Evaluation of Gas Emissions from Cattle on Different Diet Adaptation Strategies Using Either Forage or RAMP

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Summary with Implications

A 173-day finishing experiment was conducted to evaluate the effects of feeding RAMP (Cargill Corn Milling, Blair, NE) during diet adaptation compared to a traditional forage adaptation program on methane and carbon dioxide emissions, animal performance and carcass traits in beef steers. Cattle were monitored using a calorimetry emission barn to quantify production of methane and carbon dioxide during step 1 of grain adaptation and at two subsequent times while fed a common finishing diet. Feeding RAMP reduced methane by 12% during the initial diet (step 1) compared to a traditional diet that contained 43% forage. When cattle were fed the same finishing diet, there was a 9% reduction in methane due to carryover effects from feeding RAMP during grain adaptation. Cattle fed RAMP tended to increase hot carcass weight by 13 pounds. These data suggest feeding RAMP during grain adaptation instead of forage could be a strategy to reduce methane emissions. The performance benefits from RAMP would further decrease methane production per pound of gain.

Introduction

Reducing greenhouse gas emissions in agriculture has become a consumer priority, which means beef producers must try to decrease enteric methane without having negative effects on beef production. When ruminants digest cellulose, hemicellulose, starches, and sugars, then volatile fatty acids (VFA) are produced. But, ruminal fermentation results in some other byproducts such as methane, carbon dioxide, and hydrogen. These naturally produced gases need to be released from the rumen, and when released as methane, are considered to be digestible energy losses. Therefore, decreasing the loss of energy could result in a decrease in methane. A complete starter feed called RAMP (Cargill Corn Milling, Blair, NE) is a common approach in the Southern Plains, and consists of high levels of Sweet Bran (Cargill Corn Milling, Blair, NE) and low levels of forage, minerals, and vitamins. Sweet Bran is a highly digestible feed (*2022 Nebraska Beef Cattle Report*, pp 42–45) that has more energy than forages. Since corn milling byproducts have an increased energy value compared to forages, replacing forages during grain adaptation could lead to less gross energy that is lost. Therefore, the objective of this study was to determine the effects of utilizing RAMP compared to a traditional diet adaptation program on methane and carbon dioxide emissions of finishing steers during the grain adaptation and finishing phase, and the effects on performance and carcass characteristics during the entire feeding period (adaptation and finishing).

Procedures

A finishing experiment was conducted at the Eastern Nebraska Research, Extension, and Education Center near Mead, NE. Sixty-four steers (initial BW = 764 lb: ± 15 lb) were utilized to evaluate feeding RAMP during diet adaptation instead of a traditional forage program on methane (CH_4), carbon dioxide (CO_2), performance, and carcass characteristics. Cattle were limit-fed a common diet of 50% alfalfa hay and 50% Sweet Bran on a DM basis at 2% of body weight (BW) for 5 d to equalize gut fill. Weights were taken for two consecutive days before feeding to establish initial BW. Steers were blocked by BW into four weight blocks (4 paired replications), stratified within BW, and assigned randomly to pens (n=8 pens; 8 steers/pen). The four paired replications consisted of two treatments which were fed either 100% RAMP or 43% forage during step 1 (Table 1). The RAMP treatment consisted of cattle fed 100% RAMP during step 1 and then adapted to a common finisher diet consisting of 65.5% steam-flaked corn (SFC), 22.5% Sweet Bran, 8% wheat straw, and 4% supplement (DM basis). The second treatment was traditional forage adaptation program (CON) whereby cattle were fed 30.5% SFC, 22.5% Sweet Bran, 8% wheat straw, 35% alfalfa hay, and 4% supplement (DM basis) during step 1 and then adapted to the common finisher diet (Table 1). All cattle were fed 4 step-up diets over 22 d, with step 1 fed 7 d while step 2, 3, and 4 were fed for 5 d each.

