and project planning as well as Wild Idea Buffalo Company in Rapid City, South Dakota for the animals used in this investigation.

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Table 1. pH of post-mortem bison gastrointestinal compartments (Mean ± SD, *n* = 5 for rumen, *n* = 2 for omasum and abomasum).

	Gastrointestinal compartment pH (Mean ± SD)		
Sampling time (Hour)	**Rumen**	**Omasum**	**Abomasum**
0	5.85 ± 0.27	6.16 ± 0.18	4.47 ± 0.28
0.5	5.83 ± 0.24	6.10 ± 0.14	4.54 ± 0.16
1	5.80 ± 0.26	6.10 ± 0.14	4.56 ± 0.17
2	5.80 ± 0.26	6.06 ± 0.14	4.62 ± 0.21
3	5.81 ± 0.26	6.08 ± 0.16	4.60 ± 0.25
6	5.78 ± 0.27	6.12 ± 0.18	4.60 ± 0.16
12	5.79 ± 0.30	6.13 ± 0.20	4.64 ± 0.25
24	5.80 ± 0.31	6.15 ± 0.19	4.69 ± 0.18
Total period	5.81 ± 0.31	6.11 ± 0.20	4.59 ± 0.28

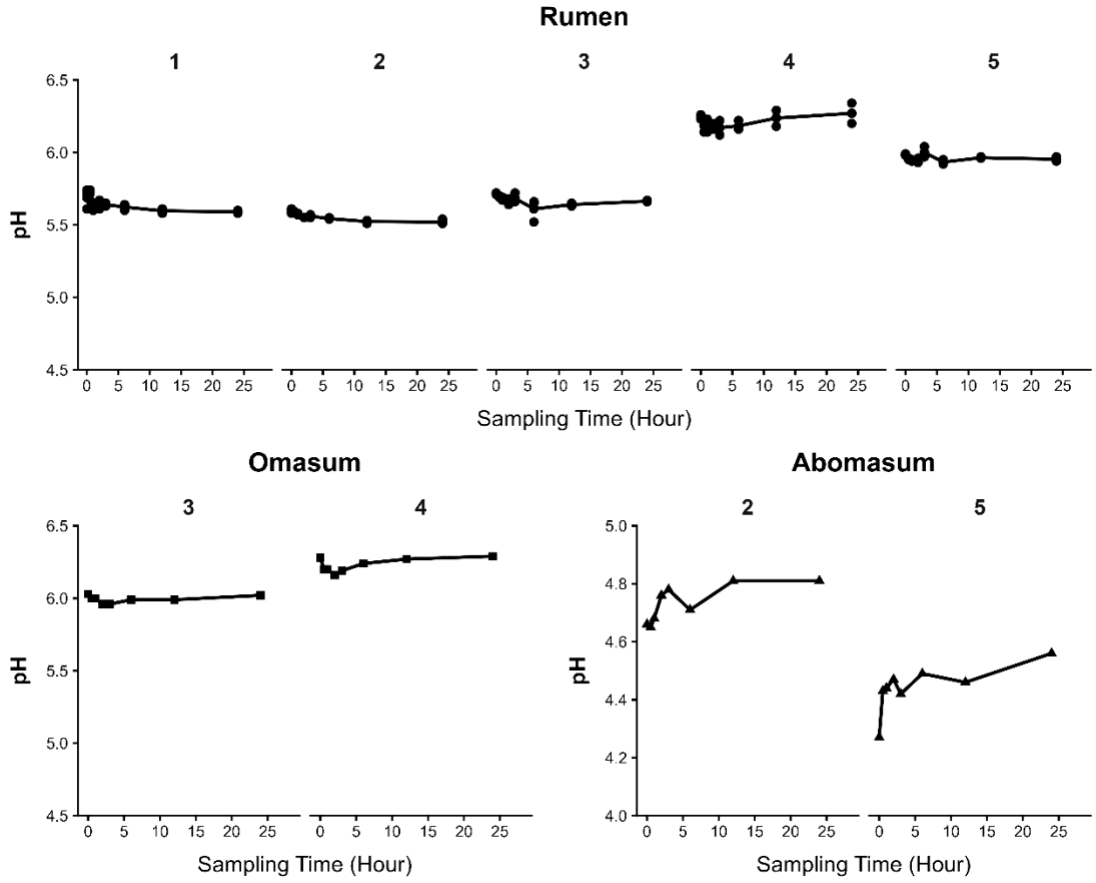

Figure 1. pH across gastrointestinal compartments in bison: rumen (*n* = 5), omasum (*n* = 2), and abomasum (*n* = 2). Number above plot indicates animal ID.

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Finishing location influences the color stability of steaks from grass-finished bison bulls

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Rationale and Approach

Approximately 12,500 grass-finished bison bulls were harvested in the United States in 2025, accounting for roughly 21% of the slaughter mix. Most bison are raised and finished across the vast landscape of the Great Plains, which is composed of diverse ecosystems that vary in climate, terrain, rainfall, forage species, and micronutrient deposits. Research in other species suggests that both the environment and the composition of the diet of grass-finished animals can influence carcass characteristics, such as meat color. Meat color significantly impacts consumer acceptance at the point of sale and has become a recent concern due to its contribution to food waste, as products that do not meet consumer expectations for color are often discounted or discarded (Ramanathan et al., 2022). Therefore, the objective of this study was to determine the influence of finishing location on the color stability of steaks from grass-finished bison bulls. Bison bulls from a common management system were grass-finished in three geographically distinct locations of the Great Plains (n = 45 bulls per location): 1) Kansas (KS), 2) Nebraska (NE), or 3) Montana (MT). Striploins were collected from a subsample (n = 30 carcasses closest to the average hot carcass weight of each treatment). This group of striploins was further subsampled [n = 15 carcasses closest to the average *a** (redness) value of each treatment] for objective color analysis. One steak from each striploin was allocated to one of two packaging strategies: 1) Aerobic overwrap (OW) or 2) Anaerobic vacuum-packaging (VAC). Steaks designated for OW were on display for 11 days (display days 0 – 10) and evaluated daily with a spectrophotometer. Steaks designated for VAC were held in dark storage for 11 days, then displayed for 31 days (display days 0 – 30) and evaluated every three days with a spectrophotometer.

Results and Discussion

No treatment-by-display day interaction ($P > 0.05$) was observed for either packaging strategy. Overwrapped steaks from KS-finished bison bulls had lower ($P < 0.05$) *a**, and *b** (yellowness), while steaks from bulls finished in MT and NE had darker ($P < 0.05$) color, as indicated by lower *L** values (Table 1). However, OW steaks from KS bulls had less ($P < 0.05$) overall color change as indicated by a lower Delta E value than those from NE, while MT was intermediate, and not different ($P > 0.05$) from the other treatments. Similar to the OW color panel, VAC steaks from KS were lighter (increased *L**), less red (decreased *a**), and less yellow (decreased *b**; $P < 0.05$) than steaks from other treatments (Table 2). Although differences were observed between finishing location for most color parameters of the VAC steaks, finishing location did not influence ($P > 0.05$) Delta E, indicating less overall color change from the start to the end of the display period.

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Implications

These data indicate that finishing location influences initial color as well as color stability of steaks from grass-finished bison bulls regardless of the packaging method. Future research is warranted to understand how the finishing location influences the mechanisms that drive the color stability of bison steaks and to develop strategies to maintain bison meat color, thereby reducing overall food waste associated with meat color.

Acknowledgements

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Table 1. Least square means for the effect of finishing location[1] on objective color measurements[2] of overwrap packaged striploin steaks from grass-finished bison bulls.

Variable	KS	NE	MT	SEM[3]	*P*-value
*L**	30.58[a]	27.83[c]	28.42[b]	0.183	< 0.01
*a**	20.30[b]	22.74[a]	22.21[a]	0.224	< 0.01
*b**	18.20[b]	20.19[a]	19.81[a]	0.203	< 0.01
Delta E	9.72[b]	13.58[a]	11.85[ab]	0.838	0.01

[1]Grass-finished in Kansas (KS), Nebraska (NE), or Montana (MT)
[2]*L**: 0 = Black, 100 = White; *a**: positive = red, negative = green; *b**: positive = yellow, negative = blue; Delta E: higher values indicate greater color change from the beginning to end of the display period
[3]Standard error of the mean
[a,b,c]Means in the same row lacking a common superscript differ ($P \leq 0.05$)

Table 2. Least square means for the effect of finishing location[1] on objective color measurements[2] of vacuum packaged striploin steaks from grass-finished bison bulls.

Variable	KS	NE	MT	SEM[3]	*P*-value
*L**	30.59[a]	29.65[b]	29.44[b]	0.199	0.01
*a**	12.55[b]	13.57[a]	13.52[a]	0.097	<0.01
*b**	13.26[b]	13.62[a]	13.62[a]	0.087	<0.01
Delta E	5.17	4.42	4.65	0.534	0.60

[1]Grass-finished in Kansas (KS), Nebraska (NE), or Montana (MT)
[2]*L**: 0 = Black, 100 = White; *a**: positive = red, negative = green; *b**: positive = yellow, negative = blue; Delta E: higher values indicate greater color change from the beginning to end of the display period
[3]Standard error of the mean
[a,b]Means in the same row lacking a common superscript differ ($P \leq 0.05$)

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Sheep

Effects of Steam Flaked Corn on Growth Performance, Carcass Characteristics, and Gastrointestinal Health in Feedlot Lambs

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Rationale and Approach

Feeding steam-flaked corn to cattle has been shown to increased feed efficiency and average daily gain (ADG). Steam flaked corn has recently become available as an affordable option to sheep producers in eastern South Dakota. However, there has been little research done to determine if the same performance effects observed in cattle are mimicked in sheep. The objective of this study was to evaluate the growth performance, carcass characteristics, and gastrointestinal health of feedlot wethers fed a TMR containing steam flaked corn. Polypay wethers (n = 32) were allocated by body weight to 16 pens (2 lambs/pen, 8 pens/treatment). Two treatments were applied: 1) TMR containing steam flaked corn (SFC) and 2) TMR containing rolled corn (RC). Lambs were fed for 63 days and received a booster vaccination of clostridium types C&D and tetanus on d -3. Ad Libitum intake was achieved by offering 10% more diet dry matter (DM) than the previous day's dry matter intake (DMI).

