Technical Report

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ADDITIVES AND OFFSETS

A Partial Life Cycle Analysis of 3NOP Supplementation in Alberta Beef Production

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A Partial Life Cycle Analysis of 3NOP Supplementation in Alberta Beef Production

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Abstract

Methane emissions from beef cattle is linked to the highest fraction of methane emissions from the Canadian agricultural sector. The majority of beef production in Canada is linked to Alberta production systems, which typically follows cattle starting in cow-calf operations through finishing in feedlots. Although emission targets have not been set for the beef production sector, increasing social, political, and environmental pressures will require the beef industry to continue adapting to increasing sustainability measures. 3NOP is highlighted as a potential mitigation strategy in beef production, especially in backgrounding and feedlot setting; however, incentive for adoption remains uncertain, as supplementation is not concretely associated with added production value. Carbon offsets may offer a potential incentivization strategy.

This research uses Monte Carlo simulation to investigate the effects of 3NOP supplementation on total lifetime emissions of steers under differing production systems dosage levels. Emissions were estimated using a modified version of the IPCC Tier 2 Gross Energy Approach Methodology and parameters specific to Canadian beef production. The potential value of emission reductions with various doses and differing stages of production was also estimated using a hypothetical offset protocol for 3NOP supplementation. This research found that lifetime emissions were reduced by between 6.1 and 10.4 kg CH_4 per head when 3NOP was supplemented at the finishing stage of production. Estimated emission reductions increased between 3.7 and 5.7 kg CH_4 per head when early supplementation at the backgrounding stage of production occurred. These reductions translate offsets valued between $7.66 and $12.97 per head in the finishing stage and between $4.62 and $7.13 while backgrounding.

Keywords: Beef Cattle, Enteric Methane, 3NOP, Carbon Offsets, Alberta Beef, Monte Carlo Simulation

Contents

Policy Recommendations

- The Government of Alberta should prioritize the development of carbon offset protocols that include frameworks for 3NOP supplementation. This is especially relevant for Alberta's critical role in feedlot operations in Canada and will ensure the province remains competitive in terms of beef production on an emission-based scale.
- Further research on the effect of 3NOP on production markers in the feedlot sector will help operators understand the impact of adoption, and potentially elucidate possible benefits and risks associated with supplementation.

Introduction

Methane (CH_4) is a potent green house gas (GHG) with a 100-year global warming potential (GWP) 25 times higher than carbon dioxide (CO_2) (United States Environmental Protection Agency, 2022b). Methane makes up about 13 percent of Canada's total GHG emissions as reported in Canada's 2021 National Inventory Report, with the agricultural sector accounting for approximately 30 percent of total national methane emissions (Environment and Climate Change Canada, 2022). Methane emissions from the agricultural sector are derived from livestock production, specifically, enteric fermentation from dairy and non-dairy cattle operations and production(Canada, 2022). Enteric fermentation is part of the natural digestive process of all ruminants and produces methane as a by-product of the microbial breakdown of fibrous plant materials. Emissions from non-dairy cattle in Canada accounts for approximately 70 percent of total agricultural methane emissions (Environment and Climate Change Canada, 2022).

Methane, relative to other GHGs, is short lived with an atmospheric lifetime of approximately 12 years (United States Environmental Protection Agency, 2022a). This factor, in combination with the high GWP, makes methane reduction strategies practically relevant for meeting the Paris Agreement targets, as near-term reductions will have resultant mitigative impacts in decades, rather than centuries.

The Government of Canada has not set specific targets for the beef and dairy sectors; however, this may change going forward, as social, political, and environmental pressures to meet international commitments under the Paris Agreement intensify. On a commodity-basis, beef is linked to the highest fraction of livestock emissions, contributing 41 percent of the sector's overall global GHG outputs (FAO, 2015). The beef sector must adapt to improve future stability and growth in the sector. Rather than broad sweeping changes to be implemented across operations, gradual changes in production practices, managing transition risk[1] through structured and strategic incentivization of BMP adoption, rather destabilizing sweeping changes, should be prioritized.

The Canadian beef cattle herd is comprised of over 10.5 million cattle, linked to a total of 765.71 kt CH_4 emissions in 2019 (Kowk & Vinco, 2022). The majority of beef cattle, and therefore beef cattle operations and productions, are located in Alberta, totalling 48 percent of the total beef national cattle population.

Research conducted by Black et al., (2021), Kowk & Vinco (2022), and Arndt et al., (2022) have highlighted several near-term mitigation strategies with potentials to significantly reduce total enteric methane emissions. One of the most promising mitigation strategies is the use of 3-Nitrooxypropanol (3NOP), a synthetic feed additive manufactured by DSM that inhibits methane formation without impacting animal health or production indicators (Heerlen, 2022). Research on the effect of 3NOP supplementation in backgrounding and feedlot settings conducted in Lethbridge, Alberta, indicates a dose-dependent response in methane reductions, demonstrating reductions between 20 to 60 percent, depending on supplementation and diet (Alemu et al., 2021; Vyas et al., 2016). The potential use of 3NOP in backgrounding and feedlot settings is especially prevalent to Alberta, as the majority of Canadian beef is finished in the province (Alberta Cattle Feeders' Association, 2018). 3NOP is currently not approved for use in Canada and would require lengthy and rigorous regulatory investigation through the Canadian Food Inspection Agency (CFIA) before being approved for use in Canadian cattle production (Canadian Food Inspection Agency, 2022). Currently, no cost information for the additive is available, obfuscating incentivization for adoption, as benefits and potential carbon credit protocols associated with adoption would have to offset costs to drive uptake.

