South Dakota State University

Department of Animal Science | SDSU Extension

Animal Science Research and Extension Report - Beef

2026

Contents

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.

- **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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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.

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).

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.
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.

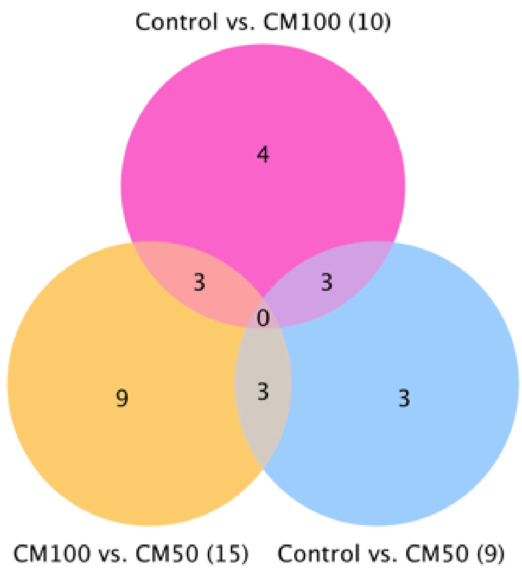

Figure 1. Differentially abundant genera in response to dietary treatments. CON: 20% DDGS (DM basis), CM50: 50% DDGS replaced by CM, and CM100: 100% DDGS replaced by CM

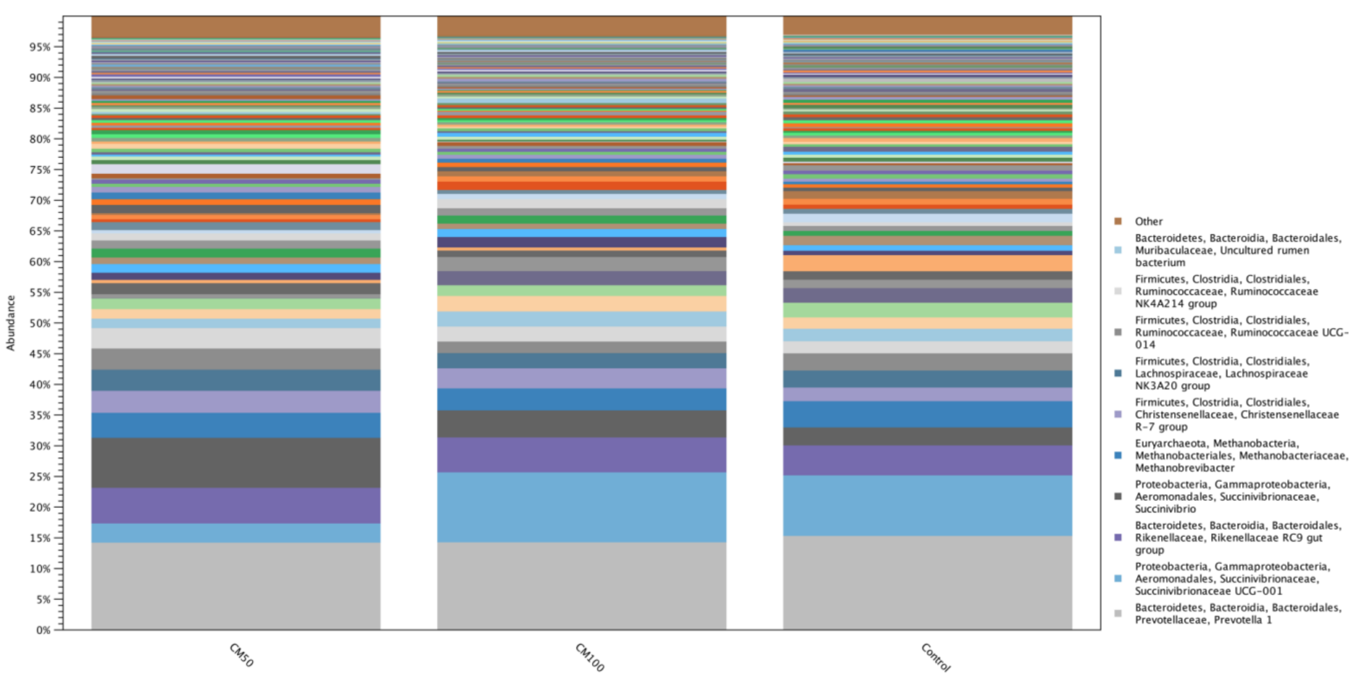

Figure 2. Most abundant bacteria families identified in response to dietary treatments. CON: 20% DDGS (DM basis), CM50: 50% DDGS replaced by CM, and CM100: 100% DDGS replaced by CM

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 ± 1.1 lbs) and dam age (< 4 years and ≥ 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 (≥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.

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

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.

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 ($P = 0.06$)

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* ≥ 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

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

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 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

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.

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).

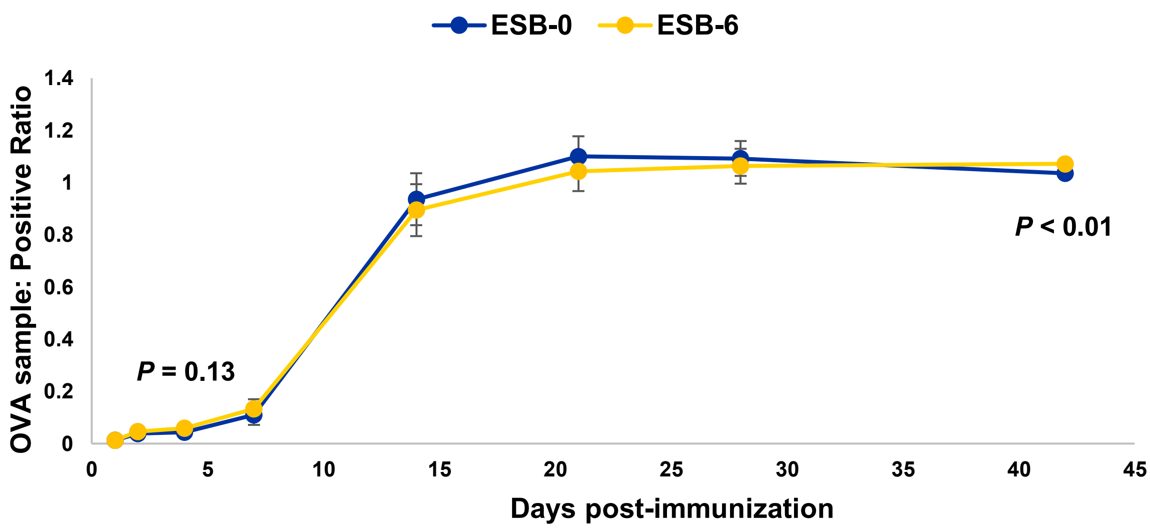

Figure 1. Seroconversion over 42-day challenge period during the feeding study. Dietary treatments were: 1) DDGS (20% diet inclusion, dry matter basis [DMB]; ESB-0) and 2) Partial replacement of DDGS with ESB included at 5.4% DM basis (ESB-6).

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).

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 ($P \leq 0.10$).

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.

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).

Animal Science Research Report 2026

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).

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.

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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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.

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.