Results and Discussion

Lambs fed the RC diet had a greater average daily gain than the SFC fed lambs (0.47 and 0.58 lb., $P = 0.03$). There was no difference in body weight, DMI, or feed efficiency between treatments ($P \geq 0.29$). No difference in carcass characteristics was observed between treatments ($P = 0.15$). Wethers fed the SFC ration tended to have more severe rumen lesions than the RC treatment ($P = 0.09$, 12.4 and 2.7%, respectively). Lambs in the RC treatment tended to have a larger absorptive surface area (ASA) and papillae area as a percentage of ASA ($P = 0.07$ and $P = 0.09$). There was no difference between number of papillae (NOP) or mean papillae area (MPA) between treatments ($P \geq 0.11$).

Implications

Lambs fed the RC ration performed better with a 19% increase in ADG and tended to have better gastrointestinal tract health. On average, the processing cost of rolling corn costs producers up to $7.00/ ton ($0.196/ bu.). The processing cost of steam flaked corn is more costly at $14.00/ ton ($0.39/ bu.). The results of this study suggest steam flaking corn in replacement of rolled corn offers no additional benefits and is more costly to producers raising feeder lambs. Future research should further explore the impact of chewing behavior in lambs, which often results in smaller particles compared to cattle mastication. Additionally, steam flaking corn is a precise process that may need more research before the same performance effects observed in feedlot cattle are seen in feedlot lambs.

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Table 1. Growth performance, carcass characteristics, and rumen morphometric responses through d 63. Two treatments were applied: 1) TMR containing steam flaked corn (SFC) and 2) TMR containing rolled corn (RC).[1]

Item	SFC	RC	SEM	*P*-value
Body Weight				
Initial BW, lb.	67.3	63.0	4.69	0.32
Final BW, lb.	101.2	104.1	3.81	0.31
Growth performance				
ADG, lb.	0.47	0.58	0.029	0.03
DMI, lb.	3.46	3.58	0.138	0.53
G:F	0.14	0.17	0.013	0.12
Dietary Energetics[2]				
O:E NEm	0.69	0.77	0.022	0.06
O:E NEg	0.62	0.72	0.028	0.07
MQ, Mcal/MBS	0.140	0.120	0.0070	0.13
Carcass Traits				
EBW, lb.	88.4	90.0	3.38	0.58
HCW, lb.	54.7	56.7	2.08	0.21
DP, %[3]	53.99	54.51	0.267	0.22
RF, in.	0.17	0.20	0.017	0.15
REA, in. sq.	2.01	2.03	0.059	0.78
Rumen Morphometrics				
Rumen papillae count	89.50	98.37	0.038	0.11
Mean papillae area, cm sq.	0.117	0.138	0.0118	0.24
Absorptive Surface Area, cm sq./ cm sq. of rumen wall	11.09	14.07	0.906	0.07
Papillae area % of ASA	92.64	94.35	0.601	0.09
Rumen Scores				
Healthy, %	23.11	60.66	-	0.09
Mild, %	44.24	30.71		
Moderate, %	20.22	5.94		
Severe, %	12.43	2.69		

[1]A 4% pencil shrink was applied to all BW measures to account for digestive tract fill.
[2]Calculated according to Zinn and Shen, 1998 using live-basis growth performance.
[3]Calculated as: (HCW/Final BW) × 100.

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Department of Animal Science | SDSU Extension

Beef

Essential oils impact rumen kinetics but not post-ruminal digestibility in steers fed high-grain finishing diets

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Rationale and Approach

Monensin, a widely used ionophore, is known to enhance feed efficiency, modify rumen fermentation, and improve volatile fatty acid (VFA) profiles. However, growing consumer demand for antibiotic alternatives has increased interest in essential oils, which possess antimicrobial properties and may modulate rumen fermentation. The objective of this study was to evaluate the effects of a specific essential oil blend (RB; eugenol, linalool, and anethole) and monensin (MON), alone or in combination, on ruminal kinetics and nutrient digestibility. Four Red Angus steers (initial BW = 959 lbs.) with ruminal and duodenal cannulas were used in a 4 × 4 Latin square with a 2 × 2 factorial arrangement. Treatments included: 1) CON (no additives), 2) RB+ (14 g/d RB), 3) MON+ (400 mg/d MON), and 4) RB+MON+ (combination). The basal diet contained 67% dry-rolled corn, 20% DDGS, 10% grass hay, and 3% premix (DM basis). Each 28-day period included a 14-day adaptation and a 14-day collection phase.

Results and Discussion

Supplementation with RB significantly altered ruminal fermentation profiles (Table 1). The molar proportion of acetate decreased ($P = 0.04$) while propionate increased ($P = 0.05$), leading to a lower Acetate:Propionate ratio ($P = 0.03$). Other VFAs, including butyrate and branched-chain VFAs, were unaffected by treatments ($P \geq 0.06$). While an RB × MON interaction was detected for lactate ($P = 0.02$), mean separation revealed no specific treatment differences. Ammonia concentrations remained consistent across all groups ($P \geq 0.70$), averaging 9.07 ± 1.74 mM. Nutrient intake, flow, and post-ruminal digestibility were largely unaffected by supplementation ($P \geq 0.16$). However, RB supplementation did result in greater total tract starch digestibility ($P = 0.05$). Microbial nitrogen flow to the small intestine was also unaffected by the additives ($P \geq 0.51$). These results suggest that while these additives—particularly the essential oil blend—can shift the rumen environment toward more efficient energetic precursors like propionate, they do not drastically alter the physical flow of most nutrients in steers fed high-corn diets.

Implications

This study demonstrates that the essential oil blend (RB) can effectively modify ruminal fermentation by increasing propionate and decreasing the Acetate:Propionate ratio, similar to the effects typically expected from ionophores. The increase in total tract starch digestibility suggests a potential for improved energy extraction. Because RB and monensin did not show synergistic or antagonistic effects on most flow parameters, producers may have flexibility in using essential oils as a tool to manipulate ruminal efficiency without compromising nutrient delivery to the small intestine.

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Acknowledgements

This research was supported by VOLAC International.

Table 1. Effects of an essential oil blend (RB; eugenol, linalool, and anethole), monensin, or the combination, on the ruminal fermentation parameters of red angus steers fed a high-grain corn-based finishing diet[1]

	Treatment[2]								
	MON-	MON-	MON+	MON+		*P*-value[4]			
Item	RB-	RB+	RB-	RB+	SEM[3]	MON	RB	MON×RB	Time
(%)									
Acetate	56.9	51.8	53.2	50.3	3.46	0.15	0.04	0.5	<0.01
Propionate	22.1	28	24.8	33.4	5.76	0.17	0.03	0.62	0.15
Butyrate	12.8	12.8	14.4	11.8	1.74	0.83	0.37	0.35	<0.01
Isobutyrate	1.00	0.88	0.92	0.75	0.113	0.14	0.06	0.68	<0.01
Valerate	2.05[a]	1.54[b]	1.40[b]	1.58[b]	0.202	<0.01	0.08	<0.01	<0.01
Isovalerate	5.18	5.01	5.29	2.16	1.61	0.21	0.14	0.18	0.85
Lactate	0.52	0.99	1.29	0.43	0.361	0.68	0.47	0.02	0.06
Ammonia	9.44	8.48	9.14	8.98	2.61	0.94	0.70	0.78	0.03
A:P[5], ratio	2.57	1.7	1.99	1.45	0.529	0.17	0.03	0.94	0.05

[1]Basal diet was comprised of (all on DM basis): dry-rolled corn 67%, grass hay 10%, dry distillers' grains 20%, vitamin and mineral premix 3%.
[2]MON-: no monensin fed; MON+: monensin fed at 400 mg/d; RB-: no essential oils fed; RB+: essential oils blend fed at 14 g/d.
[3]Standard error of the mean (n = 4 / treatment).
[4]Observed significances for the effects of: MON (monensin), RB (essential oils), MON×RB (interaction monensin by essential oils) and Time.
[5]Acetate to propionate ratio,
Interactions for: a) time × monensin, b) time × essential oils, and c) time × monensin × essential oils, were also analyzed, while non significances were detected ($P > 0.10$).

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Animal Science Research Report 2026

Effects of DDGS and/or canola meal on rumen microbiome of growing steers

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Rationale and Approach

Beef diets in the Northern Plains traditionally rely on corn and dried distiller's grains plus solubles (DDGS). While energy-dense, these diets often lack an ideal balance of essential amino acids (AA), specifically lysine and methionine. As cattle genetics improve, the demand for metabolizable protein (MP) increases to support heavier finishing weights. Canola meal (CM) offers a superior AA profile compared to DDGS, yet its impact on the rumen microbiome when substituted for DDGS remains largely unexplored. The objective of this study was to characterize the microbial composition of steers fed varying levels of CM in place of DDGS. Six rumen- and duodenal-cannulated Jersey steers (initial BW = 567 lbs.) were utilized in a duplicate 3 × 3 Latin square design. Treatments included: CON: 20% DDGS (DM basis), CM50: 50% DDGS replaced by CM, and CM100: 100% DDGS replaced by CM Each 17-day period included a 10-day adaptation and a 7-day collection phase. Rumen fluid was collected on day 17, and DNA was extracted via bead beating. Sequencing was conducted at the SDSU Seeds Laboratory using Oxford Nanopore long-reads (>100,000 reads/sample). Taxonomic classification was performed via the EMU Implementation (SILVA Ver. 132) at 97% similarity. Differential abundance was analyzed using Wald tests for three pairwise contrasts: CON vs. CM50, CM50 vs. CM100, and CON vs. CM100.

Results and Discussion

A total of 1,776 unique operational taxonomic units (OTU) were identified. At the genus level, *Prevotella* was the most abundant group across all treatments (~14% of reads). Significant shifts in microbial population were observed. We found 9 differentially abundant genera in CON vs CM50, 15 in CM50 vs CM100, and 10 in CON vs CM100 (Figure 1). Uncultured species of *Erysipelotrichaceae* and *Kandleria* were significantly higher ($P < 0.01$) in CM100 compared to CON. These groups are known sugar fermenters that produce lactate, aligning with the higher lactate concentrations measured in CM100 steers. *Prevotellaceae* abundance was higher ($P < 0.01$) in CON than CM100 (Figure 2). Given the versatile metabolic nature of this family, the reduction in CM100 suggests specific compounds in canola meal may selectively inhibit or favor certain species.

