CATTLEMEN'S DAY 2026

# Interactive Effects of Body Weight and Body Condition Score on Enteric Methane Emissions in Grazing Beef Cows

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## Abstract

Enteric methane emissions from beef cattle are both an environmental concern and a marker of digestive inefficiency; however, the role of animal-level traits such as body weight (BW) and condition in shaping these emissions remains underexplored. This study evaluated how BW and body condition score (BCS), both independently and interactively, influence methane production and emission efficiency in mature beef cows during spring grazing. Data were collected from a supplementation trial on native pasture using automated feeders and GreenFeed systems to measure individual supplement intake and gas emissions. Cows were weighed and scored monthly and categorized based on BCS changes over time (maintained, gained, or lost). A linear model explained 43% of the variation in methane output. Methane emissions increased with BW (0.79 g/day/lb; $P = 0.028$) and tended to increase with BCS (173.3 g/day/unit; $P = 0.068$). A significant BW × BCS interaction ($P = 0.050$) indicated that the emission effect of increasing BCS diminished in heavier cows. When methane was expressed relative to intake, cows maintaining BCS had the lowest emissions (185 g/lb of supplement dry matter intake), followed by cows that lost (198 g/lb) or gained (219 g/lb) condition. Similar trends were observed for methane per unit BW, although group differences were not statistically significant ($P = 0.24$). These findings suggest that moderate cow size and stable body condition are associated with improved emission profiles. Management strategies that support consistent BCS in moderate-sized cows may help balance productivity and environmental sustainability in pasture-based systems.

## Introduction

Improving digestive efficiency in beef cattle supports both animal performance and more sustainable, cost-effective operations. Methane, a byproduct of rumen fermentation, is a key environmental concern due to its high global warming potential, 28 times greater than that of carbon dioxide over a 100-year period. Rumen fermentation accounts for roughly 30% of total methane emissions in the U.S. (EPA, 2021). Although methane production represents an energy loss in cattle, its role in climate change has renewed interest in developing strategies to reduce emissions (Hristov et al., 2013). To be effective, these strategies must not only reduce emissions or prevent increases through indirect pathways but also remain practical and economically viable for producers (Thompson and Rowntree, 2020). One underexplored approach is to consider how individual animal characteristics influence methane output. Specifically, body weight (BW) and body condition score (BCS) together define cow size and energy reserves, and are linked to digestion and feed intake dynamics. Since methane production is closely tied to the amount and efficiency of feed fermented in the rumen, cow size is expected to influence emissions. While BCS is a simple visual tool to monitor fat reserves, BW reflects total metabolic demand. Understanding how BW and BCS interact to affect methane emissions can help identify management strategies that optimize both productivity and environmental outcomes. While prior research has established links between cow size, feed intake, and methane production, few studies have quantified how BW and BCS interact to shape absolute methane emissions and emission efficiency under practical grazing conditions. Initial evidence suggests that higher BW and BCS may both contribute to increased emissions, but the interaction between these variables and how they affect methane per unit of intake or BW remains poorly defined. Furthermore, it is unclear whether cows that maintain, gain, or lose condition over time differ meaningfully in methane emissions, which has direct implications for management decisions. The objective of this study was to evaluate how BW and BCS, both independently and interactively, influence enteric methane production and emission efficiency in beef cows during spring grazing. We also assessed whether temporal patterns in BCS change (gain, loss, maintenance) correspond with differences in methane emissions, to inform management strategies that align productivity with environmental stewardship.

## Experimental Procedures

This retrospective analysis used data collected during the first year of a two-year supplementation study conducted at the Kansas State University Purebred Beef Unit. The original study evaluated the effects of a monensin-containing supplement on methane emissions, forage intake, and cow-calf performance in mature spring-calving beef cows managed on native pasture. Data used in the present analysis were collected between January and June 2025 and only include cows offered a non-monensin-containing supplement.

Cows (BW = 1,219.6 ± 145.9 lb: Initial BCS = 4.6) were acclimated to automated feeding and gas measurement equipment, including SmartFeed Pro supplement feeders and GreenFeed emission monitoring systems (Automated head-chamber system [AHCS]; C-Lock Inc., Rapid City, SD), prior to the start of the spring supplementation period. During the supplementation period, cows were offered up to 1.5 lb/head/day of supplement (Table 1) with actual intake averaging 0.90 lb/head/day. Enteric methane and carbon dioxide production were determined using two AHCS. Visits were set for a maximum of six drops per visit (approximately 36 g/drop) with 30-second intervals between each drop and a minimum of four hours between each visit to encourage animals to space visits out across the day. Only visits greater than three minutes in duration were used for subsequent analyses as recommended by Velazco et al. (2016). Both BCS and BW were recorded monthly by two trained observers using a standard 9-point scale. Supplement intake was continuously monitored using the SmartFeed Pro system, and individual average daily intakes were calculated across the supplementation period.

