FINAL REPORT

South Dakota State University

Department of Animal Science

Winter-feeding high forage vs. Corn-based diets for pregnant beef cows: Impacts on offspring performance, milk production, and greenhouse gas emissions

Submitted to: Iowa Beef Industry Council

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NON-TECHNICAL SUMMARY

The experiment titled "Winter-feeding high forage vs. corn-based diets for pregnant beef cows: Impacts on offspring performance, milk production, and greenhouse gas emissions" was conducted at the South Dakota State University Cow-Calf Education and Research facility located in Brookings, SD. The study was led by Ana Clara B. Menezes, Ph.D., an Assistant Professor in the Department of Animal Science at South Dakota State University (Email: AnaClara.BaiaoMenezes@sdstate.edu ; Office #: 605-688-5455). The purpose of this experiment was to determine the effects of replacing hay by corn byproducts such as dry rolled corn and DDGS in diets fed to gestating and lactating beef cows. This experiment used forty-six Angus crossbred cows housed in a group pen equipped with electronic feeders (Insentec), waters (Insentec), and a GreenFeed trailer system to quantify methane emissions (C-Lock Inc.). Cows were fed (dry matter basis): 1) a control high-forage diet (**HFOR**) based upon bluegrass hay (55%), corn silage (30%), dry distillers grain plus solubes (10%) and a suspended supplement (5%); 2) a high concentrate diet (**HCON**) based upon dry rolled corn (DRC) (70%), dry distillers grains plus solubles (5%), corn silage (10%), bluegrass hay (10%), and a suspended supplement (5%). Winter feeding high concentrate corn-based diets resulted in lower methane emissions and improved water usage efficiency of cow-calf systems. An economic analysis revealed that producers could save $28/cow when winter-feeding HCON diets. Therefore, this study implies that limit-feeding high concentrate corn-based diets would benefit cow/calf producers by reducing feeding costs. Lastly, winter-feeding HCON diets resulted in greater milk production.

TECHNICAL REPORT

Impacts

Based upon feed cost of production, water usage, enteric methane emissions, milk yield, and calf production, cattle feeders can benefit of feeding high-concentrate diets during winter-feeding periods on dry-lot settings. Winter feeding high-concentrate diets during late gestation and early lactation increased milk production and reduced enteric methane emissions in the dry lot period.

List of quantitative impacts:

- Limit feeding high-concentrate diets compared to high-forage diets allows for decreased feed costs for producers, especially in times of limited hay supply.
- High-concentrate diets can be strategically offered to meet protein and energy needs of gestating and lactating cows at 1.2% of their body weight.
- Limit feeding high-concentrate diets resulted in decreased methane emissions and improved milk production.

Introduction

Winter feed costs typically represent the largest portion of a cow/calf operation's expenses. In time of limited hay supply and increased hay price, it can be economically advantageous to use corn rather than hay to meet the energy and protein requirements of pregnant cows. Nutrient requirements are significantly greater during lactation, however, because of the unfavorable weather, pasture growth or "green-up" (lbs. forage per acre) is often limited; a reoccurring challenge. Extending dry-lot feeding would help spare pasture which would enhance pasture growth and resilience. Therefore, it is important to realize that whether they're in a lot setting or already on pasture, cows need to be fed well enough to support lactation and consequently improve calf performance. Replacing hay by corn byproducts such as dry rolled corn and DDGS may be an alternative to Iowa beef producers to optimize nutritional management of beef females. Because corn and corn byproducts are the most readily available source of supplemental energy and protein in Iowa, limit feeding a corn-based diet in dry-lot settings can be cost-effective for meeting the nutrient requirements of beef cows. Further, this nutritional strategy has the potential to improve feed efficiency and reduce greenhouse gas emissions. Therefore, this research would benefit Iowa beef producers by optimizing land utilization, reducing feeding costs, and increasing feed efficiency of cows and calves. Further, this research would help minimize the carbon footprint of cow-calf systems.

The experimental objective was to determine the effects of winter-feeding high forage vs. corn-based diets on cow and calf performance, composition and yield of colostrum and milk, colostrum immunoglobulin concentration; pre- and post- calving on enteric methane emissions, dry matter intake (DMI) and water intake, and economic implications for cow/calf producers.

Methods and Results

Materials and Methods

All procedures involving the use of animals in this experiment were approved by the South Dakota State University Institutional Animal Care and Use Committee (Approval # 2412-013A).

