REDUCING AGE AT HARVEST: TOWARD MAXIMIZING EFFICIENCY IN BEEF PRODUCTION

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Abstract – During each of two years of study 112 spring-born steers were used to evaluate the effect of calf-fed *vs*. yearling-fed with and without growth implant and *β*-adrenergic agonist on greenhouse gas emissions (GHG), production parameters and economic potential. Steers were grouped in: 1) non-implanted feeders harvested at 11-14 mo of age, 2) growth implanted feeders harvested are 11-14 mo of age, 3) non-implanted feeders harvested at 19-23 mo of age, and 4) growth implanted feeders harvested at 19-23 mo of age. Expressed as kg CO_2e per kg carcass weight per year the carbon footprint of calf-fed production was 73.9-76.1% lower than yearling-fed production, and calf-fed implanted was 85% lower than non-implanted yearling-fed. Adjusted net return was best for calf-fed implanted (\$17.52 hd^{-1}), followed by calf-fed non-implanted (\$-41.92 hd^{-1}), yearling-fed implanted (\$-73.77 hd^{-1}), and yearling-fed non-implanted (\$-99.65 hd^{-1}) production strategies. Results of the present study suggest that reducing age at slaughter combined with growth implant can reduce cost of production, increase profit and reduce risk.

Key Words – carbon footprint, life cycle assessment, production efficiency

I. INTRODUCTION

The efficient use of energy, land and water will continue to be a challenge for agriculture as the global population increases to a predicted 9.5 billion people by 2050, food requirements increase by 70% compared with present day and resources available for agricultural production decrease [1]. Improved productivity allows the livestock industry to reduce resource use and waste outputs, primarily in the form of manure and GHG. Improved productivity has occurred due to advances in nutrition, herd fertility, animal health, genetic selection, pasture management, growth promotants and feed additives, resulting in a 16% decrease in the carbon footprint per unit of beef. The conventional, more intensive beef production systems continue to be challenged by media and public perception as having negative impacts on the environment, while more extensive production systems associated with labels such as natural, organic, hormone-free, and grass-finished are purported to have a lower carbon footprint and be more sustainable. Contrary to this belief, conventional beef production systems are consistently reported to have a lower carbon footprint and use less feed, water and land than natural or grass-finished beef productions systems [2, 3, 4, 5].

In addition, there is often a trade-off between beef carcass quality, production economics and environmental sustainability [6]. One strategy that may improve efficiency, profitability, environmental sustainability and carcass quality may be to reduce the average age at harvest for youthful cattle. In North America post-weaned calves are either directed to an intensive, calf-fed or an extensive, yearling-fed beef cattle production system. Integrated into these two beef production systems is the use of hormonal growth implants and *β*-adrenergic agonists as a routine management practices. Hormonal growth promotants are well known to improve feed efficiency, weight gain and muscle growth in grazing and feedlot cattle resulting in substantial economic gains [7, 8]. *β*-adrenergic agonists redirect nutrients away from fat deposition to protein synthesis, resulting in increased muscle fibre size and lean meat yield, and increased growth rate and feed conversion ratio [9, 10].

Hormonal growth promotants and β-adrenergic agonists increase protein deposition through separate mechanisms. Whether their effects are synergistic or additive is unknown.

Considerable production efficiencies still be gained by capitalizing on inherent inefficiencies within different beef production systems and by exploiting the finding that maintenance requirements and feed efficiency of beef cattle have remained largely unchanged over the last 100 years [11, 12, 13]. Although published studies have addressed many individual aspects of calf-fed and yearling-fed beef production, insufficient research has been conducted to evaluate the interactions among biological type, growth implant and repartitioning agents on beef production, economics and carcass quality.

Thus, the purpose of this large study was to conduct a primary scope life cycle assessment of beef cattle production for GHG emissions and to determine the production characteristics and economics using actual feed, energy and cropping inputs and beef outputs from calf-fed *vs.* yearling-fed production systems with, and without, aggressive growth implant and β-adrenergic agonist.

II. MATERIALS AND METHODS

This study used ISO-compliant life cycle assessment to compare the cradle-to-farm gate cumulative GHG emissions associated with four beef production strategies during two production cycles. The spring calving herd, consisting of 350 cows and related feedlot operations at the Agriculture and Agri-Food Canada, Lacombe Research Centre (Lacombe, AB, Canada), were used for the collection of diet ingredient and nutrient composition, feed intake, and cropping inputs and outputs from the four beef production strategies. The herd consists of Hereford-Aberdeen Angus and Charolais-Red Angus crossbred cows. The cattle used for the GHG assessment included cows, breeding bulls, replacement heifers, replacement bulls, calves from birth to weaning, and feeders from weaning to slaughter. All animals were maintained and cared for according to the guidelines of the Canadian Council on Animal Care [14].

Feeder steers were used to create four beef production strategies: 1) hormone free cattle harvested at 11-14 mo of age, 2) growth implanted cattle harvested are 11-14 mo of age, 3) hormone free cattle harvested at 19-23 mo of age, and 4) growth implanted cattle harvested at 19-23 mo of age. Feeders harvested at 11-16 mo of age are referred to as "calf-fed" while those harvested at 17-23 mo of age are referred to as "yearling-fed", which reflected the age at which the feeders are started on their finishing diet. In each of two years (2008; 2009), 112 spring-born crossbred steer calves were equally assigned at weaning to two production systems (calf-fed; yearling-fed) and two implant groups (not implanted; implanted) based on breed cross, birth date, calf weight and dam age. In each year half the calf-fed steers (n=28) were implanted with 200 mg progesterone and 20 mg estradiol benzoate (Component E-S, Elanco-Animal Health A Division of Eli Lilly Canada Inc., Toronto, ON, Canada) at weaning, and re-implanted with 120 mg trenbolone acetate and 24 mg estradiol approximately 90-100 d before slaughter. Similarly, half the yearling-fed steers each year (n=28) were implanted at weaning and then four more times at 80-90 d intervals with 200 mg progesterone and 20 mg estradiol benzoate, and then with 120 mg trenbolone acetate and 24 mg estradiol 90-100 d before slaughter. A detailed description of the animal management and experimental design can be obtained from López-Campos et al. [15]. Further descriptions of climate, location, crop and pasture complex were detailed in Basarab et al. [16].

