EFFECTS OF PRODUCTION SYSTEM AND GROWTH PROMOTANTS ON THE PHYSIOLOGICAL MATURITY SCORES IN STEERS

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Abstract –Two hundred and twenty-four crossbred steers were used to evaluate the impact of calf-fed (harvested at 11-14 mo of age) ***vs.*** yearling-fed (harvested at 19-23 mo of age) production systems with and without aggressive growth implant, on the physiological indicators of chronological age. There were significant interactions (P < 0.001) between the production system and the implanting strategies on the frequencies of the carcasses showing ossification in the sacral, lumbar and thoracic vertebral column portions. The results indicate physiological age of the carcasses might be dramatically impacted depending on the combination of the production system and growth implant strategy. However, when birth date documentation is not available, a compendium of descriptors (dentition and ossification processes at the vertebrae) should be taken into consideration in order to establish the eligibility of the carcass to meet certain age criteria.

Introduction

In the absence of verifiable chronological age such as birth records, both dentition and carcass ossification have been used as physiological indicators. Changes in production practices may have altered the relationship between chronological age and physiological maturity (Shackelford *et al.* 1995). These changes to the physiological age associated with different production strategies may impact the proportion of carcasses that can qualify for export markets that have imposed chronological age restrictions. In addition, physiological maturity is also an important consideration in the determination of meat quality, as it is generally accepted that beef tenderness decreases with increasing maturity (Purslow 2005). For this reason, maturity is also considered a key factor in most of the beef quality grading systems (Polkinghorne and Thompson 2010).

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 as a routine management practice. 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 (McAllister *et al.* 2011). Combinations of implants that contain estrogenic and androgenic hormones are a common practice in the cattle industry and they produce a greater response than single-hormone implant strategies (Reinhardt 2007). However, implanting steers and heifers with estrogenic growth-promotants, especially in combination with trenbolone acetate (TBA), also advances skeletal maturity (Reiling and Johnson 2003) with the consequent impact on beef quality.

The objective of this study was to determine the impact of calf-fed *vs.* yearling-fed production systems with and without aggressive growth implant, on the physiological indicators of chronological age.

Materials and Methods

All animals were maintained and cared for according to the guidelines of the Canadian Council on Animal Care (1993). Over two years, 224 crossbred steer calves of known chronological age were allotted to a 2×2 factorial arrangement of treatments to determine the effect of production system (calffed harvested at 11-14 mo of age; yearling-fed harvested at 19-23 mo of age) and growth implant (nonimplant; implant) on physiological indicators of chronological age. Steer calves were allocated toproduction systems and implant groups based on birth date, calf weight (42.2 kg, SD=6.3 kg) and dam age (4.8 yr, SD=2.7 yr). Each year one-half (n = 56) of the calf-fed and yearling-fed steers were implanted at prescribed intervals with 200 mg progesterone and 20 mg estradiol benzoate (Component E-S, Elanco-Animal Health). In both, calf-fed and yearling-fed steers, the last implant was with 120 TBA and 24 mg estradiol (Component TE-S, Elanco-Animal Health) approximately 90-100 d before slaughter. Further information on the production systems and experimental treatments is detailed by López-Campos *et al.* (2013).

All steers were targeted to be slaughtered at a constant backfat end point of 8-10 mm. At the time of slaughter, two experienced evaluators estimated steer age using dentition pictorial standards (USDA FSIS 2012). Based on this system, animal age is scored as: Score 3, ≤14 mo; Scores 4 & 5, 15-18 mo; Scores 6, 7 & 8, 18-24 mo; Scores 9 & 10, 24-30 mo; and Score 11 or higher, >30 mo. An experienced evaluator using the criteria established in the Canadian beef age verification study (Robertson *et al.* 2006) assessed the physiological maturity on the carcasses. The primary foci of the evaluations for maturity were the caps of the lumbar vertebrae, the caps of the thoracic vertebrae and the segments and caps of the sacral vertebrae. The lumbar score system was: Score 0 no islands of ossification; Score 1, one short island; Score 2, two short islands; Score 3, one long or thick island, or two moderately long islands; Score 4, two long islands with short gaps between them; and Score 5, two islands fused with a single island extending nearly across the width of the cap (see Figure 1). Carcasses having a lumbar score greater than 2 were rejected from the eligible pool as being >21 mo of age. Carcasses receiving lumbar scores of 2 or less were further evaluated, with particular emphasis on the degree of separation between the sacral segments and the amount of cartilage evident in the sacrum. In order to qualify for the under 21 mo of age group, the separation between the sacral segments must show no evidence of any two segments beginning to fuse together (see Figure 2). Additionally, if the ossification islands over the sacral segments were fused together, or if the islands were not fused, but were thick and extended widely over each segment, then the carcass was rejected. Thoracic vertebrae, carcasses with buttons, or evidence of ossification in the cartilaginous caps were rejected from the eligible pool (see Figure 3). All data were analyzed with the PROC FREQ (SAS 2009). Partial least squares discriminant analysis (PLS2-DA) was applied to segregate the carcasses into <21 mo of age (eligible) or >21 mo of age (noneligible)(The Unscrambler®).