[1] Transition risks are a part of economic shifts towards a lower emission economy and associated changes in sectors. Shifts in asset values and higher costs of business transactions can be linked to transition risks in some sectors and should therefore be approached with strategies that optimize this risk (The Bank of England, 2019).

This report uses a Monte Carlo simulation to investigate the effects of 3NOP on total lifetime methane emissions in steers through different production systems and different 3NOP dosage levels. The model was developed using a modified version of the IPCC Tier 2 Gross Energy Approach Methodology and parameters specific to Canadian beef production. The potential value of emission reductions with various doses and differing stages of production was subsequently estimated using a hypothetical provincial offset protocol for 3NOP supplementation. Results indicate that lifetime emissions were reduced by between 6.1 and 10.4 kg CH_4/head when 3NOP was supplemented at the finishing stage of production. An additional 3.7 to 5.7 kg/head estimated lifetime emission reductions were observed when supplementation at the backgrounding stage of production occurred. These reductions translate to potential offsets values between \$7.66 and \$12.97 per head in the finishing stage, and between \$4.62 and \$7.13 per head at the backgrounding stage.

Data and Methodology

Emission Model

The research uses a modified version of the IPCC Tier 2 Gross Energy (GE) approach, used to estimate enteric methane emissions from beef cattle (IPCC, 2019). The approach is used by 22 of 42 Annex parties to the UNFCCC, including the United States and Canada, and is the preferred Tier 2 approach by the IPCC (Bourassa & Vinco, 2022; IPCC, 2019). A Tier 1 approach is relatively straight forward – total cattle population is multiplied by a set emission factor, a measurement of enteric methane per head of cattle, over a set period of generally one year (IPCC, 2019). The methodology can be improved by differentiating cattle populations by stage or by developing emission factors specific to the location and stage of production. The GE approach used in this analysis estimates a daily emission factor as a function of energy requirements, based on cattle, production, and environmental factors. Lifetime emissions is then estimated as the cumulative sum of the daily emissions over the lifespan. Formally, daily emission factor, EF, for Steer i, on day j in treatment group t and production stage p, is estimated using Equation 1. EF is a function of gross energy intake, GE, measured in megajoules (MJ) per day, and the methane conversion factor, Y_m, representing the percentage of energy lost as methane. The constant of 55.65, the energy content of methane, is used to convert MJ to kg CH_4 (IPCC, 2019).

$$EF_{i,j,t,p} = \frac{GE_{i,j,t,p} \times \left(\frac{Y_{m_{i,j,t,p}}}{100}\right)}{55.65} \tag{1}$$

The methane conversion factor is dependent on the digestibility of feed, $DE_{i,j,t,p}$. Following guidelines in the 2019 Refinement, Y_m is equal to 7 if the diet consists of more than 75 percent of forage and has a $DE_{i,j,t,p}$ value lower than 62 percent. Y_m is equal to 6.3, if $DE_{i,j,t,p}$ is greater than or equal to 62 percent and the diet consists of high-quality forages, or a mixed ration consisting of between 15 and 75 percent forage (IPCC 2019). For cattle in feedlots fed a finishing diet, Y_m was assumed to be 3.2, the average conversion factor for Canadian beef cattle in feedlots (ECCC, 2022). As of 2021, the use of 3NOP is not accounted for in the 2019 Refinement or in any National Inventory methodology (Bourassa & Vinco, 2022). To incorporate the effects of 3NOP, this research first assumed that 3NOP only effects the rate of methane conversion and has no impact on other input variables within the model. A ratio factor equal to 1 was created when 3NOP was not provided, and between 0.55 and 0.64 depending on diet and dosage with the ratio factors based on estimates from Vyas et al. (2016). The ratio factor was multiplied by Y_m to get a modified methane conversion specific to stage of production and treatment.