Cattle were implanted with Revalor-IS on d 1 and reimplanted with a Revalor-200 on d 76 of the trial (Merck Animal Health, Summit, NJ). Cattle were harvested on d 173 at Greater Omaha (Omaha, NE) and liver abscesses and hot carcass weight (HCW) were recorded on the day of slaughter. Carcass adjusted final BW was calculated using a common dressing percent of 63%. Longissimus muscle (LM) area, 12th rib back fat, and USDA marbling scores were recorded after a 48-hr chill. Yield grade was calculated using an assumed 2% KPH (kidney, pelvis, and heart fat).

Each of the four paired replications started step 1 of the step-up diet 7 d apart, starting with the heavy weight block (replication 1) until the lightest weight block (replication 4) for a total of 21 d between the start of replication 1 and replication 4. Replications were limit-fed 8 lb of grass hay and 8 lb of Sweet Bran (DM basis) until 5 d before starting step 1 diets. Feed offerings were increased for 5 d prior to step 1 diets to achieve ad libitum intakes prior to being fed step 1 and entering the emissions barn. Cattle were fed their treatment diet for 1 d prior to entering the barn on step 1. Cattle

Table 1. Dietary composition (% of DM) for steers fed RAMP versus a traditional forage adaptation program (CON)

RAMP Diet Treatment[7]					
Ingredient	RAMP-1	RAMP-2	RAMP-3	RAMP-4	Finishing
RAMP[1]	100	75	50	25	-
Steam Flake Corn	-	16.5	32.5	49.0	65.5
Sweet Bran[2]	-	5.5	11.5	17.0	22.5
Wheat Straw	-	2	4	6	8
Alfalfa hay	-	-	-	-	-
Supplement [2]	-	1	2	3	4
Fine Ground Corn	-	0.264	0.529	0.793	1.057
Limestone	-	0.413	0.825	1.238	1.650
Tallow	-	0.025	0.050	0.075	0.100
Urea	-	0.200	0.400	0.600	0.800
Salt	-	0.075	0.150	0.225	0.300
Beef Trace Premix[3]	-	0.013	0.025	0.038	0.059
Vitamin A-D-E Premix[4]	-	0.004	0.008	0.011	0.015
Rumensin-90 Premix[5]	-	0.004	0.008	0.012	0.017
Tylan-40 Premix[6]	-	0.003	0.006	0.008	0.011
CON Diet Treatment[7]					
Ingredient	CON-1	CON-2	CON-3	CON-4	Finishing
Steam Flake Corn	30.5	40.5	50.5	58.0	65.5
Sweet Bran	22.5	22.5	22.5	22.5	22.5
Wheat Straw	8	8	8	8	8
Alfalfa hay	35	25	15	7.5	-
Supplement [2]	4	4	4	4	4
Fine Ground Corn	1.057	1.057	1.057	1.057	1.057
Limestone	1.650	1.650	1.650	1.650	1.650
Tallow	0.100	0.100	0.100	0.100	0.100
Urea	0.800	0.800	0.800	0.800	0.800
Salt	0.300	0.300	0.300	0.300	0.300
Beef Trace Premix[3]	0.059	0.059	0.059	0.059	0.059
Vitamin A-D-E Premix[4]	0.015	0.015	0.015	0.015	0.015
Rumensin-90 Premix[5]	0.017	0.017	0.017	0.017	0.017
Tylan-40 Premix[6]	0.011	0.011	0.011	0.011	0.011

[1]RAMP, Cargill Corn Milling, Blair, NE

[2]Sweet Bran, Cargill Corn Milling, Blair, NE

[3] Premix contained 6.0% Zn, 5.0% Fe, 4.0% Mn, 2.0% Cu, 0.29% Mg, 0.2% I, 0.05% Co

[4] Premix contained 30,000 IU vitamin A, 6,000 IU vitamin D, 7.5 IU vitamin per gram

[5] Supplement formulated to provide 30g/ton of Rumensin (Elanco Animal Health, DM Basis)

[6] Supplement formulated to provide 8.8g/ton of Tylan (Elanco Animal Health, DM Basis)

[7] Steers were on step 1 for 7 days and on step 2, 3, and 4 for 5 days each

were monitored for CH_4 and CO_2 emissions during three phases: step 1 of adaptation phase, early finishing phase (one week after starting the finishing diet), and later finishing phase (13 weeks after starting the finishing diet).

