SOUTH DAKOTA
STATE UNIVERSITY

Department of Animal Science

Beef Day 2020

Meats & Human Nutrition

Performance, carcass characteristics, and life cycle assessment of cattle grown utilizing different combinations of growth promoting technologies

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Objective

The objective of this study was to determine the impact of different combinations of growth promoting technologies on live animal performance, carcass characteristics, and environmental outcomes.

Study Description

Crossbred steer calves (n = 120) were assigned randomly to 1 of 4 treatments: 1) no technology (NT; no antibiotics, hormones, ionophores or beta-agonists,); 2) non-hormone treated cattle (ANT; fed monensin and tylosin); 3) implanted (IMP; ANT protocol plus a series of three implants), and 4) implanted and fed a beta-agonist (BA; IMP protocol plus ractopamine-HCl for the last 30 days prior to harvest). Steers were finished in an individual feeding system to collect performance data. At harvest, standard carcass measures were collected. Information from the cow-calf, backgrounding, and finishing phases were used to simulate production systems using the USDA Integrated Farm System Model and conduct a life cycle assessment.

Take home points

Average daily gain (ADG) was greatest ($P < 0.05$) for IMP, while BA was intermediate ($P < 0.05$), and NT and ANT were the lowest ($P < 0.01$) but did not differ ($P > 0.05$). Dry matter intake for IMP and BA were similar ($P > 0.05$) and greater ($P < 0.01$) than NT, which was intermediate ($P < 0.01$) to ANT. Gain:Feed was greatest ($P < 0.05$) for IMP compared with NT, ANT, and BA, which were similar ($P > 0.05$). Hot carcass weight (HCW) for IMP and BA were similar ($P > 0.05$) and heavier ($P < 0.01$) than NT and ANT, which were similar ($P > 0.05$). No differences ($P > 0.05$) were detected for USDA Yield Grade, or proportions of carcasses in each USDA Yield Grade (YG) or Quality Grade (QG). Marbling scores for NT and ANT were similar ($P > 0.05$) to each other and both were greater ($P < 0.01$) than IMP and BA, which were similar ($P > 0.05$). Environmental analysis revealed that IMP and BA reduced greenhouse gas (GHG; CO_2e per kg HCW) emissions by 6.5 - 7.8%, energy use (MJ per kg HCW) by 3.4 - 5.5%, water use (kg H_2O per kg HCW) by 4.4 - 5.8%, and reactive N loss (g N per kg HCW) by 1.0 - 5.5% in comparison to NT

Keywords: beef, carcass, growth promotant, life cycle assessment, technology

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Abstract

The objective of this study was to determine the impact of different combinations of growth promoting technologies on live animal performance, carcass characteristics, and environmental outcomes. Crossbred steer calves (n = 120) were assigned randomly to 1 of 4 treatments: 1) no technology (NT; no antibiotics, hormones, ionophores or beta-agonists,); 2) non-hormone treated cattle (ANT; fed monensin and tylosin); 3) implanted (IMP; ANT protocol plus a series of three implants), and 4) implanted and fed a beta-agonist (BA; IMP protocol plus ractopamine-HCl for the last 30 days prior to harvest). Steers were finished in an individual feeding system to collect performance data. At harvest, standard carcass measures were collected. Information from the cow-calf, backgrounding, and finishing phases were used to simulate production systems using the USDA Integrated Farm System Model and conduct a life cycle assessment. Average daily gain (ADG) was greatest ($P < 0.05$) for IMP, while BA was intermediate ($P < 0.05$), and NT and ANT were the lowest ($P < 0.01$) but did not differ ($P > 0.05$). Dry matter intake for IMP and BA were similar ($P > 0.05$) and greater ($P < 0.01$) than NT, which was intermediate ($P < 0.01$) to ANT. Gain:Feed was greatest ($P < 0.05$) for IMP compared with NT, ANT, and BA, which were similar ($P > 0.05$). Hot carcass weight (HCW) for IMP and BA were similar ($P > 0.05$) and heavier ($P < 0.01$) than NT and ANT, which were similar ($P > 0.05$). No differences ($P > 0.05$) were detected for USDA Yield Grade, or proportions of carcasses in each USDA Yield Grade (YG) or Quality Grade (QG). Marbling scores for NT and ANT were similar ($P > 0.05$) to each other and both were greater ($P < 0.01$) than IMP and BA, which were similar ($P > 0.05$). Environmental analysis revealed that IMP and BA reduced greenhouse gas (GHG; CO_2e per kg HCW) emissions by 6.5 - 7.8%, energy use (MJ per kg HCW) by 3.4 - 5.5%, water use (kg H_2O per kg HCW) by 4.4 - 5.8%, and reactive N loss (g N per kg HCW) by 1.0 - 5.5% in comparison to NT.