While Y_m is primarily dependent on the diet, GE depends on several different cattle and production characteristics. GE is estimated as a function of the net energy required for maintenance, $NE_{m,i,j}$, activity, $NE_{a,i,j,t,p}$, and growth $NE_{g,i,j,t,p}$, $DE_{i,j,p}$, and the ratio of net energy available in the diet for maintenance, $REM_{i,j,t,p}$, and growth, $REG_{,i,j,t,p}$, to the digestible energy consumed (IPCC, 2019), see Equation 2.

$$GE_{i,j,t} = \frac{\left(\frac{NE_{m,i,j} + NE_{a,i,j,t}}{REM_{i,j,t}}\right) + \left(\frac{NE_{g,i,j,t}}{REG_{i,j,t}}\right)}{DE_{i,j,p}} \tag{2}$$

A cold adjusted net energy requirement for maintenance was estimated and applied year-round to account for the seasonal temperature fluctuations in Alberta throughout the year. This approach differs from the Canadian methodology, which only uses a cold adjusted factor between October and April and uses average winter temperature (ECCC, 2022). $NE_{m,i,j}$ was estimated using Equation 3 and is a function of weight for steer i on day j, $Weight_{ij}$, mean daily temperature, C_j, and a coefficient, CF, equal to 0.322.

$$NE_{m,i,j} = \left(CF + 0.0048 \times \left(20 - C_j\right)\right) \times \left(Weight_{ij}\right)^{0.75} \quad (3)$$

The net energy requirement for activity is the additional energy required to acquire feed (IPCC, 2019). The estimate is dependent on the net energy requirement for maintenance and the feeding/grazing practices. The IPCC guidelines assign a value of 0 for cattle confined in stalls or barns, 0.17 for cattle confined to pasture, and 0.36 for cattle grazing large areas freely. The net energy for activity is estimated using Equation 4, with $F_{i,t,p}$ equal to the feeding/grazing coefficients.

$$NE_{a,i,j,t,p} = F_{i,t,p} \times NE_{m,i,j} \quad (4)$$

Net energy for growth ($NE_{g,i,j,t,p}$) is the net energy needed for weight gain and is estimated as a function of daily cattle weight $Weight_{i,j}$, the mature body weight MW_i, the daily weight gain $WG_{i,t,p}$, and a growth coefficient SF with a value of 0.8 for females, 1.0 for steers (IPCC, 2019), see Equation 5.

$$NE_{g,i,j,t,p} = 22.02 \times \left(\frac{Weight_{i,j}}{SF \times MW_i}\right) \times {WG_{i,t,p}}^{1.097} \quad (5)$$

The ratio of net energy available in the diet for maintenance to digestible energy consumed (REM) and the ratio of net energy available for growth in a diet to digestible energy consumed (REG) are estimated as a function of the digestibility of feed expressed as a fraction of gross energy (digestible energy/gross energy) using Equation 6 and 7, respectively (IPCC, 2019).

$$REM_{i,j,p} = 1.123 - \left(4.092 \times 10^{-3} \times DE_{i,j,p}\right) + \left(1.126 \times 10^{-5} \times {DE_{i,j,p}}^2\right) - \left(\frac{25.4}{DE_{i,j,p}}\right) \quad (6)$$

$$REG_{i,j,p} = 1.164 - (4.092 \times 10^{-3} \times p) + \left(1.126 \times 10^{-5} \times {DE_{i,j,p}}^2\right) - \left(\frac{25.4}{DE_{i,j,p}}\right) \quad (7)$$

Data Generation

This research uses Monti Carlo simulation to estimate the effects of 3NOP on lifetime enteric methane emissions from beef steers in Alberta. Input variables for each observation (steer) are generated by randomly sampling from the variable's probability distribution and estimating emissions based on the randomly generated variables, see Table 1. By repeating this process multiple times, a full range of potential outcomes are identified. A total of 20,000 observations were generated following this process, approximately 2,500 per treatment group.

A full set of input variables were first generated for each observation. Observations were randomly assigned to one of four dosage levels, 0, 100, 150, 200 mg/kg DM, and one of two production systems: Cow-Calf to Backgrounding to Finishing (CBF), or Cow-Calf to Stocking to Finishing (CSF). Once assigned to a treatment, an iterative process was used to estimate daily and cumulative emissions emission for each day in production. Time in each stage of production was determined by specific weights and growth rates. Values for Calf Weight (Mean: 40 kg, SD: 3) and Target Weight (Mean: 715 kg, SD: 15) were used to indicate the start and end points for the simulation, while Weaning Weight (Mean: 272 kg, SD: 5), and Auction Weight (Mean 408 kg, SD:5) were used to indicate transitions between stages of production. While in the Cow-Calf and Backgrounding/Stocking stages of production, daily weight gain was randomly sampled from the same normal distribution with a mean equal to 1 kg/day and a standard deviation equal to 0.16 (ECCC, 2022). For Backgrounding cattle (CBF treatment), the daily weight gain increased between 1 and 6 percent to account for the inclusion of ionophores in the ration (Hersom & Thrift, 2018). Once cattle transitioned to the Finishing stage, daily weight gain was sampled from a normal distribution with a mean of 1.4 kg/day and a standard deviation of 0.12 (ECCC 2022), increased to account for ionophore supplementation. Our model assumed consistent growth rates throughout each stage of production.