Implications

Replacing DDGS with canola meal shifts the rumen microbiome toward a higher abundance of lactate-producing species (*Erysipelotrichaceae* and *Kandleria*) while reducing *Prevotellaceae*. These alterations suggest that canola meal can be used to manipulate rumen fermentation and energy pathways. While these microbial shifts are evident, further research is required to determine the specific impacts on average daily gain (ADG) and overall feed efficiency in finishing operations.

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anticipated that the PFA would appreciably influence growth or health outcomes under the conditions of this experiment.

Acknowledgements

This research was supported by the Northern Canola Growers Association.

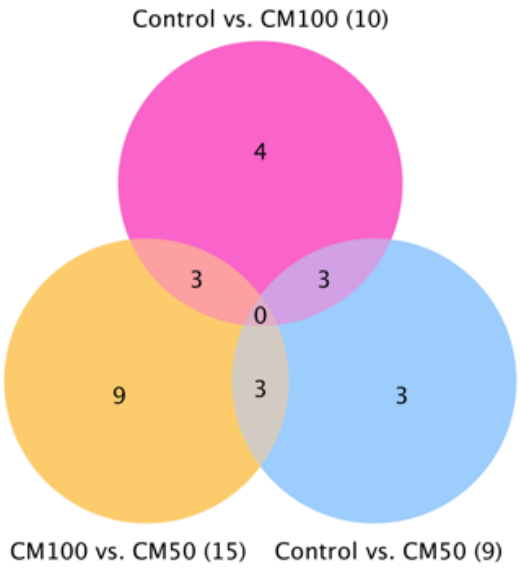

Figure 1. Differentially abundant genera in response to dietary treatments. CON: 20% DDGS (DM basis), CM50: 50% DDGS replaced by CM, and CM100: 100% DDGS replaced by CM

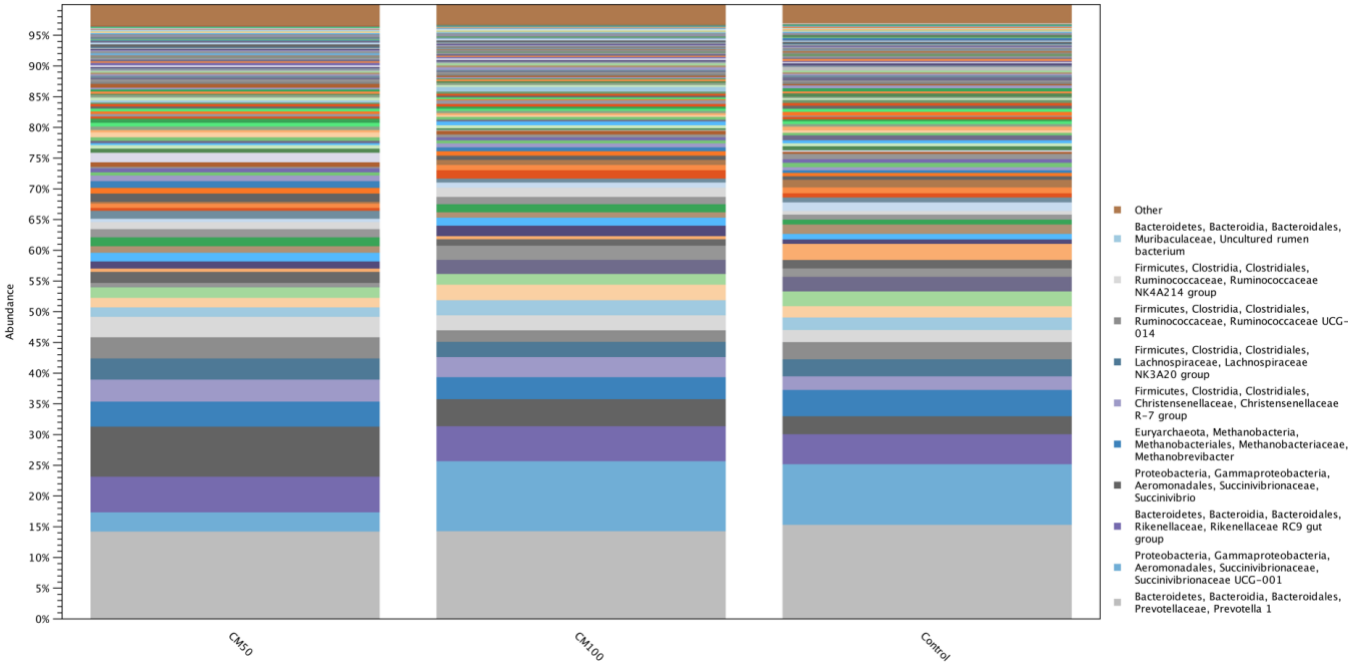

Figure 2. Most abundant bacteria families identified in response to dietary treatments. CON: 20% DDGS (DM basis), CM50: 50% DDGS replaced by CM, and CM100: 100% DDGS replaced by CM

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Evaluation of administering a suckling implant to Angus crossbred steer calves reared in a Western rangeland environment

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Rationale and Approach

Administering an implant in beef calves prior to weaning can be a useful tool in maximizing weaning weights and later growth performance, as well as optimizing forage utilization in drought conditions. The objectives of this experiment were to 1) gain a better understanding of the impact of administering a suckling implant on weaning weight, growth performance, and carcass composition during the receiving phase in Angus based steers reared in a Western rangeland environment and 2) evaluate the influence of dam age on growth performance of implanted vs non-implanted beef steers from branding to weaning. Suckling beef steer calves from the South Dakota State University Cottonwood Research Station cow herd in western South Dakota [n = 57; initial body weight (BW) 216 and 209 lbs] were utilized in a suckling and receiving study. The steers were utilized in a randomized complete block design and were blocked by location in the feedlot during the receiving phase of the study. The treatment groups of the steers were determined utilizing calf birth weight (BW = 85 $\pm$ 1.1 lbs) and dam age (< 4 years and $\geq$ 4 years of age) at equal representation in each treatment: 1) no implant administered at branding (NI), or 2) implant (Synovex-C; 10 mg estradiol benzoate and 100 mg progesterone) administered at the time of branding (IMP). Upon arrival at the feedlot following weaning, steers were assigned to 1 of 10 pens (n = 5 pens/treatment with 4, 5, or 6 steers/pen) based on treatment group and weaning weight and placed on a common diet. The steers were weighed at branding, preconditioning (25 d prior to weaning), weaning d1, d14, d28, and d49 to determine growth performance. Carcass ultrasonography was also performed and recorded on d1 and d49 to better understand the impact of suckling implants on growth composition. Additionally, a statistical analysis was performed to determine how dam age ($\geq$4 years vs <4 years) and treatment (IMP vs NI) impacted weaning weight. All data were analyzed using the GLIMMIX procedure of SAS 9.4 with treatment (NI vs IMP) as the fixed effect, and block as the random effect.

Results and Discussion

No significant differences (P > 0.05) in BW or average daily gain (ADG) were observed between treatment groups from the time of implantation/branding to weaning (Table 1). Lack of differences during this phase of the study may be a result of above average precipitation in western South Dakota for this time period, causing abnormal forage quality attributes for the area. From d1 (weaning) to d49 in the feedlot, no differences (P > 0.05) in performance measures were observed between treatments (Table 1). Ultrasound data from d1 and d49 show no differences (P $\geq$ 0.10) in carcass traits between groups (Table 2). The analysis on the impact of dam age and treatment on weaning weight showed that dam age had no influence (P = 0.62) on weaning weight for either treatment.

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Implications

Utilizing a suckling implant has the potential to maximize weaning weights and forage utilization, but this study shows that the conditions under which the implant is used may play an important role on the impact of the implant. Further research utilizing pasture in drought conditions and accounting for further background variations will provide more information on the usefulness of a suckling implant as a drought mitigation strategy.

Table 1. Pre-feedlot and receiving phase growth performance response from Angus based steers with no suckling implant (NI) vs suckling implant administered (IMP) at the time of branding[1].

Item	NI	IMP	SEM	*P*-value
Steers, n	28	29	-	-
Pens, n	5	5	-	-
Initial BW, lbs	216	209	5.0	0.38
Branding to Preconditioning				
Preconditioning BW, lbs	465	452	8.3	0.29
Average Daily Gain (ADG), lbs	2.07	1.97	0.068	0.29
Preconditioning to Weaning				
Weaning BW, lbs	540	536	7.5	0.75
ADG, lbs	2.99	3.35	0.290	0.38
Branding to Weaning				
Average Daily Gain, lbs	2.23	2.20	0.051	0.75
Weaning to d 14				
d 14 BW, lbs	595	596	2.9	0.82
ADG, lbs	3.30	4.43	0.378	0.10
Dry Matter Intake (DMI), lbs	10.46	11.13	0.418	0.32
F:G[2]	3.18	2.51	-	0.07
d 15 to d 28				
d 28 BW, lbs	612	609	4.3	0.68
ADG, lbs	1.17	0.91	0.242	0.49
DMI, lbs	13.37	13.68	0.607	0.74
F:G[2]	10.38	11.08	-	0.80
d 29 to d 49				
d 49 BW, lbs	701	695	5.8	0.50
ADG, lbs	4.25	4.09	0.145	0.47
DMI, lbs	16.89	17.32	0.548	0.61
F:G[2]	3.97	4.18	-	0.59
Weaning to d 49				
ADG, lbs	3.10	3.27	0.198	0.56
DMI, lbs	14.04	14.51	0.451	0.61
F:G[2]	4.50	4.32	-	0.66

[1]A 4% pencil shrink was applied to all body weight (BW) measures to account for gastrointestinal tract (GI) fill.

[2]Calculated as DMI/ADG; analyzed as G:F; reported as 1/G:F

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Table 2. Ultrasound measurements with projected quality and yield grades from Angus based steers with no suckling implant (NI) vs suckling implant administered (IMP) at the time of branding[1].