Angus crossbred cows (n = 46 cows; ~180 d of gestation; initial BW = 1,388.91 ± 26.46 lbs.) were housed at the SDSU Cow-Calf Education and Research Facility (CCERF; Brookings, SD) in a group pen equipped with electronic feeders (Insentec), waters (Insentec), and a GreenFeed trailer system (C-Lock Inc.). The cows used in this experiment were procured from the SDSU cow herd in Brookings, SD. After two-consecutive body weight measurements, cows were randomly assigned to one of two treatments: 1) ad-libitum forage-based diet (**HFOR**; n =

23); and 2) high concentrate corn-based diet, estimated to be an intake of approximately 1.2% of BW (**HCON**; n = 23). Experimental diets and chemical composition are shown in Table 1. Treatments started being applied on d 50 (± 10 d) pre-calving and continued until d 84 post-calving, after which the cow-calf pairs were managed a single group on pasture.

Table 1. Ingredients and chemical composition of experimental diets

	Treatments	
Ingredients, % DM	**HFOR**	**HCON**
Grass Hay	55	10
Corn Silage	30	10
DDGS	10	5
Dry Rolled Corn	-	70
Liquid Supplement[1]	5	5
TOTAL	100	100
Chemical composition, %		
Dry Matter	57.79	73.13
Organic Matter	88.22	92.00
Crude Protein	12.82	11.62
Ether Extract	1.64	2.14
Neutral Detergent Fiber	51.05	20.67
Starch	4.30	27.33

[1]Provided vitamins and minerals to meet or exceed current NASEM (2016) requirements for gestating and lactating cows, and monensin sodium (30g/ton)

The HFOR cows were fed four times a day to accomplish ad-libitum feeding, while HCON cows were fed once daily in the morning at 1.2% of their body weight. Dry matter intake (DMI) and water intake were monitored via Insentec electronic feeders and waters. Individual feed ingredients were sampled weekly and composted into pre- and post- calving periods. Ingredients were analyzed for dry matter (DM), ash, crude protein, starch, neutral detergent fiber (NDF), and ether extract.

Enteric methane emissions were collected utilizing the GreenFeed trailer system (C-Lock, Inc.). Sweetfeed pellets were used to entice the cows to visit the trailer system and was programmed to drop feed every 30s up to six times during a visit (~ 25 g); cows were allowed to visit the system up to three times a day.

Cow body weight (BW) measurements were collected weekly up to calving (d 0) and bi-weekly post- calving up to d 84. Two BW measurements were collected on pasture relative to d 129 and d 165 post- calving; and a final BW measurement was collected at weaning (d 200 post-calving). Calf BW measurements were collected at d 0 (calving), d 84, and d 200 (weaning). Blood collections were performed on cows at treatment initiation (d 50 ± 10 pre-calving), calving (d 0), and d 84 post-calving. Blood collections on calves were performed at calving (d 0) and d 84 post-calving. Blood was centrifuged immediately following collection and serum was analyzed for glucose, insulin, non-esterified fatty acids (NEFA).

Cows were closely monitored and allowed to calve in their pen. Immediately after calving, cow-calf pairs were moved inside the calving barn for pre-suckling colostrum collections. Colostrum production was determined on a single quarter (left rear) from each cow. Colostrum yield (lbs.) was recorded and subsamples were collected into 15-mL conical tubes and stored at -20℃ for immunoglobulin analysis (IgA, IgG, and IgM). An additional subsample was collected into a 50-mL tube containing a preservative (2-bromo-2-nitropropane-1,3-diol), and stored at 4 ℃ for further analysis of nutrient composition (fat, protein, other solids, and lactose). Milk collections occurred bi-weekly up to d 84 post-calving. Cows were separated from their calves for a 12-hour period prior to collections to allow for udder fill up. Cows were administered 1ml of Oxytocin at milk collections to allow for milk let-down and portable milk machines evacuated milk from the udder until >1 teat flow stopped. Measurements of milk yield (lbs.) were recorded, and samples were stored for nutrient analysis as previously described for colostrum.

Results

Dry Matter and Water Intake

As designed, DMI was lower ($P < 0.01$) for HCON than HFOR cows in both pre- and post-calving periods (13.29 ± 1.15 lbs./d and 33.77 ± 1.15 lbs./d pre-; 27.21 ± 1.15 lbs./d and 42.42 ± 1.15 lbs./d post-calving for HCON and HFOR, respectively). A similar pattern was observed for water intake, with HCON lower than HFOR ($P < 0.01$; 56.44 ± 3.55 lbs./d and 89.73 ± 3.53 lbs./d pre-; 103.39 ± 3.46 lbs./d and 137.57 ± 3.46 lbs./d post- calving for HCON and HFOR, respectively).