To simplify the model, the start date for the analysis was set to March 15, 2019 (Day 0) for all observations. Mean daily temperature for the city of Lethbridge, Alberta was then joined to the data set and used for estimating the cold adjusted factor, with weather data provided by Alberta Agriculture, Forestry and Rural Economic Development (AAFRED), Alberta Climate Information Service (ACIS) (2022). Canada's methodology does not consider either spatial or temporal variation of pasture digestibility. In order to account for this variability, our model based the magnitude of the seasonal fluxes on examples presented in Australia's 2022 National Inventory Report. A value of 55, 60, 65, and 60 percent were selected and assigned for winter, spring, summer, and fall pasture digestibility, respectively. Linear interpolation was used to estimate daily pasture digestibility with the lowest DE value found on January 1st and the highest on July 1st of each year. To allow for some variability in digestibility, a value between -5 and 5 was randomly sampled from a uniform distribution for each observation, added to daily DE value, and the sum was used in the emission estimate. Steers in the background stage of production were assumed to be fed a high forage diet, therefore DE was also assumed to remain consistent throughout the stage, and randomly sampled from a normal distribution with a mean of 65 percent and a standard deviation of 1. Steers in the finishing stage were assumed to be fed a high grain diet, therefore DE values were high and consistent throughout the stage of production, and values for each observation were randomly sampled from a normal distribution with a mean of 80 and a standard deviation of 0.5.

Lastly, activity for each stage of production was randomly assigned. During the cow-calf and stocking stages of production, a value between 0.17 and 0.36 was randomly sampled from a uniform distribution. This range was selected to account the variation in activity required to acquire feed across a variety of grazing and pasture management practices. For cattle in the backgrounding stage, a value between 0 and 0.17 was randomly sampled; it is assumed this range would cover confined steer, 0, to intensively managed grazing practices on improved pasture, 0.17. Cattle in the finishing stage were assumed to be confined and assigned a value of 0.

Table 1

Model Input Variables

Variable	Mean/Range		SD	Distribution	Source
Calving Date	15-Mar-19			Constant	
Temp	-31.4	27.1		Daily	[1]
Calving Weight	40		3	Normal	[2]
Weaning Weight*	272		5	Normal	[3]
Auction Weight*	408		5	Normal	[3]
Target Weight*	715		15	Normal	[3]
Non-Feedlot Growth Rate**	1		0.16	Normal	[2]
Feedlot Growth Rate	1.4		0.12	Normal	[2]
Growth Rate Modifier (Ionophores)	1.01	1.06		Uniform	[4]
Cow Calf and Stocking Activity	0.17	0.36		Uniform	[5]
Background Activity	0	0.17		Uniform	[5]
Feedlot Activity	0			Constant	[5]
RF 3NOP - Background	0.77	0.84		Constant	[6]
RF 3NOP - Finishing	0.55	0.74		Constant	[6]
Pasture DE Mod	-5	5		Uniform	
Background DE*	65		1	Normal	[5]
Feedlot DE*	80		0.5	Normal	[2]
Ym (DE < 62)	7			Constant	[5]
Ym (DE >= 62)	6.3			Constant	[5]
Ym Feedlot	3.2			Constant	[2]

Note: * indicates standard deviation was set to fit a plausible range of values, ** Growth rate used for Cow-Calf, Backgrounding, and stocking stages of production. [1} The Government of Alberta - Alberta Agriculture, Forestry and Rural Economic Development (2022) [2] ECCC (2022) [3] Canadian Cattle Association (2022) [4] Hersom & Thrift (2018) [5] IPCC (2019) [6] Vyas et al., (2016)

Regression Model

An OLS regression model was used to estimate the effects of dose, and production system on lifetime enteric methane emissions. As seen in Equation 8, lifetime emissions denoted as EM_i is a function of 3NOP dosage, $Dose_i$, production system, $System_i$, and an interaction between the two terms, $(Dose_i \times System_i)$.

$$EM_i = \beta_0 + \beta_1 Dose_i + \beta_2 System_i + \beta_3 (Dose_i \times System_i) + \varepsilon_i \quad (8)$$

As the model input variables are randomly generated from the same distributions, it can be assumed that the variation in lifetime can be directly attributed to either 3NOP supplementation or production or attributed to random variation in the input variables which is accounted for by the error term ε_i.

Results

Observations within the CSF group not supplemented with 3NOP (CSF/NA) were used as the control group for this analysis. Within the group, mean lifetime emissions were estimated to be 94.5 kg CH_4 (SD: 11.5), approximately 2.36 t CO_2 eq. At dosages of 100, 150, and 200 mg/kg DM/day while in the finishing stage of the CSF production system, mean emissions were reduced to 88.4 kg CH_4 (SD: 11.1), 86.68 (SD: 11.5), and 84.1 kg CH_4 (SD: 11.5), respectively. Mean emissions were significantly lower in the CBF production system than in the CSF system. For the CBF/NA group, mean lifetime enteric emissions were estimated to be 79.0 kg CH_4 (SD: 8.5). Higher average feed digestibility, the use of growth promoting supplements, and decreased steer activity between weaning and auction all contributed to lower average emissions in the CBF/NA. When 3NOP was supplemented at the start of the backgrounding stage, mean lifetime enteric emissions were reduced to 69.2 kg (SD: 8.2), 66.2 kg (SD: 8.0), and 62.9 kg (SD: 8.2) when treated with 100, 150, and 200 mg/kg DM/day, respectively. The variation in results by treatment group is demonstrated in Figure 1. The cumulative distribution function shown in the figure can be used to identify the probability of being at or below a specific emission level given the treatment group, or the probability of being between two levels. Observations within the control group were between 71.5 kg and 122.32 kg CH_4 at the 1st and 99th percentile and had an interquartile range (IQR) between 86.1 kg and 102.4 kg. When 3NOP was supplemented to cattle in the CSF production system, a leftward shift in the cumulative distribution function is observed, but the distribution shape did not change. The distribution narrows when comparing results in the CBF to the CSF groups, primarily as a result of more consistent feed digestibility while in the backgrounding stage. For CBF/NA, the 1st and 99th percentile results were between 64.4 kg and 104 kg CH_4 and the IQR was estimated to be between 72.9 kg and 83.9 kg.