Item	NI	IMP	SEM	*P*-value
Weaning (d 1)				
12th Rib Fat, in	0.115	0.104	0.0046	0.12
Loin Depth, in	1.73	1.78	0.037	0.38
Intramuscular Fat, %	4.02	3.88	0.065	0.12
% Choice[2]	85.4	84.1	0.68	0.20
% Premium Choice[2]	61.4	58.5	1.22	0.10
% Prime[2]	12.7	10.4	0.98	0.10
% Yield Grade 4 and 5[3]	45.7	44.6	0.56	0.17
Projected Quality Grade Distribution[4]				
High Choice, n	2	0	-	0.31
Average Choice, n	24	26		
Low Choice, n	1	1		
d 49 Post-Weaning				
12th Rib Fat, in	0.143	0.134	0.0058	0.28
Loin Depth, in	1.98	1.98	0.037	0.95
Intramuscular Fat, %	4.15	4.18	0.065	0.69
% Choice[2]	87.0	86.9	0.65	0.88
% Premium Choice[2]	63.3	64.0	1.26	0.70
% Prime[2]	12.6	14.6	1.09	0.19
% Yield Grade 4 and 5[3]	47.9	47.0	0.43	0.17
Projected Quality Grade Distribution[4]				
High Choice, n	2	5	-	0.17
Average Choice, n	26	23		
Low Choice, n	0	1		

[1]Measured at the 12th and 13th rib

[2]Confidence score of carcasses that are expected to receive a choice (Small = 400, Modest = 500, and Moderate = 600 marbling), premium choice (Modest = 500 and Moderate = 600 marbling), or prime (Slightly Abundant = 700 or greater marbling) quality grade at harvest.

[3]Confidence score of carcasses that are expected to receive a yield grade of 4 or 5 at harvest.

[4]Projected quality grade distribution for carcasses to be graded as high (Moderate = 600), average (Modest = 500), or low (Small = 400) choice at harvest.

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Evaluation of partial replacement of distillers' grains with heat-treated full-fat soybeans on growth and carcass characteristics in finishing beef steers

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Rationale and Approach

Distillers' grains (DGS) are widely used as a source of protein and energy in feedlot diets. Soybeans are rich in essential amino acids (as a % of CP), particularly lysine. Heat treating full-fat soybeans increases ruminal undegradable protein (RUP) content and reduces anti-nutrition factors. Previous research at SDSU showed that complete replacement of DGS with heat-treated soybeans enhanced growth performance and increased carcass weight. However, under current market conditions, the additional carcass weight value was not sufficient to overcome the increased diet costs. Feeding a blend of DGS with heat-treated soybeans might optimize potential performance gains with the greater costs of heat-treated soybeans compared to DGS.

The objective of this study was to determine the effects of partially replacing modified distillers' grains (MDGS) with full fat extruded (heat-treated) soybeans (ESB) on growth performance and carcass characteristics of finishing beef steers. Simmental x Angus steers (n=128; 906 ± 54 lbs) were allotted by initial BW to one of 16 dry lot pens (n = 8 pens/treatment, and 8 steers/pen) at the Southeast Research Farm (Beresford, SD) in a randomized complete block design. Basal diets (DM basis) were based on dry-rolled corn (DRC) and differed by protein supplement: 17.1% MDGS (ESB-0) or 10.38% MDGS and 5.8% ESB (ESB-6) and are presented in Table 1. Diets contained similar CP concentration and ESB-6 contained 1 percentage unit greater dietary fat. Steers were implanted with 200 mg TBA and 20 mg E_2-17B (Revalor-200; Merck Animal Health) on d 28. Lubabegron fumarate (Experior; Elanco Animal Health) was fed for 54 days (d 85 to d 139) at 36 mg/head daily followed by a 4-d voluntary withdrawal. Steers were weighed and shipped for harvest on d 143 and harvested the following day.

Results and Discussion

Results are presented in Table 2. During the first 28-d, ESB-6 did not affect DMI or ADG ($P \geq 0.22$) but tended to improve F:G by 4.5% ($P = 0.08$). For the 28-d period post-implanting (d 29 to d 56), feeding ESB-6 increased ADG by 10.4% ($P = 0.01$) and decreased F:G by 8.5% ($P = 0.03$) with no difference in DMI ($P = 0.53$). Treatment did not affect DMI, ADG, or F:G ($P \geq 0.52$) from d 57 to d 84. Feeding ESB-6 with Experior (d 85 to d 143) increased ADG by 11.5% ($P = 0.05$) and tended to improve F:G by 9.5% ($P = 0.10$). Cumulatively, feeding ESB-6 increased ADG by 7.3% ($P = 0.01$) and tended to decrease F:G by 5.6% ($P = 0.08$) but did not affect DMI ($P = 0.58$). Feeding ESB-6 increased final body weight and HCW by 43 and 27 lbs, respectively ($P = 0.01$) and tended to increase rib fat thickness ($P = 0.06$)

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and calculated USDA YG (P = 0.09), with a greater proportion of cattle in YG 4 and 5 (P = 0.02). Treatment did not affect ribeye area or USDA marbling scores. ($P \geq 0.22$).

Implications

Under the conditions of this experiment, replacing one-third of MDGS on a DM basis with ESB increased ADG and carcass weight and tended to improve feed efficiency. This approach could be a tool to increase revenue for cattle feeders while also providing new markets for soybean growers.

Acknowledgements

We wish to acknowledge the efforts of Scott Bird at the Southeast Research Farm for the daily management of the cattle in this experiment.

Table 1. Composition of diets (Percentage DM basis)

Ingredient	ESB-0	ESB-6
Dry rolled corn	67.3	68.0
MDGS[1]	17.1	10.4
Extruded soybeans	--	5.8
Sorghum/corn silage blend[2]	7.9	8.0
Grass hay	3.9	3.9
Liquid supplement[3]	3.9	3.9
Nutrient composition[4]		
Dry matter, %	70.5	73.2
Crude protein, %	14.0	14.2
Neutral detergent fiber, %	17.7	17.2
Fat, %	3.2	4.1
NEg[5], Mcal/cwt	63.5	64.7

[1]Modified distillers grains with solubles
[2]Blend of intercropped forage sorghum and corn
[3]Formulated to exceed nutrient requirements for trace mineral and vitamins. Contained 30 g/ton monensin.
[4]Tabular nutrient composition estimates (Preston, 2017)
[5]Net energy for gain

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Table 2. Growth performance and carcass responses in steers fed either diets consisting of 17.1% modified distillers (ESB-0) or a blend of 10.4% modified distillers and 5.8% extruded soybeans (ESB-6).

Item	ESB-0	ESB-6	SEM	*P*-value
Initial wt, lbs[1]	907	906	0.9	0.60
d 0 to d 28 (pre-implant)				
d 28 wt, lbs[1]	1021	1027	5.0	0.30
ADG, lbs	4.08	4.31	0.161	0.22
DMI, lbs	23.6	23.7	0.65	0.87
Feed:gain[2]	5.75	5.49	--	0.08
d 28 to d 56				
d 56 wt, lbs[1]	1168	1191	6.1	0.01
ADG, lbs	5.25	5.86	0.129	0.01
DMI, lbs	25.4	26.0	0.84	0.53
Feed:gain[2]	4.83	4.42	--	0.03
d 57 to d 84				
d 84 wt, lbs[1]	1292	1314	6.3	0.01
ADG, lbs	4.41	4.38	0.255	0.91
DMI, lbs	27.0	27.5	0.89	0.52
Feed:gain[2]	6.10	6.29	--	0.63
d 85 to d 143 (Experior phase)				
d 143 wt, lbs[1]	1450	1493	8.6	0.01
ADG, lbs	2.68	3.03	0.147	0.05
DMI, lbs	26.0	26.5	0.87	0.58
Feed:gain[2]	9.61	8.69	--	0.10
Cumulative				
ADG, lbs	3.80	4.10	0.055	0.01
DMI, lbs	25.6	26.0	0.78	0.58
Feed:gain[2]	6.71	6.33	--	0.08
Carcass Data				
Hot carcass weight, lbs	939	966	8.3	0.01
Rib fat, in	0.69	0.76	0.031	0.06
Ribeye area, sq in	13.9	14.1	0.11	0.22
Marbling score[3]	510	525	16.9	0.40
Yield grade	3.7	3.9	0.12	0.09
YG > 4 & 5, %	32.8	56.2	--	0.02

[1]A 4% pencil shrink was applied to all body weight measures.
[2]Analyzed as gain:feed and reported as 1/gain:feed.
[3]400 = Small[00], low Choice; 500 = Modest[00], average Choice

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Influence of nutrient restriction during mid-gestation on calf performance through weaning

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Rationale and Approach

The U.S. beef industry continues to produce more pounds of beef with fewer cows, making each calf born increasingly valuable to overall herd profitability. Pre-weaning growth plays a major role in determining pounds weaned per cow exposed, which is one of the most important drivers of profitability for cow-calf producers. Research suggests that a cow's nutritional status during gestation, particularly during mid-gestation when key muscle and fat cells are developing, may influence how a calf develops and grows after birth. However, limited information exists on how maternal energy restriction during this period affects calf performance through weaning. Understanding these relationships could provide producers with management strategies to optimize calf growth and efficiency before calves ever reach the feedlot. To evaluate the impacts of mid-gestation nutrient restriction on calf response gestating beef cows were assigned to either maintain/improve body condition during mid-gestation [positive energy status (PES); n = 22] or undergo intake restriction to reduce body condition [negative energy status (NES); n = 16]. All cows received the same total mixed ration delivered twice daily via bunks. This diet was intended to typify fall rangeland grazed forage conditions. Treatment differences were based on the amount of feed that each group was provided (nutrient restricted treatment received less feed). Following the mid-gestation treatment period, all cows were managed to achieve a positive energy status through late gestation. At parturition calf birth weight was recorded and pairs were managed as a common group until weaning.

Results and Discussion

Nutrient-restricted cows lost body condition as expected and had a reduction in the size of ultrasound-measured body fat depots and muscle mass. However, calf birth weight was not affected ($P > 0.05$) by maternal nutrient restriction during mid-gestation (Table 1). This aligns with previous research showing that late gestation nutrition has a greater influence on birth weight, as most fetal growth occurs during the final trimester. In this study, cows likely prioritized nutrients to support fetal development despite mid-gestation restriction, resulting in similar calf size at birth. Additionally, no differences were observed in pre-weaning average daily gain or weaning weight ($P > 0.05$) between treatment groups (Table 1).

Implications

Maternal nutrient restriction during mid-gestation did not impact calf birth weight, or pre-weaning performance. While these findings show that short-term mid-gestation restriction did not reduce pre-weaning performance under the conditions of this study, producers should carefully weigh the risks of body condition loss, subsequent reproductive success, and overall herd health before implementing

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such management strategies. Further research is needed to determine potential impacts on post-weaning growth and long-term performance of beef calves.