Both calf-fed and yearling-fed steers were targeted for slaughter at 8-10 mm of backfat in four groups of 14 per year. The calculations of the daily enteric CH_4 emissions and emissions of CH_4 and N_2O from manure handling, storage and land application for each class of cattle and feeding period were based on the IPCC [17] Tier 2 methodology and modified for nitrogen excretion according to NRC [18].

Final live and hot carcass weights were obtained at the time of slaughter. The carcasses were then chilled at 2°C overnight for 24 h, knife-ribbed at the grade site between the 12th and 13th ribs, and assessed the full blue tag quality grade [20]. The right and left sides were subsequently weighed and the left side of each carcass was separated into nine wholesale cuts or primals, which were further divided into body-cavity, subcutaneous and intermuscular fat depots, lean and bone. An

economic evaluation was performed taking into consideration input costs and net returns
All data were analysis using PROC MIXED [21].

III. RESULTS AND DISCUSSION

Enteric CH_4 was the largest source of GHG emissions (53-54%), followed by manure N_2O (20-22%), cropping N_2O (11%), energy use CO_2 (9-9.5%), and manure CH_4 (4-6%). Beef cows accounted for 77% and 58% of the GHG emissions in the calf-fed and yearling-fed systems. Feeders accounted for the second highest GHG emissions (15% calf-fed; 35-36% yearling-fed). Implants reduced the carbon footprint by 4.9-5.1% compared with hormone-free. Calf-fed reduced the carbon footprint by 6.3-7.5% compared with yearling-fed (data not shown). When expressed as kg CO_2e per kg carcass weight per year the carbon footprint of calf-fed production was 73.9-76.1% (No implant, 20.2; Implant, 19.0 kg CO_2e per kg carcass wt yr^{-1}) lower than yearling-fed production (No implant, 33.0; Implant, 31.2 kg CO_2e per kg carcass wt yr^{-1}), and calf-fed implanted was 85% lower than non-implanted yearling-fed (Table 1). Beauchemin et al. [22] simulated beef and cropping production over eight years using the HOLOS whole-farm model and reported a carbon footprint of 21.73 kg CO_2e kg^{-1} carcass weight for implanted feeder cattle harvested at 16.5 mo of age. Similar cattle from our study are estimated to have carbon footprint of 21.20 kg CO_2e kg^{-1} carcass weight which is 2.4% lower than those presented by Beauchemin et al. [22].
The adjusted net return was most profitable for implanted calf-fed (\$17.52 hd^{-1}), then non implanted calf-fed steers (\$-41.92 hd^{-1}) and was least profitable for non-implanted yearling-fed steers (\$-99.65 hd^{-1}) primarily because of relatively higher costs and lower income compared with implanted yearling-fed steers. These results are similar to an Oklahoma study where profitability tended to favour the calf-fed over the yearling-fed system [23].

Table 1 Main results on GHG emissions intensity and economic traits on the 2 yr study.

	Calf-Fed		Yearling-Fed		
	No implant	Implant	No implant	Implant	SEM
kg CO_2 kg^{-1} carcass wt.	18.8	17.7	18.9	17.9	
kg CO_2 kg^{-1} carcass wt. yr^{-1}	20.2	19.0	33.0	31.2	
Cost, \$·hd^{-1}					
Total cost	1130^a	1147^a	1434^b	1492^c	14.1
Income	1087^a	1163^b	1318^c	1344^c	18.5
Adjusted^z	-41.9^b	17.5^c	-99.6^a	-73.8^{ab}	19.5

^{a,b,c} P<0.005.
^{z} Adjusted net return based on Alberta monthly average slaughter rail price from 2006 to 2010.

IV. CONCLUSIONS

There are many systems of management used to produce beef cattle. Yearling-fed compared with calf-fed production systems decreased feed efficiency, carcass quality and profitability as well as use more time and land and could have higher carbon footprints. Calf-fed beef production systems improved feed efficiency and profitability. Strategies to reduce GHG emissions should emphasize improving feed efficiency of the cow herd and decreasing the length of time feeder cattle. Growth implants improved feed efficiency and profitability. Results of the present study suggest that reducing age at slaughter combined with growth implant can reduce cost of production, increase profit and reduce risk.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge funding support from Alberta Livestock and Meat Agency Ltd., Alberta Agriculture and Rural Development (ARD), Alberta Environment, Agriculture and Agri-Food Canada Matching Initiatives Program, Elanco Animal Health and Pioneer Hybrid International, and the in-kind contribution in animals, facilities and people received from Agriculture and Agri-Food Canada (AAFC), Lacombe Research Centre, AB, Canada. We also wish to thank the significant contributions of Cathy Bryant and Sheldon Johnston of ARD, and Ivy Larsen, Adele Ohama and Dave Young of AAFC for technical support. Special thanks are extended to Cletus Sehn, Ken Grimson, and their staff at the Lacombe Research Centre Beef Unit of AAFC for animal care, animal management and sample collection. The efforts of Mr. Chuck Pimm and the Meat Processing staff at AAFC for animal slaughter and carcass data collection are also acknowledged.

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