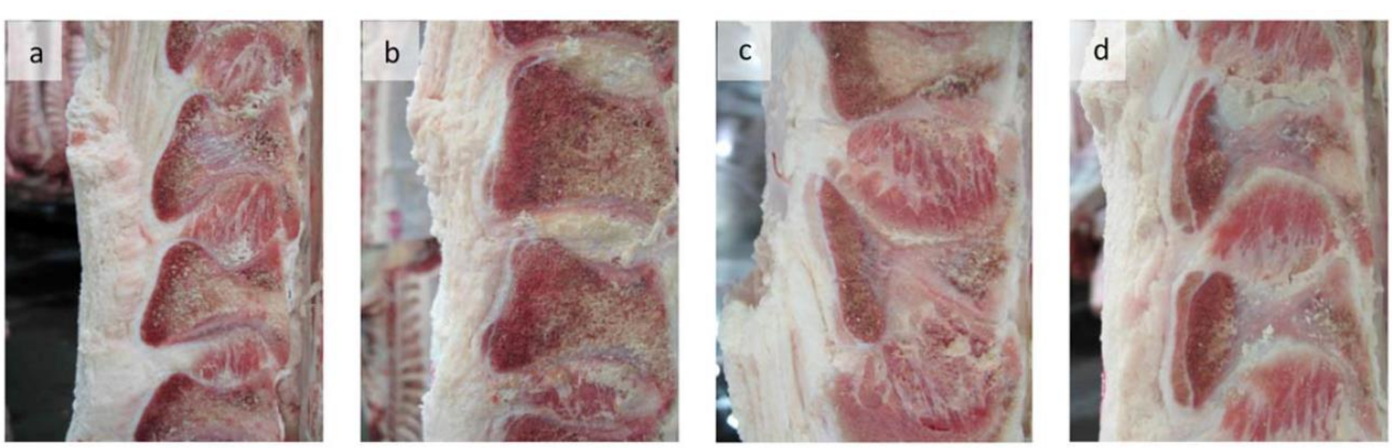


Figure 1: Illustration of a) lumbar score of 0, b) lumbar score of 3 (upper vertebra) and 2 (lower vertebra), c) lumbar score of 4 and d) lumbar score 5.

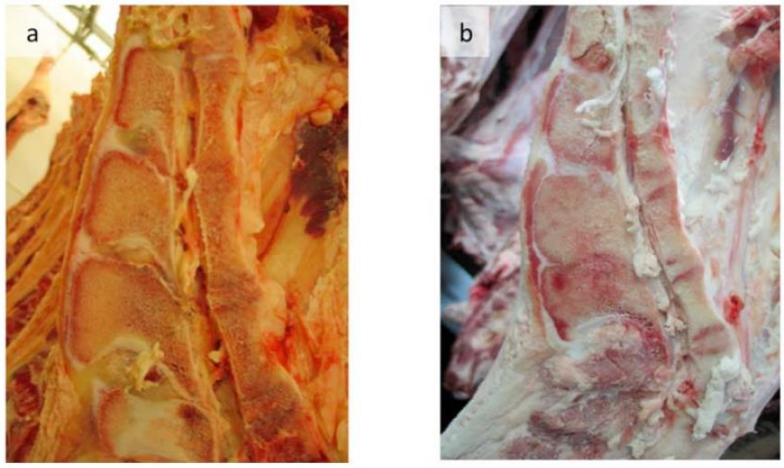
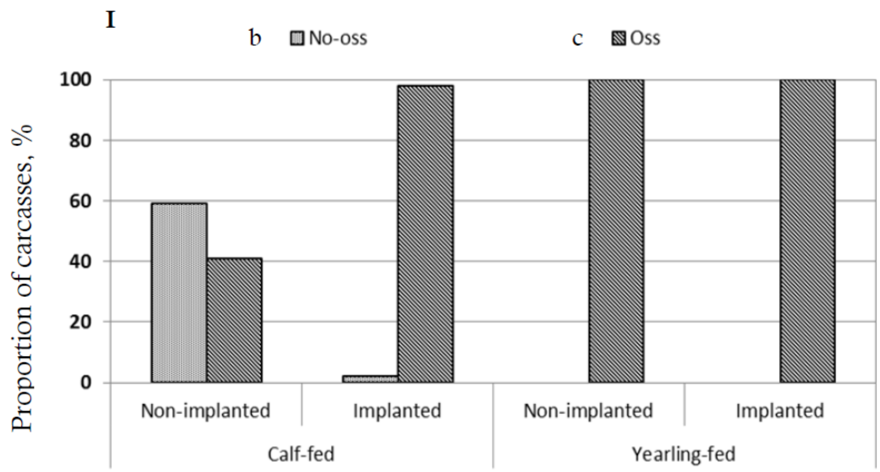