Emissions were measured with the pen scale emissions barn (*2019 Nebraska Beef Cattle Report*, pp 60–62). The barn uses a negative air pressure system equipped with LI-COR 7700 and LI-Cor 7500 analyzers (LI-COR, Lincoln, NE) that quantify concentrations of CH_4 and CO_2. The barn contains two separate enclosed pens with air flow controlled, and are designed so no emission crossover between pens with the barn. Paired replication remained paired through the duration of the experiment. Cattle entered the chambers at 0700 on d 1 (Wednesday) and remained in the chamber until d 5 (Monday) at 0700, then returned to their respective home pen. Each day was approximately 24 hours, from feeding to feeding. Methane and carbon dioxide from

Table 2. Effects of RAMP versus a traditional starter feedlot diet (CON) on gas emissions of steers during step 1

	Treatments[1]			
	CON	RAMP[2]	SEM	*P*-value
Gas emissions[3]				
DMI, lb/d[4]	22.7	22.7	0.81	0.95
CH_4, g/d	174	153	2.5	0.03
CH_4, g/lb of DMI	7.9	6.9	0.45	0.25
CO_2, g/d	7960	8692	83.6	0.03
CO_2, g/lb of DMI	362.5	396.9	18.16	0.31
CH_4:CO_2	0.0217	0.0177	0.0004	0.02

[1] Treatments included cattle adapted with a traditional forage diet or with RAMP and then fed the same common finisher diet

[2] RAMP is a complete starter feed (Cargill Corn Milling, Blair, NE)

[3]Emission were measured during step 1 of step-up diets

[4]Dry matter intake (DMI) was observed intake while in emission chambers

Table 3. Effects of RAMP versus a traditional forage adaptation program (CON) on gas emissions of steers during the finishing period

	Treatments[1]			
	CON	RAMP[2]	SEM	*P*-value
Gas emissions[3]				
DMI, lb/d[4]	26.9	26.0	0.46	0.34
CH_4, g/d	175	159	3.50	< 0.01
CH_4, g/lb of DMI	6.6	6.1	0.13	0.03
CO_2, g/d	10312	10338	96.1	0.85
CO_2, g/lb of DMI	386.9	396.7	7.57	0.39
CH_4:CO_2	0.0170	0.0153	0.0003	<0.01

[1] Treatments included cattle adapted with a traditional forage diet or with RAMP and then fed the same common finisher diet

[2]RAMP is a complete starter feed (Cargill Corn Milling, Blair, NE)

[3]Emission were measured 1 week on finishing diets and at 13 weeks on finishing diets

[4]Dry matter intake (DMI) was used to unitize reported emissions and was averaged from the weekly intakes of each treatment during rotation through the respective emission chambers

manure from the previous five days while cattle were in the barn were measured from 0700 h on d 5 (Monday) to 0700 h on day 6 (Tuesday) to adjust for only enteric emissions and exclude any from manure. After 24 h of manure collection, the manure was removed via skid steer on d 6 (Tuesday). After the manure was removed, CO_2 and CH_4 were measured until the next morning to get a baseline measurement, which was considered d 7, which was the final day in one rotation through the emissions barn. Manure emission levels of CO_2 and CH_4 were subtracted from baseline emission levels of CO_2 and CH_4 to determine the actual cattle production of CH_4 and CO_2 without manure contributions.

Data were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, NC) as a randomized complete block design. Pen was the experimental unit. For performance data and for emissions for step 1 of the step-up diet, treatment and BW block were fixed effects. The early and late finishing periods had treatment, BW block, cycle (1 week or 13 weeks on finishing diets), and chamber as fixed effects. Significance was declared at $P \leq 0.05$ and a tendency at $P \leq 0.10$.