Cow and Calf Performance

Cow performance and calf performance are presented in Figures 1 and 2, respectively. A treatment × day interaction was observed for cow body weight ($P <0.01$), with HFOR cows being heavier than HCON cows (1417.73 ± 29.95 lbs.; 1323.05 ± 29.94 lbs. for HFOR and HCON, respectively) from d -42 pre-calving up to d 84 post-calving. Calf performance was not affected by treatment ($P = 0.70$) or treatment × day interaction ($P = 0.79$), and as expected calf BW was greater at weaning ($P < 0.01$; average 567.03 ± 9.32 lbs.).

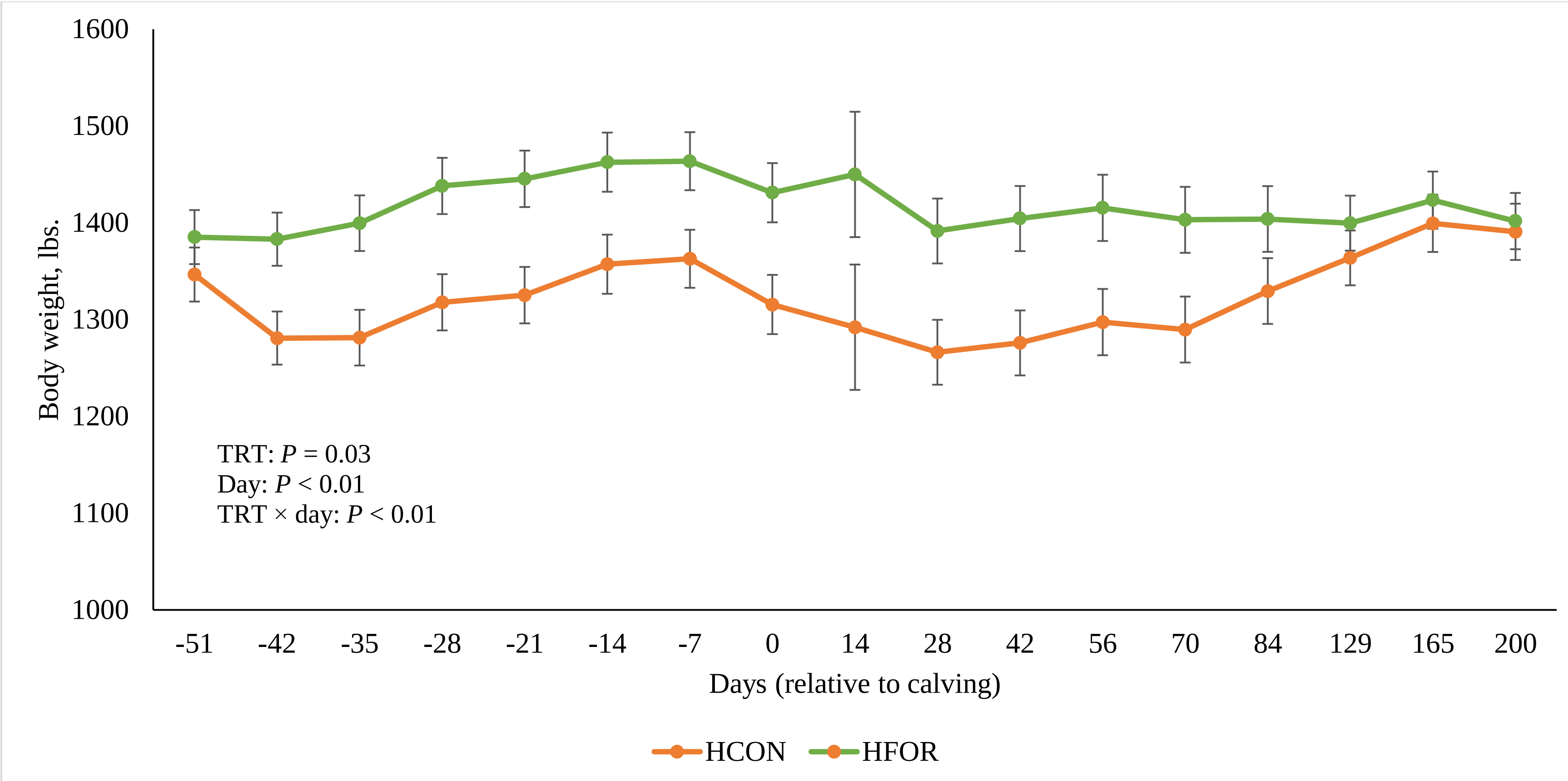

Figure 1. Effects of winter-feeding high concentrate (HCON) or high forage diets (HFOR) on cow body weight