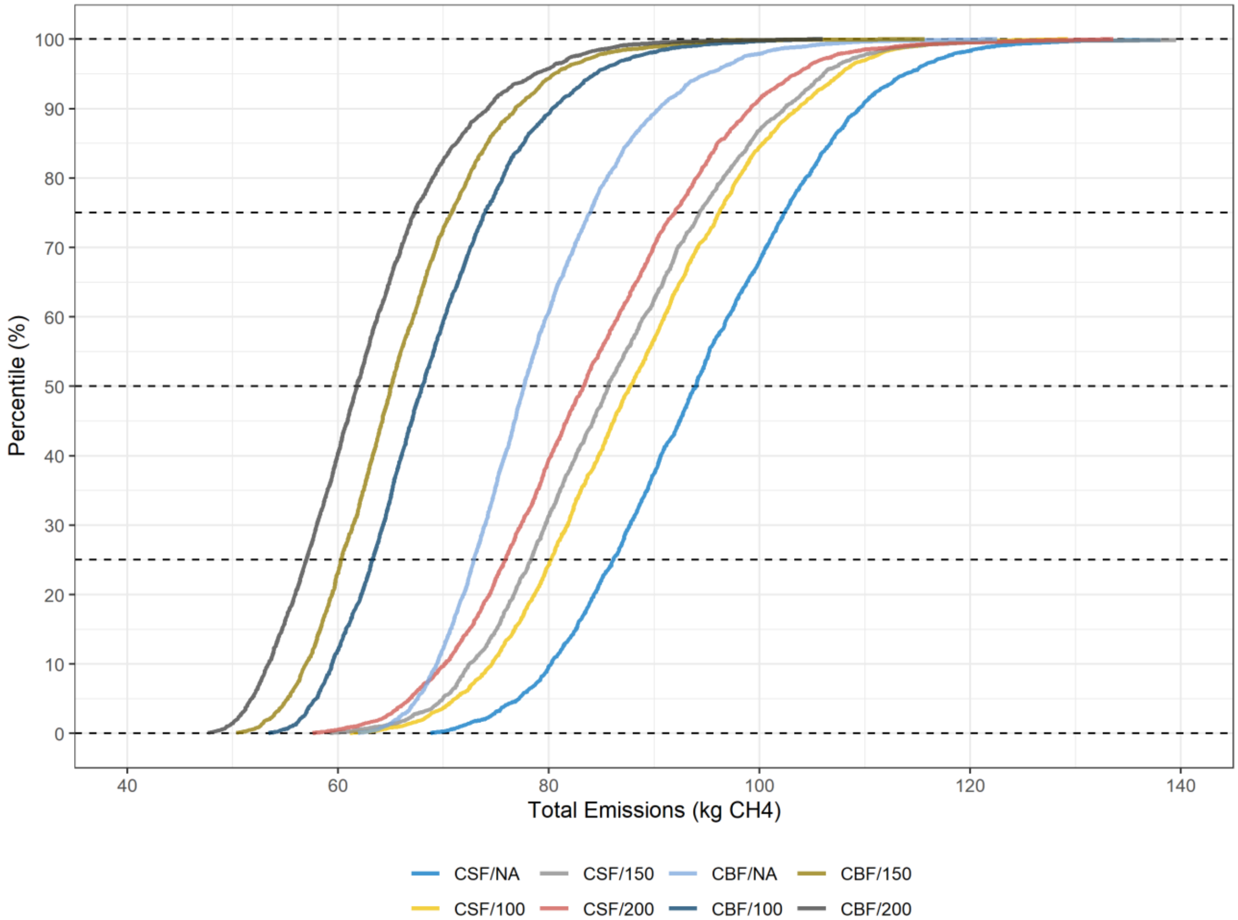
Figure 2 shows daily and cumulative enteric methane emissions for a representative example within each treatment group. The example was estimated by calculating the mean values for the input variables within each treatment group. The mean values were input into the emission model. In the Cow-Calf stage of production, emission estimates for each example were approximately equal, as seen by the overlapping lines. This was expected as the starting data was sampled from the same distributions, and practices were the same at this point. During the Cow-Calf stage of production, average daily emissions were 0.125 kg CH_4 per day, and cumulative emissions reached approximately 29 kg CH_4 for all treatment groups. At weaning, approximately 231 days into production (November 1, 2019), steers either remained on pasture (CSF) or moved to the backgrounding stage (CBF). This transition can be clearly observed within the figure as daily emissions significantly decrease for cattle in the CBF groups compared to the CSF groups; 0.20 for CBF/NA compared with 0.31 CSF/NA. Daily emissions were further reduced for steers provided 3NOP; however, differences between CBF/100, CBF/150, and CBF/200 appear minor, and differences between CBF/150 and CBF/200 appear insignificant, 0.165 kg, 0.155 and 0.151 respectively. Emissions for steers in the CSF group continued to increase throughout the winter given decreasing pasture digestibility and increasing energy requirements. While in the stocking stage of production, significant differences between CSF treatment groups were not observed, as the data originated from the same distribution, the sample size was large enough, and no treatment was yet applied. For steers in the CSF groups, cumulative emissions in the stocking stage of production were approximately 42 kg, significantly higher than cumulative emissions in the CBF/NA, CFB/100, CBF/150, and CBF/200 treatment group, which had values of 26.0, 21.8, 20.5, and 20.0 kg CH_4, respectively. At day 363 for CBF and 368 for CSF treatment groups, March 12th and 17th, respectively, steers transitioned into the finishing stage of production. Average daily emissions while in the finishing stage of production were not significantly different after accounting for 3NOP dose. When 3NOP was not supplemented, average daily methane emissions were 0.106 kg for CBF/NA and BSF/NA, 0.078 for CBF/100, and CFS/100, 0.071 for CBF/150, and CFS/150, and 0.058 for CBF/200, and CFS/200. The example steers reached their target weights at approximately 574 and 580 days in production for CBF and CSF groups respectively (October 9th and 15th 2020), and cumulative emissions for the finishing stage were between 22.4 and 12.3 kg CH_4 for the CBF examples and 22.3 and 12.4 kg CH_4 for the CSF groups.