Acknowledgements

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Table 1. Least square means for the effect of cow energy status treatment during mid-gestation on calf performance from birth to weaning

Variable	PES[1]	NES[1]	SEM[2]	*P*-value
Birth weight, lb	82.0	77.2	3.40	0.22
Weaning weight, lb	426.4	411.4	13.12	0.42
Average daily gain, lb/day	2.29	2.29	0.071	0.76

[1]PES = cows maintained or gained a BCS during mid-gestation; NES = cows lost BCS during mid-gestation
[2]Standard error of the mean

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Evaluation of partial replacement of distillers grains with extruded soybeans and the effects on growth and immune function

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Rationale and Approach

A critical period in the beef production system is when freshly weaned, bawling calves are being received into the feedlot to grow. When a newly weaned calf comes to the feedlot, the stress that is encountered along the way may negatively affect calf health and performance. When a stressed animal arrives in the feedlot, intake is the mechanism most affected, which then increases the risk of illness, such as bovine respiratory disease, as well as many other diseases that may arise from inadequate nutrition. If antibody production is diet-dependent, then tailoring protein and energy intake is a key strategy for managing overall health. The objective of this study was to compare growth performance and antibody production based on partial replacement of dried distillers grains (DDGS) with extruded soybean (ESB). Dietary treatments were: 1) DDGS (20% diet inclusion, dry matter basis [DMB]) and 2) Partial replacement of DDGS with ESB included at 5.4% DM basis. Ten pens were used, with 5 pens per treatment, and 8 head per pen (40/treatment). Steers were allocated to pens within 24 hours of arrival at the feedlot. Cattle were fed over a 55-day period. Animals were given a 2 mg/mL ovalbumin immunization vaccine, subcutaneously, to test the immune response in relation to the diet and over time. Blood was collected every two days for the first week, and weekly until day 42 of the challenge. An enzyme-linked immunosorbent assay (ELISA) test was performed to measure seroconversion between the two groups.

Results and Discussion

No animals were removed from study. One steer had an occurrence of respiratory illness and was treated. No cases of mortality were observed or recorded. Growth performance results are presented in Table 1. There was a tendency for a treatment by day interaction for seroconversion of ovalbumin antibodies where steers fed ESB had greater seroconversion of ovalbumin post-immunization compared to control steers. A difference ($P < 0.01$) was observed on day 42 in seroconversion between the diets. No appreciable differences in BW, ADG, or F:G in the 55-day receiving period. There was a tendency ($P = 0.08$) for lesser DMI in the ESB group compared to the DDGS group.

Implications

This data suggests that the partial replacement of DDGS with ESB may modulate the immune response of receiving calves by increasing antibody production in response to infection.

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Table 1. Growth performance responses for extruded soybean inclusion (ESB) in replacement of dried distillers grains plus solubles (DDGS) during the 55-d receiving period. Dietary treatments were: 1) DDGS (20% diet inclusion, dry matter basis [DMB]; ESB-0) and 2) Partial replacement of DDGS with ESB included at 5.4% DM basis (ESB-6).

	Treatment			
Item	**ESB-0[3]**	**ESB-6[3]**	**SEM**	***P*-value**
Steers, n	40	40	-	-
Pens, n	5	5	-	-
Body weight				
Initial BW[1], lb	520	520	0.7	0.59
d 55 BW, lb	656	651	7.0	0.49
Growth performance				
ADG, lb	2.46	2.39	0.120	0.43
DMI, lb	13.76	13.12	0.262	0.08
G:F	0.183	0.183	0.0067	0.97
F:G[2]	5.46	5.46	-	-

[1]No shrink was applied to initial BW.
[2]Calculated as: 1/G:F.
[3]Based on diet of either 20% inclusion DDGS (DDGS) or 14:6% inclusion DDGS to 5.4% ESB (ESB-6).

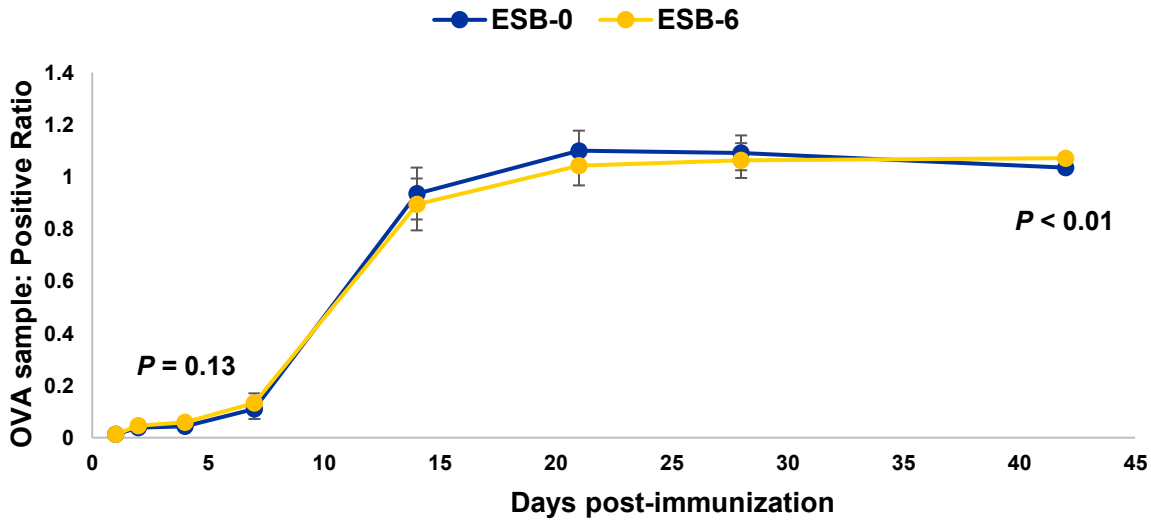

Figure 1. Seroconversion over 42-day challenge period during the feeding study. Dietary treatments were: 1) DDGS (20% diet inclusion, dry matter basis [DMB]; ESB-0) and 2) Partial replacement of DDGS with ESB included at 5.4% DM basis (ESB-6).

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Hammer-milled rye and inter-planted corn and forage sorghum blends as alternatives to corn-based ingredients for growing beef steer diets.

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Rationale and Approach

Corn has long been a staple feedstuff for both grain and silage sources alike in backgrounding operations. Nonetheless, cereal hybrid rye and forage sorghum can be viable feedstuffs to help reduce feed costs and mitigate production risk from drought, disease, and pest pressure. However, forage sorghum can be difficult to dry down to favorable dry matter for optimal fermentation or patience is needed to wait for a killing frost to direct-chop as a standing crop. Interplanting forage sorghum with corn and direct chopping may be advantageous for improved feed value compared to forage sorghum and reduced input costs compared to planting corn for silage. Previous research from SDSU demonstrated that hybrid rye can partially replace dry-rolled corn in finishing diets but less in known about the value of rye grain in backgrounding diets. The objective of this study was to determine the effects of dry-rolled corn (DRC) compared to hammer-milled cereal hybrid rye (RYE) fed with either corn silage (CSL) or a forage sorghum/corn silage blend (SCO) arranged as a 2 x 2 factorial in a 63-day growing study. Simmental x Angus crossbred steers (n = 224 steers, initial BW = 637 lbs) were blocked by weight and allocated into pens (n = 24 pens, 8-10 head/pen) resulting in six pens per treatment. Starch concentrations (dry matter basis) for each silage type were similar. Treatment diets are presented in Table 1. Outcome variables of interest were dry matter intake (DMI) average daily gain (ADG), and feed efficiency (F:G).

Results and Discussion

Results are presented in Table 2. Feeding DRC increased ADG 6.8% through d35 ($P = 0.04$) and tended to increase DMI from d1-35 and d36-63 ($P \leq 0.09$). Cumulative DMI increased by 1.8% when DRC was fed (21.09 and 20.72 lb/d for DRC and RYE, respectively; $P = 0.01$). Feeding SCO increased DMI from d1-35 and d36-63 ($P \leq 0.05$) and cumulatively increased DMI by 2% (20.69 and 21.11 lb/d for CSL and SCO, respectively; $P = 0.01$). Grain source and silage type tended to interact for cumulative ADG and F:G. No differences for ADG or F:G were noted between grain sources when CSL was fed, but feeding RYE with SCO tended to reduce cumulative ADG (3.53, 3.54, 3.65, and 3.42 lb/d for DRC/CSL, RYE/CSL, DRC/SCO, and RYE/SCO, respectively; $P = 0.09$) and tended result in poorer F:G (5.9, 5.7, 5.8, and 6.1 for DRC/CSL, RYE/CSL, DRC/SCO, and RYE/SCO, respectively; $P = 0.09$).

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Implications

Under the conditions of this experiment, a direct chopped forage sorghum/corn silage blend can replace corn silage, and hammer-milled rye can be suitable replacement for dry rolled corn, but feeding rye and a forage sorghum/corn silage blend tended to reduce ADG and feed conversion.

Table 1. Composition of diets (Percentage DM basis)[1]

Ingredient	DRC/CSL	DRC/SCO	RYE/CSL	RYE/SCO
Dry rolled corn	21	21	-	-
Hammer milled rye	-	-	21	21
Corn silage	55	55	-	-
Sorghum corn blend	--	--	55	55
MDGS[2]	20	20	20	20
Liquid supplement	4	4	4	4
Nutrient composition				
% DM	43.2	43.2	43.2	43.2
% CP[3]	14.5	14.5	15.0	15.0
% NDF[4]	28.7	29.3	30.8	31.4
NEg[5], Mcal/cwt	55.3	55.3	52.8	52.8

[1]Four dietary combinations of either dry-rolled corn (DRC) or hammer-milled rye (RYE) fed with corn silage (CSL) or a blend of forage sorghum and corn planted in a 50:50 ratio (SCO).
[2]Modified distillers grains with solubles
[3]Crude protein
[4]Neutral detergent fiber
[5]Net energy for gain

Table 2. Growth performance responses in steers fed either dry-rolled corn (DRC) or hammer-milled rye (RYE) with silage from corn (CSL) or an inter-planted blend of corn and forage sorghum (SCO)[1].