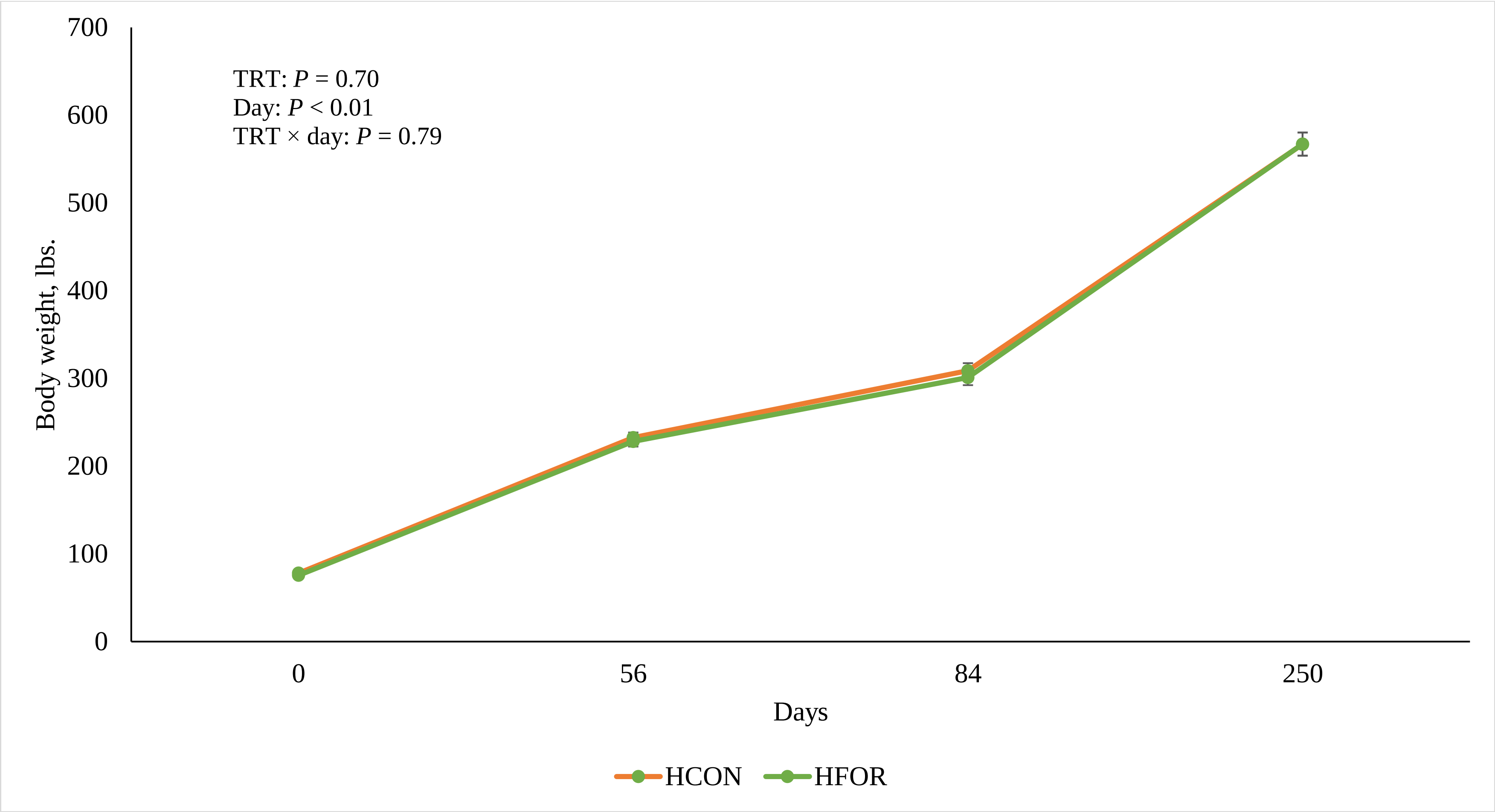

Figure 2. Effects of winter-feeding high concentrate (HCON) or high forage diets (HFOR) on calf body weight

Enteric Methane Emissions

Pre- and post-calving, HFOR had greater ($P \leq 0.05$) CH_4 emissions than HCON (270.77 ± 8.19 g/d and 247 ± 9.29 g/d pre-; 340.31 ± 9.23 g/d and 306.03 ± 9.35 g/d post-calving for HFOR and HCON, respectively). Both groups presented dynamic changes in CH_4 emissions over time ($P < 0.01$; Figure 3).