Introduction

Producing more food with fewer resources is a growing global demand (AgMRC, 2012). Accompanying this demand is the conflicting consumer desire for products that are raised without growth promoting technologies and antibiotics (AgMRC, 2012; Mathews and Johnson, 2013). Growth promoting technologies are known to improve animal productivity resulting in more efficient meat production (Lawrence and Ibarburu, 2007; Johnson et al., 2013). However, the average American beef consumer is several generations removed from production agriculture and given this disconnect, use of technologies are often questioned and have created a growing demand for beef with credence attributes such as, "raised without the use of hormones" and "raised without antibiotics" (Umberger et al., 2009; USDA-FSIS, 2016; USDA-PVP, 2018). The implications of not utilizing growth promoting technologies on animal performance and the environmental impact of cattle fed to a similar compositional endpoint is unclear. Therefore, the objective of this study was to determine the effects of different of growth promoting technologies on animal performance, carcass characteristics, use of natural resources, and production of emissions impactful to the environment.

Experimental Procedures

Angus × Simmental steer calves (n = 120) sourced from the SDSU Antelope Range and Livestock Research Station were stratified by birth date, birth weight, and dam age, then randomly assigned to 1 of 4 treatments. The first treatment was a negative control (NT) that were not implanted or fed any sub-therapeutic antibiotics, beta-agonists, or ionophores. In addition, steers in the NT treatment did not receive any therapeutic antibiotics. The second treatment (ANT) were administered therapeutic antibiotics as needed for treatment and were fed 300 mg monensin [Rumensin 90, Elanco Animal Health]) and 90 mg tylosin [Tylan 40, Elanco Animal Health] during the finishing phase. This study was conducted prior to January 1, 2017; thus, a Veterinary Feed Directive was not required for the use of tylosin. The third treatment (IMP) received the ANT protocol plus a series of three implants including a suckling calf implant [Ralgro, Merck Animal Health] at an average of 74 ± 12 d of age on June 29, a moderate-potency initial feedyard implant [Revalor-IS, Merck Animal Health] at an average of 235 ± 12 d of age on December 8, and a high potency finishing implant [Revalor-200, Merck Animal Health] at an average of 330 ± 12 d of age on March 11. The final treatment (BA) was administered the IMP protocol plus fed a beta-agonist (200 mg ractopamine hydrochloride per steer per day [Optaflexx 45; Elanco Animal Health]) for the last 30 days before harvest.

At weaning on October 26, 2015 steers were shipped to the SDSU Cottonwood Field Station. Following a 2-week acclimation period steers were blocked into 12 pens (3 blocks of 4 treatments) according to body weight (BW) blocks (light, medium, and heavy). Steers were managed on a high-roughage diet during a 56-day backgrounding period then shipped to the University of Nebraska West Central Research and Extension Center feedlot in North Platte, NE. Upon arrival at the feedlot, all steers were stepped up to a common finishing diet (NEg = 62.7 Mcal/cwt and CP = 13.9%) containing dry rolled corn, wet corn gluten, prairie hay and a supplement containing vitamins and minerals. On March 11, steers were placed into pens equipped with a GrowSafe feeding system (GrowSafe Systems, Calgary, AB, Canada) to collect individual feed intake. On April 26, steers were ultrasounded to predict the harvest date for each treatment to achieve a common endpoint of approximately 0.6-inch backfat thickness (FT). Steers from NT and IMP were harvested on June 8 and ANT and BA steers were harvested on June 27. Standard carcass data was collected.