						P-value		
Item	DRC/CSL	DRC/SCO	RYE/CSL	RYE/SCO	SEM	Grain	Silage	G x S
Pens, n	6	6	6	6				
Steers, n	56	55	55	56				
Initial wt, lbs[2]	639	636	637	635	1.0	-	-	-
d0 to d35								
d35 wt, lbs[2]	775	774	769	760	4.0	0.02	0.25	0.32
ADG, lbs	3.89	3.93	3.76	3.56	0.108	0.04	0.47	0.30
DMI, lbs	19.73	20.08	19.41	19.77	0.158	0.06	0.04	0.99
Feed:gain[3]	5.05	5.05	5.08	5.52	--	0.15	0.24	0.21
d36 to d 63								
d 63 wt, lbs[2]	861[a,b]	866[a]	860[a,b]	851[b]	4.2	0.07	0.71	0.09
ADG, lbs	3.07	3.31	3.26	3.25	0.158	0.67	0.48	0.44
DMI, lbs	22.31	22.85	21.90	22.40	0.240	0.09	0.05	0.93
Feed:gain[3]	7.14	6.84	6.62	6.80	--	0.36	0.91	0.47
Cumulative								
ADG, lbs	3.53[a,b]	3.65[a]	3.54[a,b]	3.42[b]	0.065	0.12	0.92	0.09
DMI, lbs	20.87	21.31	20.52	20.94	0.132	0.01	0.01	0.95
Feed:gain[3]	5.88[a,b]	5.78[a,b]	5.71[a]	6.06[b]	--	0.65	0.30	0.09

[1]Four dietary combinations of either dry-rolled corn (DRC) or hammer-milled rye (RYE) fed with corn silage (CSL) or a blend of forage sorghum and corn planted in a 50:50 ratio (SCO).
[2]A 4% pencil shrink was applied to all body weight measures.
[3]Analyzed as gain:feed and reported as 1/gain:feed.
[a,b]Means within a row lacking a common superscript tend to differ ($P \leq 0.10$).

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Animal Science Research Report 2026

Estimation and application of a performance-derived maintenance energy coefficient for beef × dairy feedlot cattle

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Rationale and Approach

Increased dry matter intake (DMI) and poorer feed conversions suggest beef × dairy (B×D) cattle have greater maintenance energy requirements than that of native beef cattle. Our objective was to derive a performance-based maintenance energy coefficient for finishing B×D cattle and validate its accuracy using synthetic populations of feedlot steers. From published B×D feedlot trials (steers, n = 7; heifers, n = 1; mixed pens = 2), performance and carcass variables were weighted by the inverse of the standard error of the mean squared. The weighted variables were used to calculate a common adjusted final body weight (AFBW) and maintenance energy coefficient (MQ), being 1,243 lb and 0.086 Mcal/$W^{0.75}$, respectively. The AFBW was used to determine equivalent BW (EqW). Retained energy (RE, Mcal/d) was determined according to: RE = 0.0557 × EqW × average daily gain$^{1.097}$. The MQ (Mcal/$W^{0.75}$) was determined according to: [(DMI - (RE / tabular net energy for gain (NE_g))) × tabular net energy for maintenance (NE_m)] /$W^{0.75}$. The synthetic dataset was a normal population created from performance close-out information of B×D steers from commercial feedlots. Using the synthetic dataset, the calculated B×D MQ (0.086 Mcal/$W^{0.75}$, MQ_{BD}) was compared to the native beef MQ (0.077 Mcal/$W^{0.75}$, MQ_B), and the dairy MQ (0.084 Mcal/$W^{0.75}$, MQ_D), in their ability to predict growth and intake. Performance-predicted NE_m, NE_g, and predicted DMI were calculated and compared to the expected NE_m and NE_g, and observed DMI, based on their respective observed-to-expected ratio (OBS:EXP). The ratios were sorted into 5 groups, representing < 90%, 90% to 94.9%, 95% to 105%, 105.1% to 110%, and > 110% of the expected value. A Chi-square test was used to evaluate the frequency of observations within each group.

Results and Discussion

The MQ_{BD} resulted in the most accurate estimates of DMI, NE_m, and NE_g, with the average ratios for OBS:EXP falling within 2% of the expected value, compared to 7% and 3% for MQ_B and MQ_D, respectively. Expected DMI using the derived MQ_{BD} resulted in 62.53% of observations falling within 5% of the actual DMI, compared with 39.79% and 59.63% ($P < 0.01$) for MQ_B and MQ_D, respectively. Similarly, performance-predicted NE_m using MQ_{BD}, showed 70.45% of observations were within 5% of the expected NE_m, compared with 52.21% and 68.82% ($P < 0.01$) for MQ_B and MQ_D, respectively.

Implications

The application of this performance-derived MQ could allow for more accurate predictions of growth performance by B×D cattle than the current models used in feedlot cattle.

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Table 1. Observed and expected dry matter intake (DMI), and diet net energy for maintenance (NE_m) and gain (NE_g) calculated from treatment maintenance coefficients.

	Maintenance Coefficient[1]		
	MQ_B	**MQ_D**	**MQ_{BD}**
DMI, lbs/d			
Observed	20.5	20.5	20.5
Expected[2]	19.2	20.0	20.2
OBS:EXP[3]	1.07	1.03	1.02
NE_m, Mcal/cwt			
Observed[4]	91.8	94.8	95.7
Expected	96.2	96.2	96.2
OBS:EXP[3]	0.95	0.98	0.99
NE_g, Mcal/cwt			
Observed[4]	61.9	64.5	65.3
Expected	66.7	66.7	66.7
OBS:EXP[3]	0.93	0.97	0.98

[1]MQB = 0.077 Mcal/W .75; MQD = 0.084 Mcal/W .75; MQBD = 0.086 Mcal/W .75.
[2]Calculated as: DMI, lbs/d = (NEm required, Mcal/d / dietary NEm, Mcal/lb) + (NEg required, Mcal/d / dietary NEg, Mcal/lb).
[3]OBS:EXP = observed value / expected value. For DMI, a ratio greater than 1.0 indicates cattle ate more than expected based on growth and tabular NE value. For NEm and NEg, a ratio less than 1.0 indicates observed net energy based on DMI and gain was less than expected using tabular dietary values.
[4]Calculated according to Zinn et al., (2008).

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Effect of increasing potency of a steroidal implant in beef steers on growth performance, and carcass traits from wean to finish

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Rationale and Approach

There is limited information regarding the dose-dependent response to trenbolone acetate (TBA) and estradiol benzoate (EB) in newly weaned steers fed low-energy diets during an initial dry-lot phase. Previous research indicates that while anabolic implants improve growth, early use may adversely affect carcass marbling (Bruns et al., 2004). The objective of this study was to evaluate the effects of increasing doses of TBA and EB in a weaning implant on cumulative growth performance and carcass characteristics when steers were followed through a standard finishing implant program. Newly-weaned Charolais-cross steers [n=240; initial body weight (BW) = 554 ± 48.3 lb] were allocated by BW to 24 uncovered concrete pens (10 steers/pen). Pens were assigned to one of three weaning implant treatments (d 1): no implant (NI), Synovex Primer (PR; 50 mg TBA + 7 mg EB), or Synovex Choice (CH; 100 mg TBA + 14 mg EB). Following a 117-d dry-lot phase (49.0 Mcal/cwt NEg & CP 14.8% of DM), steers were reallocated into two unrelated finishing studies and reimplanted twice with a Synovex Choice (d 154 and 156) followed by Synovex Plus [d 222 and 224 (200 mg TBA + 28 mg EB)]. Growth performance was recorded from both studies (n = 232), while one study recorded carcass traits (n = 162).

Results and Discussion

Administration of an implant at weaning did not affect DMI ($P = 0.67$), but showed a linear increase in final BW and average daily gain (ADG) ($P < 0.01$) during the dry-lot feeding phase. Body weight differences and increased ADG from the weaning implant were maintained throughout finishing ($P < 0.01$) when an initial and re-implant finishing implant program was employed to provide steroid coverage for ~300 days on feed. Linear increases were also observed ($P < 0.01$) for hot carcass weight (HCW) and adjusted final body weight (AFBW). Notably, weaning implant use did not affect marbling score ($P = 0.69$) or quality grade ($P = 0.73$) and tended to increase dressing percentage linearly ($P = 0.10$). Growth performance and carcass characteristics are presented in Table 1. Overall, these results show that at weaning, increasing the implant dose for newly weaned steers can enhance growth performance and HCW without detrimental effects on carcass quality.

Implications

Overall, these results show that at weaning, increasing the implant dose in steers gaining at least 2.4 lb/d can enhance growth performance and HCW without detrimental effects on carcass quality, while providing implant coverage from weaning through ~300 days on feed.

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Table 1. Growth performance responses for treatments during entire post-weaning to finishing period and carcass trait responses.

	Implant strategy[1]				Contrasts	
Item	**NI**	**PR**	**CH**	**SEM**	**Linear**	**Quadratic**
Steers, n	74	74	73	-	-	-
Initial body weight[2], lb	557	560	557	13.3	-	-
Growth Performance						
Final body weight[3], lb	1520	1547	1565	12.7	0.01	0.70
Average daily gain, lb/d	3.20	3.28	3.36	0.035	<0.01	0.90
Carcass characteristics						
Hot carcass weight, lb	966	998	1012	10.3	<0.01	0.49
Dressing percentage[4], %	65.6	65.8	66.2	0.28	0.10	0.81
Calculated yield grade	3.32	3.59	3.41	0.084	0.42	0.03
Longissimus muscle area, in	15.5	15.6	15.8	0.15	0.18	0.60
12th rib fat thickness, in	0.64	0.71	0.65	0.022	0.66	0.01
Marbling score[5]	492	500	485	11.9	0.71	0.44
Empty body fat[6], %	31.6	32.6	31.9	0.36	0.51	0.04
AFBW[7], lb	1386	1391	1438	16.1	0.03	0.30

[1]NI: No implant; PR: SYNOVEX® Primer™ (50 mg TBA + 7 mg EB); CH: SYNOVEX® Choice™ (100 mg TBA + 14 mg EB)
[2]No shrink was applied to initial body weight.
[3]A 4% shrink was applied to account for digestive tract fill.
[4]Dressing percentage was calculated as: hot carcass weight/(final body weight x 0.96).
[5]400=small^{00}, 500=modest^{00}
[6]Estimated percentage empty body fat calculated from Guiroy et al. (2001) = 17.76207 + (4.68142 × fat thickness, cm) + (0.01945 × hot carcass weight, kg + (0.81855 × QG) – (0.06754 × ribeye area, cm^2); QG = quality grade (Select = 4, Low Choice = 5, Average Choice = 6, High Choice = 7, Low Prime = 8).
[7]Final body weight adjusted to 28% EBF (Guiroy et al., 2002).