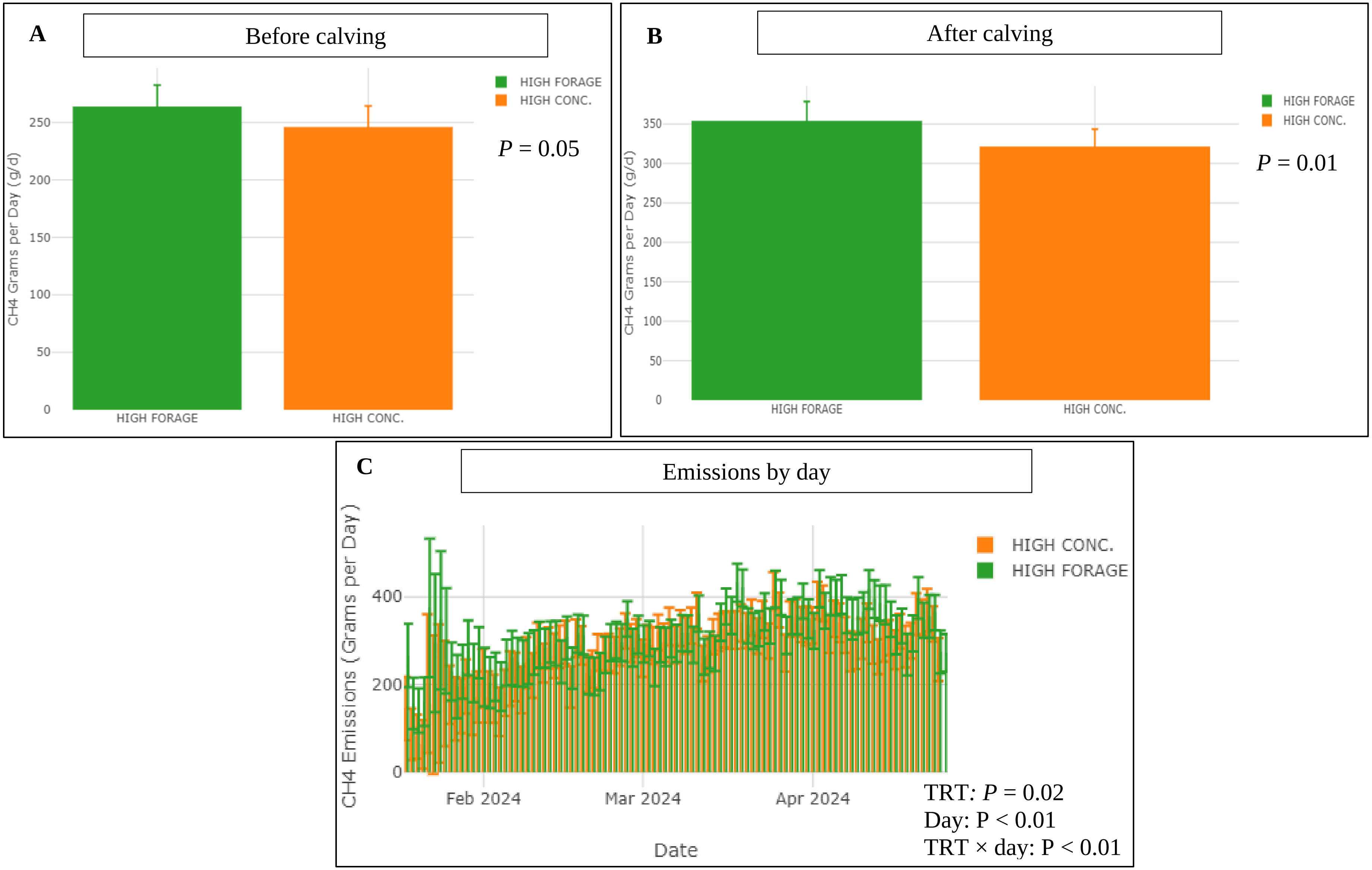

Figure 3. Effects of winter-feeding high concentrate (HCON) or high forage diets (HFOR) on enteric methane emissions pre (A)- and post-calving (B), and during the whole feeding trial (C).