To determine carbon emissions, energy use, water use, and reactive N footprint, a life cycle assessment was conducted for each production system. Each segment was simulated using typical production practices for the Northern Plains region based upon production information gathered for this study and supplemented with data reported by Asem-Hiablie et al. (2016). The Integrated Farm Systems Model is a software tool (USDA-ARS, 2016) used to assess the environmental impact of agricultural production systems including beef operations (Rotz et al., 2015). Environmental impacts were summed across the three segments (suckling, backgrounding, and finishing) and divided by the HCW to obtain the collective environmental impacts.

Results and Discussion

Treatment did not influence ($P > 0.05$) pre-weaning, backgrounding, or initial feedyard BW. Cattle in the IMP and BA treatments were similar ($P > 0.05$) to each other and heavier ($P < 0.05$) on March 28 and 29 compared with NT and ANT calves, which were similar ($P > 0.05$). These differences persisted ($P = 0.001$) at ultrasounding on April 26 and at harvest, (June 8 for NT and IMP; June 27 for ANT and BA) where BW of IMP and BA steers were similar to each other ($P > 0.05$), but heavier ($P < 0.05$) than NT or ANT, which were similar ($P > 0.05$). Throughout the finishing segment (March 29 to harvest), ADG was greatest ($P < 0.05$) for IMP, while BA was intermediate, but greater ($P < 0.05$) than NT and ANT, which were not different ($P > 0.05$). Dry matter intakes of IMP and BA steers were similar ($P > 0.05$) and greater ($P < 0.05$) than NT, which was intermediate and greater ($P < 0.05$) than ANT. Gain:Feed was greatest ($P < 0.05$) for IMP compared with NT, ANT, and BA, which were similar ($P > 0.05$).

Influences of growth promoting technologies on carcass characteristics are presented in Table 1. As expected based on BW, IMP and BA steers had HCW that did not differ ($P > 0.05$) but were heavier ($P < 0.001$) than NT and ANT, which were similar ($P > 0.05$). Ribeye area was largest ($P < 0.001$) for IMP, and REA in BA carcasses were larger than in NT carcasses ($P < 0.001$). Carcasses from ANT steers had REA intermediate to NT and BA, but were not different from either ($P > 0.05$). By design, no differences ($P > 0.05$) were observed between treatments for FT as cattle were harvested at similar FT endpoints. Treatment influenced ($P < 0.001$) advancements in overall maturity. Each treatment differed in the following order from most to least mature: BA, ANT, IMP, and NT. Treatments with limited or no technology (ANT and NT) had similar ($P > 0.05$), but greater ($P < 0.05$) marbling scores compared with treatments using more potent growth promoting technologies (IMP and BA), which were similar ($P > 0.05$). Treatment did not influence ($P > 0.05$) YG, or proportions of carcasses in each YG and QG.

Life cycle assessment revealed that IMP and BA reduced GHG (CO_2e per kg HCW) emissions by 6.5 - 7.8%, energy use (MJ per kg HCW) by 3.4 - 5.5%, water use (kg H_2O per kg HCW) by 4.4 - 5.8%, and reactive N loss (g N per kg HCW) by 1.0 - 5.5% in comparison to NT (Figure 1).

Implications

Steers receiving monensin, tylosin, and growth promoting implants with and without ractopamine-HCl had greater BW, DMI, HCW. Use of implants and ractopamine-HCL also resulted in reduced GHG emissions, energy use, water use, and reactive N loss in comparison to steers not receiving any growth promoting technology.