The results from the OLS regression model can be seen in Figure 3. The results indicate that supplementing high grain diets with 3NOP during the finishing stages of production would reduce emissions by 6.1, 7.8, and 10.4 kg CH_4 per head at 100, 150, and 200 mg/kg DM dosages compared with the control group. Early supplementation while in the backgrounding stage further reduced CH_4 emissions by an estimated 3.7, 5.0, and 5.7 kg CH_4 per head. Backgrounding cattle was also estimated to further reduce lifetime emissions by 15.5 kg CH_4 when compared to Stocking.

If further research concludes that 3NOP supplementation does not significantly affect feed efficiency or growth, incentivization strategies will need to be developed to encourage its adoption. Carbon offsets could be an effective strategy given its ease of implementation and the existing framework for agricultural offset development within Alberta's TIER program (The Government of Alberta, 2020). The research suggests that at $50 per tonne of CO_2eq, offsets would be valued between $7.66 and $12.97 per head when supplementing 3NOP at the finishing stage of production. In early supplementation at the backgrounding stage, the additional increase in the offset value would be between $4.62 and $7.13 per head. Averaging the offset value across time in production, the value of 3NOP can be estimated on a per day basis for the backgrounding and finishing stages of production. As 3NOP is supplemented daily, this estimate can be viewed as the revenue neutral price of 3NOP in the absence of other incentivization programs, and if assumed that 3NOP does not affect productivity. This research found that the average daily value of 3NOP was between $0.034 and $0.052 per day in the backgrounding stage, and between $0.036 and $0.061 while in the finishing stage.

Figure 1:

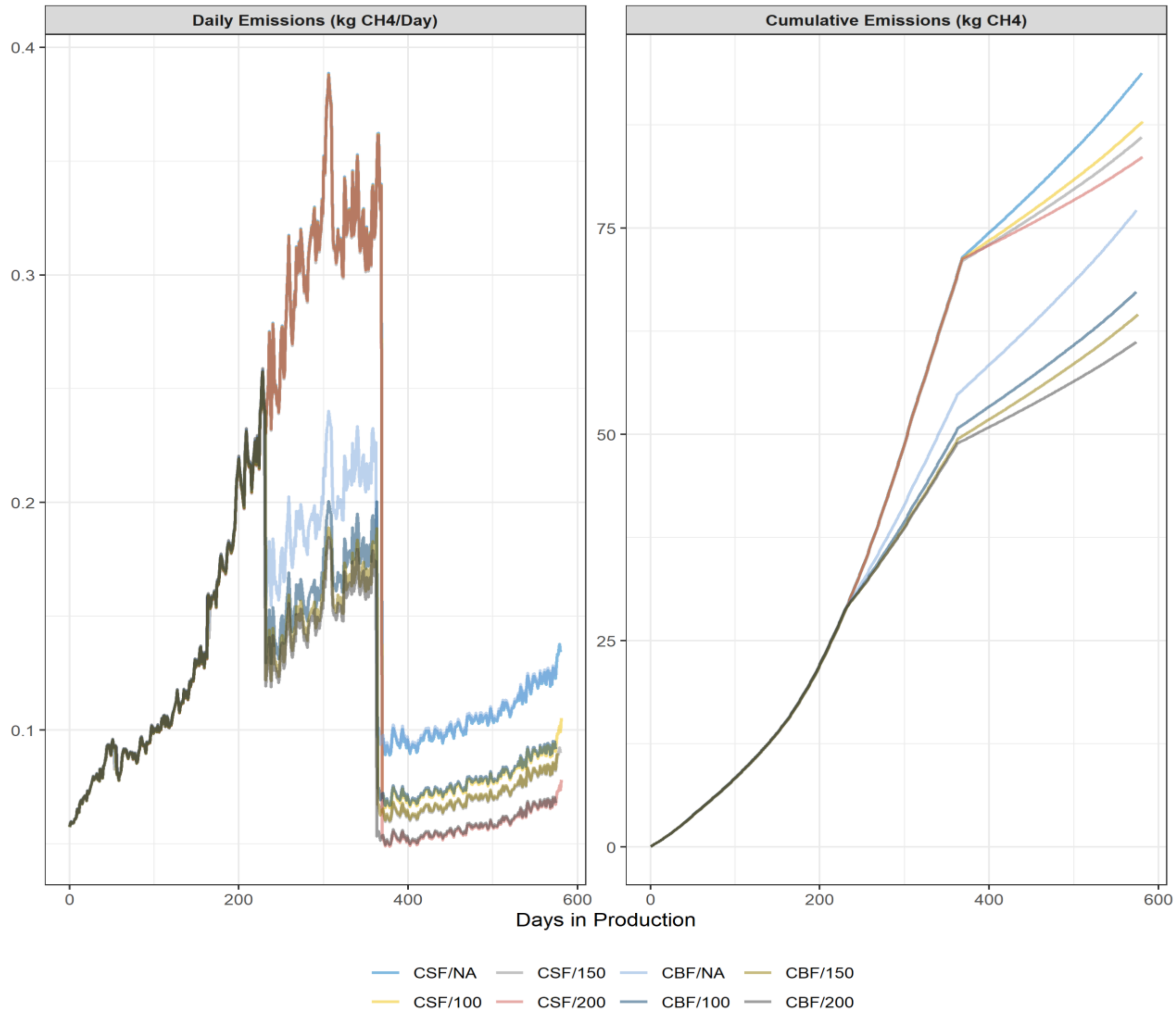
Cumulative Distribution of Estimated Lifetime Enteric Methane Emissions by Treatment Group



Note: The figure displays the cumulative distribution functions for estimated lifetime enteric methane emissions for each of the eight treatment groups. The dashed horizontal lines indicate the 25th, 50th, and 75th percentiles as well as the maximum and minimum values. For illustrative purposes, the x axis was limited to between 40 and 140 kg CH_4. This restriction removed three observations from the CSF/NA group which were equal to 140.6 kg, 148.1 kg, and 162.1 kg CH_4, and three observations from the CSF/150 group which were equal to 140.2 kg, 144.0 kg, and 144.3 kg CH_4.

Figure 2

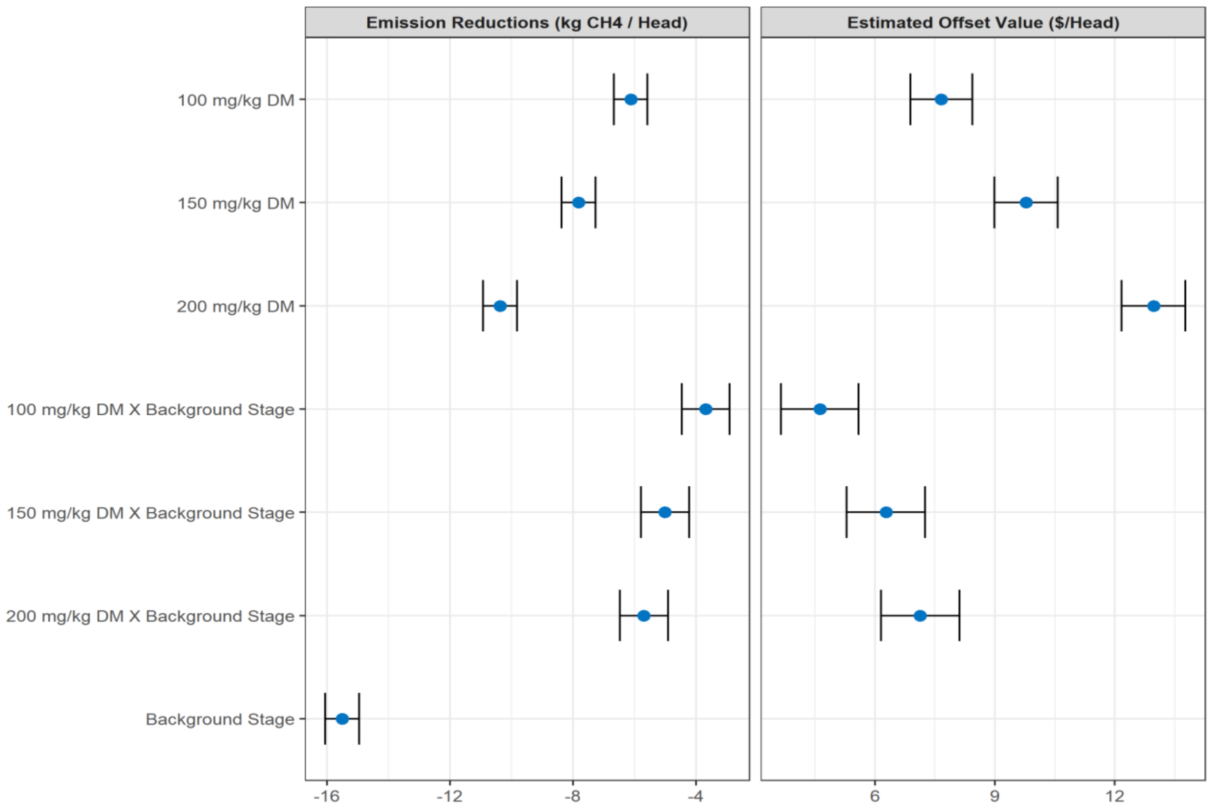
Daily and Cumulative Emission Estimated using Treatment Group Average Input Variables