Figure 2: Illustration of sacrum showing a) distinct separation between sacral vertebrae and b) lack of cartilage between 2 vertebrae and islands of ossification extending widely over the vertebral segment.

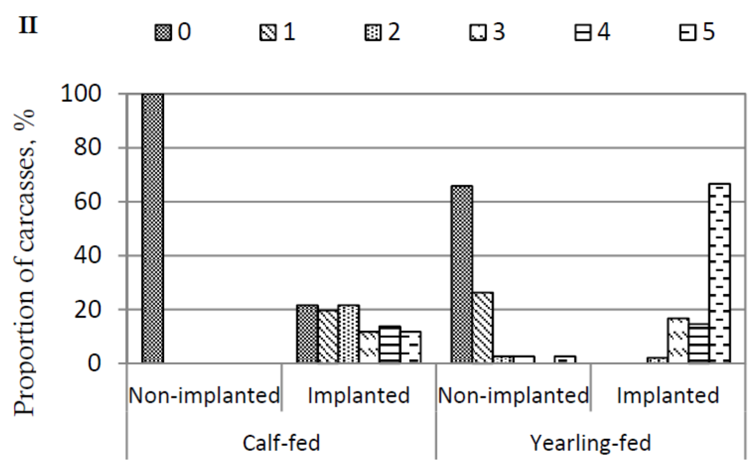
Figure 3: Illustration of thoracic cap with ossification.

Results and Discussion

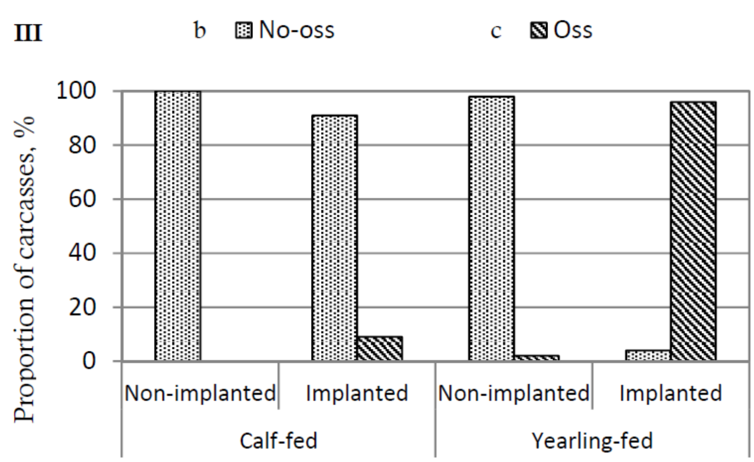
There were significant interactions ($P < 0.001$) between the production system and the implanting strategies on the frequencies of the carcasses showing ossification in the sacral, lumbar and thoracic vertebral column portions (Figure 4). In the calf-fed steers, 59% of the non-implanted and 2% of the implanted carcasses were at earlier stages of physiological maturity and did not show any evidence of fusion in the sacral portion of the vertebral column. In the lumbar portion of the vertebral column, none of the non-implanted calf-fed steers showed any ossification (score 0), while most of the implanted calffed steers (80%) showed varying degrees of ossification (scores 1-5). In the yearling-fed steers, all the carcasses from the implanted animals showed advanced ossification ranging from two islands (score 3, 17% and score 4, 15%) to a long fused island on the vertebral cap (score 5, 67%). On the contrary, 66% of the non-implanted yearling-fed steers did not show any osseous formations in the lumbar vertebral caps (score 0) and 26% showed a single island (score 1) with minimal frequencies in the remaining scores (scores 2, 3 and 5, 3% each). Implanted yearling-fed steers (96%) clearly showed ossification in the thoracic portion, while most of the non-implanted yearling-fed (98%) and both implant groups of the calf-fed steers (non-implanted 100% and implanted 91%), did not show ossification in the thoracic caps. These results support that the physiological maturity of the carcasses might be dramatically impacted depending on the combination of the production system and growth implant strategy. Advanced ossification may result in non-eligible carcasses for specific markets or branded programs with a subsequent impact on the beef industry profits. For example, until January 2013, the Japanese market only accepted beef from cattle that were less than 21 mo of age at the time of slaughter.