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Animal Science Research Report 2026

Effects of kernel processing high moisture ear corn on growth performance and carcass characteristics in finishing steers

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Rationale and Approach

High Moisture Ear Corn (HMEC) is frequently used in finishing rations in a feedlot setting. Kernel processing ensiled feed sources such as corn silage and high moisture ear corn at the time of harvest has been thought to improve performance for cattle fed in feedlots. By kernel processing these feeds it reduces waste in the bunk and increases digestibility; often resulting in better feed efficiency and decreased dry matter intake (DMI). The harvesting window for HMEC is short, making the process of acquiring this feedstuff time sensitive and requiring close attention to harvest signals. Even with proper attentiveness, harvest equipment and kernel processors may break and require maintenance during this short window for harvest ultimately deterring a successful harvest and ensilage of HMEC. The objective of this study was to evaluate the effect of kernel processing HMEC on growth performance and carcass characteristics of cattle fed a finishing diet. Crossbred steers (n = 176, BW = 906 ± 69.6 lbs.) were allocated by body weight to 22 pens (8 head/pen, 11pens/treatment). Two treatments were applied; 1) finishing diet with kernel processed HMEC (KP) and 2) finishing diet with non-kernel processed HMEC (NKP). High moisture ear corn for both treatments were harvested with a snapper header on a forage harvester equipped with a kernel processing unit. Chop length was set at 0.75 inches. Kernel processor roll gap for KP and NKP were set to 0.08 and 1 inch, respectively. The diets were based upon (DM basis): HMEC (70%), dried distillers grains (20%), high moisture corn (10%), and suspended supplement (5%).

Results and Discussion

Growth performance and carcass characteristics are presented in Table 1. NKP steers had a lower DMI than steers fed the KP diet ($P = 0.04$, 22.34 and 22.89 lbs., respectively). No other differences in growth performance ($P \geq 0.41$) or carcass characteristics ($P \geq 0.18$) were observed between treatments. Additionally, yield grade, quality grade and liver abscess scores did not differ between treatments ($P \geq 0.27$).

Implications

Steers in both treatments performed well however cattle fed the NKP diet consumed less DM and showed no difference in any other performance measures. Overall, this study suggests that performance benefits previously observed for kernel processed corn silage may not be comparable with kernel processed HMEC. Additionally, delays due to kernel processor issues should not delay timely harvesting of HMEC.

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Table 1. Growth performance responses and carcass traits through d 168. Two treatments were applied; 1) finishing diet with kernel processed HMEC (KP) and 2) finishing diet with non-kernel processed HMEC (NKP). Both treatments HMEC were harvested with a snapper header on a forage harvester equipped with a kernel processing unit. Chop length was set at 0.75 inches. Kernel processor roll gap for KP and NKP were set to 0.08 and 1 inch, respectively.[1]

	Treatment			
Item	**NKP**	**KP**	**SEM**	***P* -value**
Pens, n	11	11	-	-
Steers, n	88	88	-	-
Body Weight				
Initial SBW, lb.	906	905	3.2	0.79
Final BW, lb.	1498	1506	10.6	0.49
Growth Performance				
Initial to d 168				
ADG, lb.	3.43	3.58	0.059	0.41
DMI, lb.	22.34	22.89	0.230	0.04
G:F	0.158	0.156	0.0022	0.53
***Dietary Energetics*[2]**				
NEm, Mcal/cwt	95.14	94.17	0.595	0.13
NEg, Mcal/cwt	64.84	63.99	0.522	0.13
Carcass Traits				
HCW, lb.	996	987	9.1	0.52
DP, %[3]	66.47	65.53	0.398	0.18
RF, in	0.67	0.65	0.021	0.43
REA, in. sq.	15.67	15.53	0.150	0.51
Marbling[4]	495	491	9.0	0.80
KPH, %	1.83	1.79	0.021	0.27
cYG[5]	3.32	3.28	0.083	0.65
RY, %[6]	49.86	49.98	0.178	0.61
EBF, %[7]	32.61	32.32	0.332	0.52
AFBW, lb.[8]	1388	1385	16.4	0.90
Quality Grade				
Select, %	11.54	14.46	-	0.27
Low Choice, %	46.15	46.99		
Average Choice, %	33.33	24.10		
High Choice, %	8.97	13.25		
Prime, %	0.00	1.20		
Liver Scores				
Normal, %	94.87	95.24	-	0.99
A-, %	1.28	0.00		
A, %	2.56	0.00		
A + or greater, %	1.28	4.76		

[1]A 4% pencil shrink was applied to all BW measures to account for digestive tract fill.
[2]Calculated according to Zinn and Shen, 1998 using live-basis growth performance.
[3]Calculated as: (HCW/BW at d 168) × 100.
[4]400 = small[00]
[5]Calculated Yield Grade; calculated using the USDA regression equation (USDA, 2017).
[6]Retail Yield; calculated using Murphey et al. 1960.
[7]Empty Body Fat; calculated according to Guiroy et al. 2001.
[8]Adjusted Final Body Weight; calculated according to Guiroy et al. 2001.

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Animal Science Research Report 2026

Influence of nutrient restriction during mid-gestation on beef cow metabolism and composition

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Rationale and Approach

Body weight of beef cows naturally fluctuates throughout the production year due to changes in forage availability, quality, and feed costs. In spring-calving herds, mid-gestation occurs in late summer and fall when forage quality typically declines, often resulting in nutrient restriction. However, how this mid-gestation nutrient restriction affects cow metabolism and energy efficiency is not fully understood. The objective of this study was to evaluate the influence of a global nutrient restriction during mid-gestation on body composition, metabolic function, and energetic efficiency in gestating beef cows. Gestating beef cows were assigned to either maintain/improve body condition during mid-gestation [positive energy status (PES); n = 22] or undergo intake restriction to reduce body condition [negative energy status (NES); n = 16]. Body weight, body condition score (BCS), body composition, and blood metabolites were evaluated before and after the treatment period. Following mid-gestation, all cows were managed to a positive energy status through late gestation. Oxygen consumption, carbon dioxide emissions, methane emissions, heat production, and peak lactation milk production and composition were also measured.

Results and Discussion

Treatment and day interacted for the treatment period ($P < 0.05$) for cow body weight, BCS, and ultrasound measures with NES cows having greater losses in BCS, body fat stores and muscle mass compared to the PES cows (Table 1). Serum glucose concentrations interacted for treatment × day with NES cows having a larger ($P < 0.05$) decrease in glucose (Table 1) indicating they were energy deficient. Serum non-esterified fatty acid (NEFA) concentrations were affected by treatment ($P < 0.05$) with NES cows having greater NEFA levels compared to PES cows indicating mobilization of adipose tissue. Mean NEFA concentrations for PES and NES cows were 0.29 mmol/L and 0.41 mmol/L, respectively (SEM = 0.035 mmol/L). Serum urea nitrogen concentrations were not affected ($P > 0.05$) by treatment (12.63 mg/dL vs 14.00 mg/dL for PES and NES calves, respectively; SEM = 0.623 mg/dL). Energy status treatment and gestation period interacted ($P \leq 0.05$) for carbon dioxide (CO_2), oxygen (O_2), and methane (CH_4) levels (Table 2). Cows in the NES treatment had lower O_2 consumption and emissions of CO_2 and CH_4 than PES cows during mid-gestation, but similar CO_2 and CH_4 production and O_2 consumption to PES cows in late gestation indicating that the nutrient restriction during mid-gestation resulted in decreased enteric emissions. Energy lost through heat produced as a result of rumination and metabolic processes can be calculated from enteric emissions and O_2 consumption. Energy status treatments and gestation periods interacted ($P < 0.05$) for heat production (Table 2) with NES cows producing less ($P < 0.05$) heat than PES cows in mid-gestation. There were no differences ($P > 0.05$) in milk production or milk components.

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Implications

Cows that experienced nutrient restriction during mid-gestation mobilized their own tissue stores as observed through changes in body weight, BCS, ultrasound measures of body composition, and blood metabolite responses. However, subsequent milk production and composition were unaffected by the mid-gestation restriction. Results suggest gestating beef cows will use their own body reserves and become more energetically efficient to protect the fetus from a nutritional insult.

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Table 1. Least squares means for energy status treatment[1] × time interactions for cow responses to mid-gestation nutrient restriction at the start and end of the mid-gestation treatment period

Variable	PES[1] Start	PES[1] End	NES[1] Start	NES[1] End	SEM[2]	*P*-value
Body weight, lb	1286.4^{a}	1398.4^{b}	1228.4^{a}	1242.3^{a}	26.44	<0.01
Body condition score	5.5^{b}	5.9^{c}	5.1^{b}	4.6^{a}	0.16	<0.01
Rump fat, in	0.19^{b}	0.23^{c}	0.10^{ab}	0.08^{a}	0.039	0.04
Rib fat, in	0.18^{bc}	0.20^{c}	0.11^{b}	0.07^{a}	0.027	0.01
Marbling score[3]	497^{c}	471^{b}	491^{bc}	424^{a}	16.8	0.03
Loin depth, in	2.02	1.93	1.93	1.93	0.066	0.43
Ribeye area, sq in	11.5^{b}	11.5^{b}	10.9^{b}	10.6^{a}	0.37	0.02
Glucose, mg/dL	59.1^{b}	55.8^{ab}	66.0^{b}	50.2^{a}	2.64	0.02

^{a,b,c} Values within a row with different superscripts differ ($P < 0.05$)

[1]PES = cows maintained or gained BCS during mid-gestation; NES = cows lost BCS during mid-gestation; [2]Standard error of the mean; [3]Marbling score = 400=Small^{0}, 500=Modest^{0}, etc.

Table 2. Least squares means for energy status treatment[1] × gestation period interactions for O_2 consumption, CO_2, and CH_4 emission levels, and heat production by cows during mid- and late-gestation.