Note: The figure displays a representative example of the daily and cumulative emissions estimated for this analysis. The representative example was created by first taking the mean values of the starting variables using all observations within each treatment group, and then using the mean values to estimate emissions.

Figure 3

OLS Regression Coefficients and Estimated Offset Values for 3NOP



Note: The blue circle indicates the estimate coefficients *for* β_1, β_2, and β_3, the range lines indicate a 95 percent interval around the coefficient estimate. The constant, β_0, was estimated to be 94.5 kg, R-squared was estimated to be 0.5425. To estimate offset value, lifetime emissions were converted to tonnes of CO_2 equivalent which were then valued at $50 a tonne. Using the same OLS model shown in equation 8, lifetime emissions shown in $/head was estimated and the absolute value of the coefficients were then used as the offset value.

Conclusion

Reducing methane emissions is becoming a greater priority for the Government of Canada. This shift in priorities can be seen with the joining of the Global Methane Pledge and the release of *Faster and Further: Canada's Methane Strategy* which aims to reduce domestic methane emissions by more than 35 percent of 2020 levels by 2030 (The Government of Canada, 2022). If targets were to be set for the beef sector, Black et al., (2021) and Kowk & Vinco (2022) highlight a number of strategies with potential to significantly reduce enteric methane emissions while maintaining current production levels. Of those strategies, the supplementation of 3NOP appears to be well suited for beef production in Alberta, given the share of feedlot operations within the province.

Our research found that on average, supplementing 3NOP has the potential to reduce methane emissions by between 6.1 and 16.1 kg CH_4 per head (125.5 kg and 402.5 kg CO_2 eq), depending on the dose received and when supplementation began. If 100 percent adoption were to occur within Alberta, total annual emission could be reduced by as much as 342.3 kt CO_2 eq[2], approximately 4 percent of total enteric methane emissions within the province.

While some research has indicated that 3NOP increases productivity while in feedlot settings, the development of incentivization programs may be required to help facilitate faster and more widespread adoption within the sector. This could be accomplished through the development of carbon offset protocols within Alberta's existing TIER framework. At $50 a tonne CO_2 eq potential offset values could be between $7.62 and $20.12 per head; by 2030, the offset could be worth as much as $68.42 per head with carbon prices reaching $170 per tonne.

There are currently two critical barriers impeding the adoption of 3NOP in Canada. First, CFIA has classified 3NOP as a veterinary supplement which requires a significantly longer approval process than if it was classified as a dietary feed supplement, as of 2022, commercially available 3NOP remains years away in Canada (Arnason, 2022). As a result of regulatory barriers, Canada cannot be considered a global leader in low emission beef production as 3NOP has been approved for use in over 40 countries including Brazil Chile

[2] Based on total number of cattle in feeding operations as of July 1st, 2021 (Statistics Canada, 2022).

the EU/EEA and Australia (DSM, 2022). The second possible barrier to widespread adoption is consumers. Despite a growing demand for sustainably produced or low-emission commodities, little is known about consumer perception towards the use of synthetic feed additives as a method to reduce emissions in livestock production. Consumers may react negatively, aligning synthetic additives with antibiotics and hormones; this is an area of future research and outreach.

Beef production in Alberta is critical to Alberta's culture and identity. Alberta cow-calf and feedlot operators have remained leaders in the beef sector in terms of prioritizing safe and sustainable beef, especially firm in the role of grazing cattle in the protection and maintenance of Canadian native grasslands. With shifting consumer preferences and increased pressure to increase outputs while maintaining or decreasing inputs, Alberta beef and its stakeholders will continue to act as leaders in ensuring Canadian beef remains competitive across dimensions, including methane emissions, through progressive adoption of sustainable practices and innovation along the beef supply chain.

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