Colostrum Yield, Composition, and Immunoglobulin Concentration

Colostrum yield, composition, and concentration of immunoglobulins were similar between treatments ($P \geq 0.11$; Table 2).

Table 2. Effects of winter-feeding high forage (HFOR) or high concentrate (HCON) diets on colostrum composition, yield, and concentration of immunoglobulins.

	Treatments		SEM	*P*- value
Item	HFOR	HCON		
Composition, %				
Fat	4.24	4.62	0.47	0.57
Protein	16.15	16.77	0.44	0.32
Other solids	5.07	5.27	0.13	0.29
Lactose	2.54	2.79	0.11	0.11
Yield[1], lbs.	1.29	1.26	0.18	0.98
Immunoglobulins, mg/dL				
IgG	8,769.57	8,332.80	482.96	0.53
IgA	191.18	198.40	18.19	0.78
IgM	468.35	425.96	29.45	0.31

[1]Colostrum was collected pre-suckling from the left rear quarter.

Milk Yield and Composition

No treatment × day interaction ($P = 0.39$) was observed for milk yield. However, main effects of treatment ($P = 0.02$) and day ($P = 0.01$) were observed, with HCON yielding more than HFOR (15.26 ± 0.51 lbs. for HCON and 13.56 ± 0.51 lbs. for HFOR; Figure 4). Further, milk production was greater for d 56 compared to d 28, 70, and 84, with intermediate values observed for d 14 and 42. Concentrations of protein, fat, other solids (OS), and lactose in milk were not affected ($P \geq 0.08$) by treatment × day interaction or treatment (Table 3). Concentrations of protein and fat decreased over time, while OS and lactose increased ($P < 0.01$). A treatment × day interaction was observed for MUN ($P < 0.01$), with HFOR greater than HCON throughout the study.

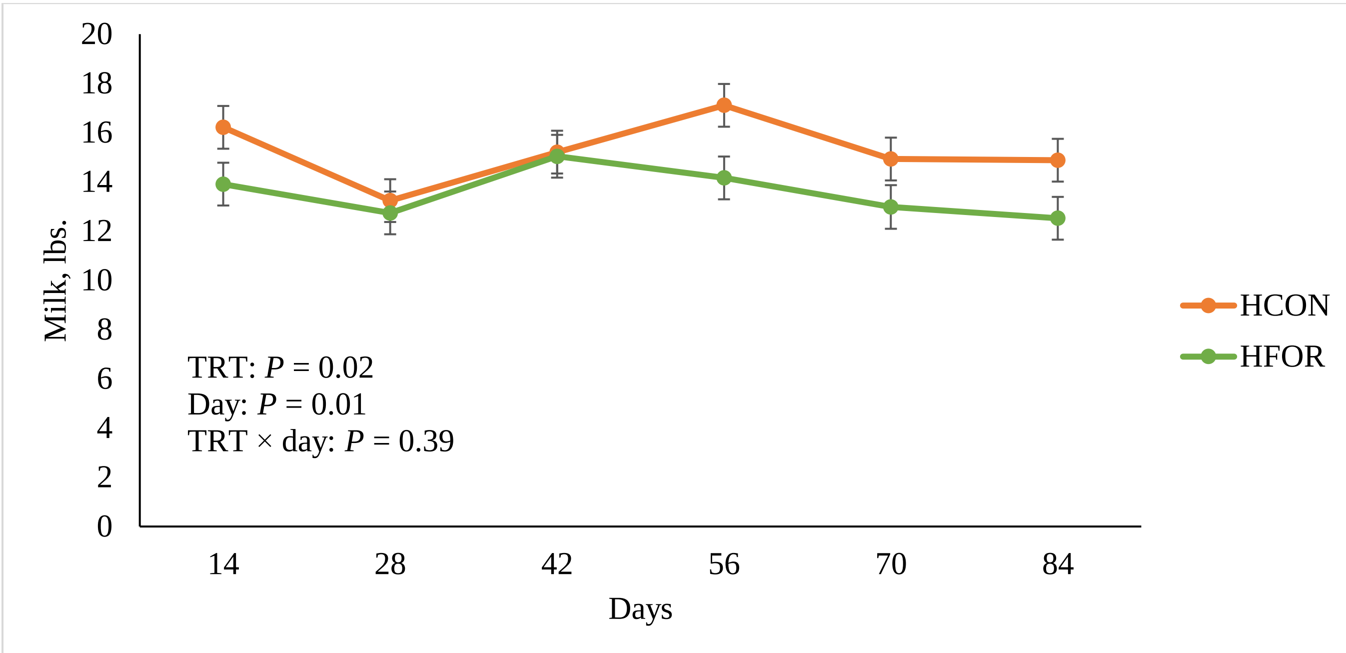

Figure 4. Effects of winter-feeding high forage (HFOR) or high concentrate (HCON) diets on milk yield.