For the present analysis, we examined how BW and BCS, as well as their interaction, influenced methane emissions in beef cows during the spring grazing period. Repeated monthly measurements were collected, and a statistical model was used to evaluate how these factors affected both total methane output and emission efficiency. To better reflect management implications, cows were grouped each month into BCS change categories (loss, maintain, or gain), and methane efficiency was compared across these groups using mixed models and graphical summaries. Model diagnostics, including residual plots and information criteria, were examined to confirm the appropriate model fit and assumptions.

## Results and Discussion

A statistical model to evaluate how BW and BCS interact to influence methane emissions in beef cows, based on repeated monthly measurements during the spring grazing period, was used. The model explained 43% of the variation in methane output. Heavier cows were observed to emit more methane, regardless of body condition, with emissions increasing by 0.79 g for each additional pound of BW ($P = 0.028$). Higher BCS also tended to increase emissions, with an estimated effect of 173.3 g/day/BCS unit ($P = 0.068$); however, this effect diminished at higher BW due to a significant negative interaction ($-0.14$, $P = 0.050$). In practical terms, methane output is already elevated in heavier animals, so further increases in BCS have less additional impact. These results suggest that cows with moderate BW and BCS offer a better balance between production efficiency and environmental impact. Previous research exploring the effects of cow BW on weaning weights would further suggest that weaning performance will likely be improved as well (Thompson and Rowntree, 2020).

When methane was expressed as an efficiency ratio (Table 2), cows that maintained BCS across months had the lowest emissions per unit of supplement intake (methane/dry matter intake = 185 g/lb of supplement intake), while cows that gained condition had the highest emissions (methane/dry matter intake = 219 g/lb of supplement intake). Cows that lost condition had intermediate emission rates (methane/dry matter intake = 198 g/lb of supplement intake). Although mixed model comparisons across groups did not reach statistical significance ($P = 0.24$), the direction of differences was consistent across months and animals and more research is required to explore this relationship. Methane per unit of body weight followed a similar pattern, with maintainers averaging 0.15 g/lb, gainers 0.18 g/lb, and losers 0.16 g/lb. These results suggest that cows that were in moderate and stable body condition emitted 15 - 20% less methane per unit of supplement intake compared to cows gaining condition, even though absolute daily methane production varied across months, ranging from approximately 135 g/day in February to 300 - 360 g/day in May. This indicates that it is energetically expensive to improve the body condition of beef cows in spring months when the quality of standing forage is poor, and supplemental feed is required.

## Implications

Results from this study suggest that managing cows for moderate body weight and stable body condition can reduce methane emissions. Heavier cows emitted more methane overall, and although cows in better condition tended to produce more methane, this effect was less pronounced in larger animals. Notably, cows that maintained their condition throughout the grazing period were more efficient, producing less methane per pound of supplement intake than those that gained or lost condition. These findings indicate that prioritizing moderate-sized cows that maintain condition through consistent management may support both production goals and environmental sustainability.

## References

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**Table 1. Supplement Cube**

| **Ingredient** | **Dry matter, %** |
|---|---|
| Soybean meal | 45.5 |
| Distillers grains | 15.0 |
| Protein supplement | 8.9 |
| Salt | 6.7 |
| Wheat middling | 6.5 |
| Molasses | 5.0 |
| Vitamins and minerals | 12.5 |
| | |
| Nutrient composition | |
| Dry matter, % as fed | 91.2 |
| Crude protein | 30.0 |
| Acid detergent fiber | 6.5 |
| Total digestible nutrients | 55.5 |

**Table 2. Impact of body condition score changes over the spring grazing period on enteric methane emissions**

| | Body condition score change group[1] | | | | |
|---|---|---|---|---|---|
| **Item** | **LOSS** | **MAIN** | **GAIN** | **SEM[2]** | ***P*-value** |
| Methane g/day | 191.0[a] | 196.1[a] | 276.9[b] | 13.5 | 0.03 |
| Methane g/day/lb of supplement dry matter intake | 198.0 | 185.0 | 219.0 | 10.0 | 0.24 |

[ab] Values within a row with different superscripts differ ($P < 0.05$).
[1] LOSS = lost body condition score; MAIN = maintained body condition score; GAIN = gained body condition score.
[2] Standard error of the mean.