Results

No differences in DMI were observed during step 1 of the grain adaptation phase ($P = 0.95$; Table 2). Feeding RAMP during step 1 decreased CH_4 as g/d ($P = 0.03$) by 12% and decreased CH_4:CO_2 ratio ($P = 0.02$) by 18%. Numerically, RAMP decreased CH_4/ lb of DMI by 12%; however, due to variation, the decrease in CH_4/ lb of DMI was not significant ($P = 0.25$). Steers fed RAMP had increased CO_2 as g/day ($P = 0.03$) because of the increased digestibility of the RAMP diet compared to the CON step 1 diet. No significant differences were observed between treatments when CO_2 was expressed as g per lb of DMI ($P = 0.31$).

No differences in DMI were observed due to different adaptation treatments during the 2 finishing period phases ($P = 0.34$; Table 3). Feeding RAMP during the adaptation phase compared to CON adaptation reduced CH_4 on a g/d basis by 9% ($P < 0.01$) and by 8% as g/lb of DMI ($P = 0.03$) during the finishing phase when both treatments were fed the same finishing diet. There was a decrease in the CH_4:CO_2 ratio for the RAMP treatment ($P < 0.01$), which was primarily driven from the decrease in CH_4. The decrease in methane in the finishing phase was a carryover effect from the grain adaptation phase as both treatments were fed the same finishing diet for 1 and 13 weeks prior to measurement.

There were no significant differences in initial BW between treatments as designed ($P = 0.30$; Table 4). During the entire 173 d trial, DMI ($P = 0.80$) and ADG ($P = 0.14$) did not differ among treatments. Cattle adapted with RAMP tended ($P = 0.10$) to have a greater carcass adjusted final BW (1574 lb) compared to the CON treatment (1553 lb; $P = 0.10$). The hot carcass weight was increased by 13 lb for RAMP (991 lb) compared to CON (978 lb; $P = 0.10$) which is similar to the 11 to 19 lb increases observed in other studies designed to better assess performance changes (*2012 Nebraska Beef Cattle Report*, pp 85–86). No significant differences ($P \geq 0.40$) were observed between treatments for marbling, 12th rib back fat, or in LM area. Liver abscess prevalence averaged 47% for both treatments but all abscesses were classified as A- (mild) except for 1 animal.

Conclusion

These data suggest that the complete starter diet, RAMP, was a more digestible diet compared to a traditional forage

Table 4. Effects of RAMP versus a traditional forage adaptation program (CON) on performance and carcass characteristics on fattening steers

	Treatments[1]			
	CON	RAMP[2]	SEM	*P*-value
Performance				
Initial BW, lb	784	786	1.1	0.30
Carcass Adjusted Final BW, lb[3]	1553	1575	6.4	0.10
ADG[4], lb	4.80	4.91	0.04	0.14
DMI, lb/d	25.9	25.8	0.44	0.80
Feed:Gain	5.41	5.24	-	0.24
Carcass characteristics				
HCW, lb	978	991	4.2	0.10
Marbling[5]	608	592	11.1	0.40
LM area, in^2	15.2	14.8	0.40	0.46
12th rib fat, in	0.71	0.70	0.026	0.80
Liver Abscesses, %	47	47	-	-

[1]Treatments included cattle adapted with a traditional forage diet or with RAMP and then fed the same common finisher diet

[2]RAMP is a complete starter feed (Cargill Corn Milling, Blair, NE)

[3]Carcass adjusted final BW was determined from hot carcass weight (HCW) divided by common dressing percentage of 63%

[4]The average days on feed 162 days

[5]Marbling score: 400=small^{00}, 500 = Modest^{00}, 600 = Moderate^{00}, minimum required for U.S. Low Choice

diet program that is used during grain adaptation. Adapting cattle with RAMP reduced methane (g/d) by 12% during grain adaptation. Methane was reduced by 9% (g/d) while cattle were on a common finishing diet due to carryover effects from adapting cattle with RAMP. Using RAMP during grain adaptation could be a strategy to reduce methane emissions. The performance benefits from RAMP would further decrease methane per pound of gain.

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