Table 3. Effects of winter-feeding high-concentrate or high-forage diets on milk composition from d 14 to d 84 post-calving.

Components	Treatments	Days						trt average	SEM	*P*-value		
		14	28	42	56	70	84			TRT	Day	TRT × Day
Fat, %	High concentrate	4.27	4.36	3.90	3.95	3.97	3.87	4.06	0.15	0.40	0.05	0.95
	High forage	4.34	4.03	3.72	3.69	3.87	3.64	3.88				
	day average	4.31	4.19	3.81	3.82	3.92	3.75					
Protein, %	High concentrate	3.34	3.15	3.10	3.06	3.06	3.04	3.13	0.05	0.08	< 0.01	0.19
	High forage	3.51	3.25	3.24	3.07	3.21	3.17	3.24				
	day average	3.43	3.20	3.17	3.07	3.14	3.10					
MUN[1], mg/100g	High concentrate	9.53	7.90	5.82	5.06	5.20	5.91	6.57	0.42	< 0.01	< 0.01	0.004
	High forage	11.59	10.38	10.20	8.56	10.20	10.85	10.30				
	day average	10.56	9.14	8.01	6.81	7.70	8.38					
Other solids, %	High concentrate	5.53	5.51	5.75	5.77	5.78	5.75	5.68	0.04	0.85	< 0.01	0.41
	High forage	5.39	5.65	5.81	5.79	5.76	5.74	5.69				
	day average	5.46	5.58	5.78	5.78	5.77	5.75					
Lactose, %	High concentrate	4.63	4.62	4.85	4.84	4.87	4.82	4.77	0.04	0.76	< 0.01	0.42
	High forage	4.50	4.75	4.90	4.88	4.87	4.83	4.79				
	day average	4.57	4.68	4.88	4.86	4.87	4.82					

[1]MUN, milk urea nitrogen

[2]Milk collections were performed biweekly by fully milking cows using a portable milking machine

Concentrations of Glucose, NEFA, and Insulin in Blood

For cows, concentrations of glucose were similar between treatments (*P* = 0.48), averaging 70.84 ± 3.43 mg/dL for HCON and 74.41 ± 3.74 mg/dL for HFOR. Further, concentrations of glucose peaked at calving, averaging 105.07 mg/dL. Interestingly, a treatment × day interaction was observed for glucose in calves, with concentrations being greater for HFOR calves (80.64 ± 7.99 mg/dL) compared to HCON (52.36 ± 7.26 mg/dL) on day 0.

Concentrations of NEFA were significantly greater for HFOR compared to HCON cows (*P* = 0.02; 0.37 ± 0.02 mmol/L and 0.30 ± 0.02 mmol/L for HFOR and HCON, respectively). Further, NEFA concentrations were greater (*P* < 0.01) on d 50 ± 10 pre-calving (0.57 ± 0.03 mmol/L), followed by d 0 (0.31 ± 0.02 mmol/L), with lower concentrations on d 84 post-calving (0.13 ± 0.01 mmol/L). Concentrations of NEFA in calf blood were not affected by maternal treatment (*P* = 0.28) nor by a treatment × day interaction (*P* = 0.59), but were greater (*P* < 0.01) on d 0 (0.60 ± 0.05 mmol/L) compared to d 84 (0.19 ± 0.02 mmol/L).

Concentrations of insulin in cows were not affected by treatment, day, or their interaction (*P* ≥ 0.14). In calves, concentrations of insulin were not affected by maternal treatment (P = 0.56), but were greater (*P* = 0.02) on d 84 compared to d 0.

Economic Analysis

We performed an economic analysis, where hay prices were based on the average price of grass hay in the winter of 2023 (South Dakota) and the prices of other dietary ingredients were the average of current prices in SD, ND, IA, and MN (Table 4). In summary, producers can save $0.21/hd/d when adopting the limit-feeding high concentrate corn-based diet adopted in this study ($1.54 and $1.33 for HFOR and HCON groups, respectively). This translates to a total savings of $28.67/cow during the winter period. Lastly, the HCON group was economically more advantageous on a $/treatment ($4887.96 for HFOR compared to $4228.56 for HCON, an 8% difference). An economic tool to be housed at the SDSU extension website is currently being developed and is expected to be launched in January 2025.