Variable	Mid- PES[1]	Mid- NES[1]	Late- PES[1]	Late- NES[1]	SEM[2]	*P*-value
CO_2, g/d	7256.27^{b}	6151.56^{a}	7524.89^{b}	7231.66^{b}	220.0	0.01
O_2, g/d	5439.06^{b}	4598.32^{a}	5462.19^{b}	5325.93^{b}	181.9	0.01
CH_4, g/d	218.46^{b}	172.26^{a}	242.81^{b}	220.29^{b}	11.66	0.05
Heat production, Mcal/d	17.89^{b}	15.13^{a}	17.97^{b}	17.52^{b}	0.562	0.01

^{a,b} Values within a row with different superscripts differ ($P < 0.05$)

[1]PES = cows maintained or gained BCS during mid-gestation; NES = cows lost BCS during mid-gestation; [2]Standard error of the mean

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Substitution of DDGS with canola meal in finishing diets affects amino acid intake but does not affect post-ruminal amino acid flow and digestibility

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Rationale and Approach

Northern Plains steers fed corn-based diets often lack a high-quality balance of essential amino acids (AA). Improved cattle genetics have increased growth capacity, driving a greater demand for high-quality metabolizable protein. Canola meal offers superior protein content and a more favorable AA profile compared to traditional DDGS inclusion. Therefore, the objective of this study was to evaluate the effects of substituting dried distiller's grains plus solubles (DDGS) with canola meal (CM) on AA intake, flow, and digestibility. Six rumen- and duodenal-cannulated Jersey steers (BW = 567 lbs.) were used in a duplicate 3 × 3 Latin square design. The basal diet consisted of 65% dry-rolled corn, 10% hay, and 5% liquid supplement. The remaining 20% comprised the test treatments (DM basis): 1) CON: 20% DDGS inclusion, 2) CM50: 50% DDGS replacement with CM, and 3) CM100: 100% DDGS replacement with CM. Each period lasted 17 days, consisting of a 10-day adaptation followed by a 7-day collection period.

Results and Discussion

The inclusion of CM linearly increased the intake of lysine, tryptophan, and glycine ($P \leq 0.05$; Table 1), while tyrosine intake was greater for CON and CM100 compared to CM50 ($P = 0.05$, quadratic). Despite these differences in dietary intake, the amount of essential (EAA) and nonessential (NEAA) amino acids reaching the small intestine, as well as post-ruminal digestibility, were not affected by treatment ($P \geq 0.20$). This consistency is explained by the ruminal AA utilization index, which remained similar across all treatments ($P \geq 0.13$). Notably, a net gain of EAA was observed in the rumen, with gains ranging from 1% for histidine to 128% for lysine, indicating significant microbial protein synthesis. These findings suggest that the rumen microbial environment effectively stabilizes the flow of amino acids to the small intestine regardless of whether DDGS or CM is the primary protein source.

Implications

This research indicates that CM and DDGS deliver comparable amounts of metabolizable protein and amino acids to the small intestine. Because post-ruminal digestibility and ruminal AA utilization were similar across treatments, cattle producers in the Northern Plains can consider these protein sources interchangeable regarding AA supply. Consequently, selection between DDGS and CM should be driven by cost-effectiveness and regional availability rather than concerns over metabolic protein delivery.

Acknowledgments

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Table 1. Intake, flow, and digestibility of lysine and tryptophan in steers fed finishing diets containing varying levels of canola meal.

	Treatments[1]				*P*-value		
Item	**CON**	**CM50**	**CM100**	**SEM**	**Linear**	**Quadratic**	**DDGS vs CM**
Lysine							
Intake, g/d	20.67	23.88	34.32	4.09	0.021	0.29	0.065
Duodenal flow, g/d	49.37	48.32	52.93	8.24	0.54	0.54	0.81
Microbial flow, g/d	26.39	24.86	24.44	3.56	0.63	0.87	0.63
Fecal excretion, g/d	6.27	6.17	6.23	1.21	0.93	0.84	0.88
Digestibility							
Ruminal, % of intake	-128.28	-117.2	-65.08	25.36	0.13	0.52	0.27
Post-ruminal, % of entering small intestine	86.96	86	86.77	1.99	0.92	0.64	0.75
Total Tract, % of intake	70.68	71.24	79.52	6.59	0.05	0.20	0.16
Tryptophan							
Intake, g/d	4.41	4.55	6.81	0.87	0.030	0.13	0.12
Duodenal flow, g/d	7.12	7.49	7.68	1.37	0.58	0.91	0.61
Microbial flow, g/d	4.29	4.16	4.22	0.62	0.91	0.83	0.85
Fecal excretion, g/d	0.82	0.72	0.66	0.15	0.32	0.84	0.35
Digestibility							
Ruminal, % of intake	-56.37	-74.31	-21.67	20.53	0.28	0.21	0.75
Post-ruminal, % of entering small intestine	87.37	90.01	90.77	2.44	0.21	0.66	0.20
Total Tract, % of intake	81.00	84.12	89.74	3.51	0.040	0.64	0.090

[1]CON, 20% DDGS inclusion; CM50, 50% DDGS replacement with canola meal; CM100, 100% DDGS replacement with canola meal.

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South Dakota State University

Department of Animal Science | SDSU Extension

Extension

SDSU Extension Calving Camp

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Program Objective

Record-low cow inventory is continuing to put stress on the market and, in turn, is returning more revenue for cattlemen selling calves. To secure some of this additional revenue, calves must be born and weaned successfully. Calving season can be stressful for even the most experienced cattlemen; therefore, training and education on calving practices are warranted for both beginning and experienced cattlemen to ensure successful parturition. The objective of these calving camps was to discuss calving preparations and practice delivering and processing calves.

2026 Program

To do this, calving camps were hosted at two locations in South Dakota on January 6th and January 14th in partnership with Mitchell Technical College and Lake Area Tech College. Currently licensed large-animal veterinarians were on-site to assist with training participants. A presentation was given on preparing for calving season (facilities, supplies, labor) and normal stages of labor. Two breakout sessions were conducted, including calf processing (esophageal feeding, banding, tagging, vaccinations, udder scoring) and dystocia management. All participants (32) were allowed to properly place chains on a full-size calf model, evaluate and correct fetal presentation, use calving equipment (jack or head snare), and successfully pull a calf from the cow model.

Program Outcomes

Attendees were made up of commercial cow/calf and seedstock operations, including students, beginning farmers/ranchers, part-time and full-time operators. In addition, several family members attended and participated in the camp to learn together. The main reason attendees wanted to learn more about calving season was to solve calving problems and know when to call for assistance. A quote from one attendee - “You can always pick up new tricks and tips to improve your skills. Also, we had a lot of backward- and front-foot-down calves last year. Just looking to learn how to be successful and save the most calves.” – Anonymous. Therefore, there was a lot of discussion at both locations on post-delivery calf health, vaccinations, and supplements. The comfort level of attendees assisting with dystocia increased from 44% to 89% before and after the camp, respectively, in the somewhat comfortable and very comfortable categories. Overall, attendees rated the camps 4.5 out of 5 stars, with 93% stating they will apply what they learned at the camp during the next calving season.

Future Programs

This calving camp was designed for beginning farmers and ranchers, while many experienced cattlemen still attended to brush up on their calving skills. In the future, we will extend the camp to provide more time for education in other areas of calving management (facilities, health, and recordkeeping), while maintaining sufficient time for the hands-on breakout sessions.

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SDSU Youth Beef Summit

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Program Objective

The objective of this program is to provide youth and young adults with hands-on learning activities involving beef reproduction, nutrition, management, health, showmanship and evaluation, and meat quality to make participants more informed beef producers and consumers. This goal promotes the positive image of the cattle industry and the consumption of beef by equipping future stakeholders with the knowledge to advocate for the industry and produce high quality beef.

2025 Program

This program was held in Brookings, SD on July 16, 2025 at the Cow Calf Education and Research Facility (CCERF). The program included presentations about livestock handling, Artificial Insemination, nutrition, managing animal stress, steak cookery and palatability, and showmanship and daily care of show animals. There were also tours of the CCERF and the Ruminant Nutrition Center. A total of 13 youth attended the program.

Program Outcomes

Participants indicated that they were most interested in the nutrition and reproduction sections of the program. All participants indicated they would attend the program again citing that it is fun to learn new things and that it was a good experience.

Future Programs

The planning team intends to hold another event during the summer of 2026 with a date to be determined. For more information on the program, visit the SDSU Extension website and contact any of the program leaders listed above.

Acknowledgement

The 2025 Youth Beef Summit was supported by South Dakota State University Extension, Beef Logic Inc., Dakotaland Feeds, LLC, and Prairie View Veterinary Clinic

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Animal Science Research Report 2026

Elevate Ewe

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Program Objective

Elevate Ewe is a comprehensive, year-long development program designed to equip beginning sheep producers with the knowledge, skills, and confidence needed to build successful and sustainable operations. Through an online classroom, monthly webinars, and four hands-on field days, the program provides practical, research-based education tailored to participants' needs. Instruction covers the full spectrum of sheep production—including nutrition, reproduction, financial management, marketing, lambing, and grazing—to help new producers make informed decisions, strengthen management practices, and increase long-term operational success.

2025 Program

In 2025, 15 individuals from three states (SD, MN, NE) were enrolled in Elevate Ewe. The 4 field days were also designed to expand the participants' network by hosting activities on operations across the state. Locations included Rosholt, Pierre, Newell, and Sturgis, SD. The Rosholt, Pierre, and Sturgis programs were open to anyone, not just Elevate Ewe participants, to expand networking opportunities. Field days covered biosecurity and intensive lambing, spring lambing and body condition scoring, commodity markets, and grazing management, respectively. There were 8 webinars with topics on financial management, nutrition, reproduction, marketing, and lambing. The webinars were recorded to accommodate numerous schedules. Through the Traininghouse platform, the online classroom housed additional fact sheets, video links, and other resources for participants to view as they please and download for future reference.

Program Outcomes

From the 2025 cohort, one participant mentioned, "I learned a little bit in a bunch of different areas …. I think all these factors combined will help me increase the efficiency and profit of our operation." Throughout the program, 55% of participants indicated that they intended to increase the size of their operation.

Future Programs

Applications for the 2027 Elevate Ewe course will be available on the SDSU Extension website in August 2026. For questions about the program, contact Jaelyn Whaley at jaelyn.whaley@sdstate.edu or 605-374-4177.

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