Acknowledgements

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| Table 1. Influence of growth promoting technologies on carcass characteristics						
	Treatment[1]					
	NT	ANT	IMP	BA	SEM	*P*-value[2]
HCW, lb	756.41[a]	779.75[a]	854.03[b]	856.78[b]	14.64	< 0.001
Ribeye area, in^2	12.70[a]	13.01[ab]	14.28[c]	13.57[b]	0.23	< 0.001
Adj. KPH, %	1.78[a]	2.19[b]	1.75[a]	1.85[a]	0.049	< 0.001
Yield grade	2.83	2.66	2.67	2.93	0.108	0.194
Carcass maturity[3]	122.20[a]	132.45[c]	127.38[b]	142.94[d]	1.66	< 0.001
Marbling score[4]	553.93[b]	561.61[b]	486.49[a]	503.67[a]	18.1	0.004

[1] NT = received no growth promoting technology, ANT = administered monensin and tylosin but no implants or beta-agonists, IMP = administered monensin, tylosin, and implants, BA = administered monensin, tylosin, implants and a beta-agonist.

[2] Probability of a greater F for test of fixed effect.

[3] Combined skeletal and lean maturity: 100 = A0; 200 = B0; 300 = C0.

[4] Marbling score: 300 = slight0; 400 = small0; 500 = modest0; 600 = moderate0.

[a,b,c,d] Least squares means within row with different superscripts differ.
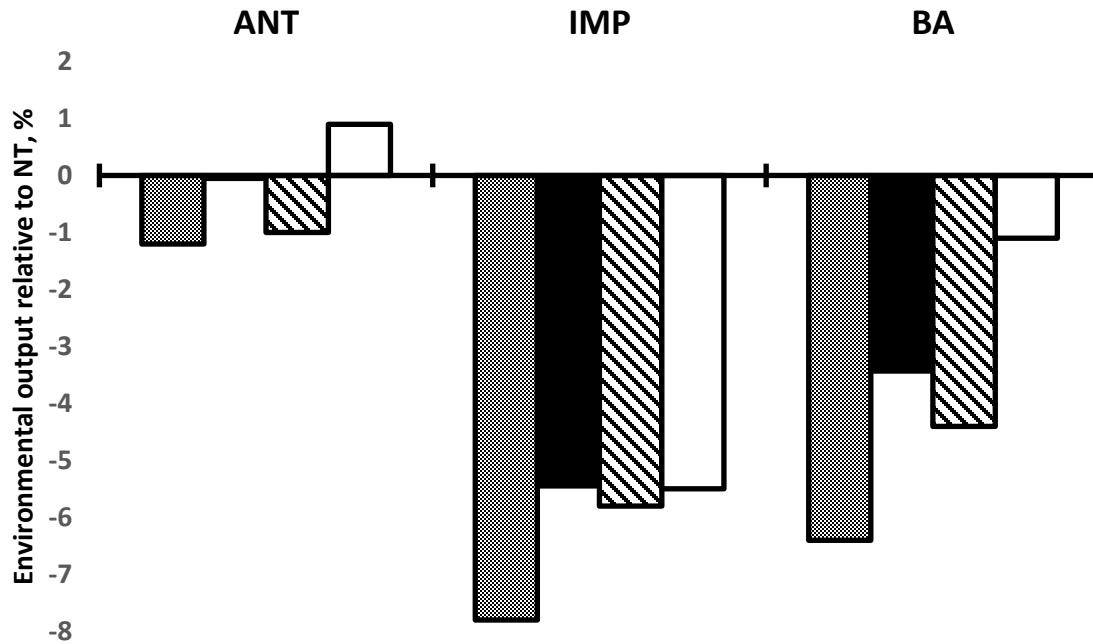
administered antibiotics and implants, BA = administered antibiotics, implants and a beta-agonist.
[2] Greenhouse Gas (GHG) emissions
[3] $CO_2e = CO_2$ equivalents
[4] Non-precipitated water use primarily includes water to irrigate feed crops and drinking water
[5] Includes all forms of reactive N loss, including ammonia, nitrate leaching and runoff, nitrous oxide and NOx from denitrification and combustion of fossil fuels

Figure 1. Influence of growth promoting technologies[1] on relative differences in environmental output expressed per kg of hot carcass weight