Table 4. Economic analysis of winter-feeding high forage (HFOR) and high concentrate (HCON) diets[1]

	$/hd/d	**$/ton DM**	**$/ton AF**	**Total $/hd**	**$/treatment**
HFOR	1.54	164.71	140.00	212.52	4887.96
HCONC	1.33	177.63	131.92	183.85	4228.56

[1]Hay prices were based on the average price of grass hay in the winter of 2023 SD. Prices of other dietary ingredients were the average of current prices in SD, ND, IA, and MN (USDA, 2024).

Conclusions

In conclusion, limit-feeding high concentrate corn-based diets resulted in greater milk yields, lower enteric methane emissions, reduction of feed costs, and lower DM and water intakes compared to conventional high forage hay-based diets. Based upon feed cost of production, milk yield, and enteric methane emissions, producers can feed a high concentrate diet in replacement of conventional high forage diets during the winter-feeding period.

Unexpected Problems or Outcomes

Initially, we had 53 cows enrolled in the study; however, 4 cows were removed from the trial because they had twin-calves and 3 cows did not adapt to the electronic feeders. Therefore, we ended up with a total number of 46 cows, being 23 per treatment, which still gives us a reliable number of experimental units per treatment.

As early lactation is a period with greater nutritional demands, we had to adjust the intake of HCON cows to avoid loss of BCS and ensure maternal tissues were in a positive energy balance. The HCON cows were still limit-fed (1.5% BW), and individual intake was calculated to maintain BW.

Additional milk collections and body weight measurements were performed when cow-calf pairs were turned out to pasture. We observed that HCON cows had a compensatory gain, weighing similar to HFOR cows by the time of weaning. Further, milk production of both groups were similar at weaning.

Completed and Planned Publications, Presentations, and Outreach Media:

-Refereed Journal Publication: Plan to submit the results from this experiment to either Journal of Animal Science (JAS) or Translational Animal Science (TAS) by July 2025.

-Reviewed Abstracts:

Wehrbein, M.A.; Velasquez-Moreno, E.; Menendez, H.M.; Rusche, W.C.; Smith, Z.K.; **Menezes, A.C.B.** PSVII-30 Winter-feeding high concentrate diets reduces enteric methane emissions pre-calving in beef cows, *Journal of Animal Science*, Volume 102, Issue Supplement_3, September 2024, Pages 679–680, doi:10.1093/jas/skae234.768 . Data presented at the National ASAS Meeting (Calgary, Canada, July 2024)

Wehrbein, M.A.; Velasquez-Moreno, E.; Menendez, H.M.; Rusche, W.C.; Smith, Z.K.; **Menezes, A.C.B.** Winter-feeding high concentrate diets reduces enteric methane emissions pre- and post-calving in beef cows. *Minnesota Nutrition Conference*, September 2024. *Economic data was also presented at the MN Conference.

Wehrbein, M.A.; Jardon, G.H.; Menendez, H.M.; Rusche, W.C.; Smith, Z.K.; **Menezes, A.C.B.** Winter-feeding a high concentrate corn-based diet pre- and post-calving improves milk production in beef cows. *Submitted and to be presented at the 2025 ASAS Midwest meeting (March 9 – 12th, Omaha, NE)*

Wehrbein, M.A.; Jardon, G.H.; Menendez, H.M.; Rusche, W.C.; Smith, Z.K.; **Menezes, A.C.B.** Winter-feeding high concentrate diets minimizes the carbon footprint and improves water usage efficiency in cow/calf systems. *Submitted and to be presented at the 2025 ASAS Midwest meeting (March 9 – 12th, Omaha, NE)*

-Extension Publications: The results from this experiment will be prepared for submission to the South Dakota State University Animal Science Research Report for 2025 release that will occur around April of 2025.

Personnel Support

Megan Wehrbein (M.S. student) was partially supported by this grant which covered a full year graduate research assistant stipend, fringe benefits, and tuition.

Budget (through November 30, 2024)[1]

Item	Requested, $	Expenses, $	Available, $	Remaining, %
GRA Salaries	18,536	17,040	1,496	8
Benefits	185	490.69	-	-
Contractual, supplies, and travel	49,975	49,720	255	0.5
Tuition	8,840	8,840	-	-
Equipment	1,895	1,895	-	-
Total Funds	79,431	77,985.69	1,751	1.82

[1] Reports are generated at the end of each month.