[a]*Calf-fed × implanting strategy* χ^2 *P* < 0.001; *Yearling-fed x implanting strategy* χ^2 *P* = 0.5.
[b]*No-oss: No presence of the ossification processes.*
[c]*Oss: Presence of the ossification processes.*



[a]*Calf-fed × implanting strategy* χ^2 *P* < 0.001; *Yearling-fed x implanting strategy* χ^2 *P* < 0.001.
[b]*Lumbar score (Robertson et al. 2006).*



[a]*Calf-fed × Implanting strategy* χ^2 *P* = 0.03; *Yearling-fed x Implanting strategy* χ^2 *P* < 0.001.
[b]*No-oss: No presence of the ossification processes.*
[c]*Oss: Presence of the ossification processes.*

Figure 4. Interaction effects between production systems×implant strategies on ossification processes at the sacral (I), lumbar (II) and thoracic (III).

According to birthdate, 100% of calf-fed and 22% of yearling-fed animals were <21 mo of age. However, using physiological age estimates based on ossification as proposed by Robertson *et al.* (2006) only 2% of the implanted, while 55% of the non-implanted calf-fed steers were considered eligible for <21 mo of age and hence eligible for the Japanese market (Data not shown). At the same time, 100% of both implanted and non-implanted yearling-fed steers were considered >21 mo and non-eligible.

When the dentition score and all the ossification scores were used to discriminate into eligible (<21 mo of age) or non-eligible (>21 mo of age) carcasses in the overall population, the regression model developed using a PLS2-DA correctly classified 88.2% of the <21 mo of age carcasses and 63.6% of the >21 mo of age. Similar results were observed when the calibration model used dentition, lumbar and thoracic scores (87.8% and 63.2% eligible and non-eligible carcasses correctly classified, respectively), which indicated that the sacrum score did not provide much information for discrimination. The percentage of misclassified carcasses over 21 mo of age was high (36.4%); further examination showed that all carcasses corresponded to the non-implanted yearling-fed (Table 1).

Table 1. Results obtained by partial least squares discriminant analysis using dentition and ossification scores (thoracic, lumbar and sacrum) to segregate into eligible (<21 mo of age) or noneligible (>21 mo of age) carcasses on the overall population.

		Classified	
		Cross-Validation	
Physiological criteria	Carcass eligibility	Eligible	Non-eligible
Dentition+thoracic+lumbar+sacrum	Eligible	**88.2**	11.8
	Non-eligible	36.4	**63.6**
Dentition+thoracic+lumbar	Eligible	**87.8**	12.2
	Non-eligible	36.8	**63.2**
Thoracic+lumbar	Eligible	**87.8**	12.8
	Non-eligible	44.1	**55.9**
Dentition+thoracic	Eligible	**87.8**	12.2
	Non-eligible	44.1	**55.9**

As previously discussed, implanting practices have an impact on physiological ossification thus introducing a treatment variable which reduces the ability of the model to discriminate on a chronological age basis. In addition, both development and verification stages of the ossification scoring criteria used in the present study (Robertson *et al.* 2006) used cattle from commercial sources, which mostly (90%) receive some type of growth promotant (Johnson, R. and Hanrahan 2012). When only two criteria were included in the discrimination model, either thoracic and lumbar ossification or dentition and thoracic scores, the percentage of <21 mo of age carcasses correctly classified was similar (87.8%) to that found for the overall population (88.2%). However a decrease in the number of >21 mo of age carcasses correctly classified (55.9% *vs.* 63.6%) was observed (Table 1). These results suggest that when birth date documentation is not available, a compendium of descriptors should be taken into consideration in order to establish the eligibility of the carcass to meet certain age criteria. In addition, since dentition score equates to a range of chronological age, there are potential gaps that dentition criteria may not cover, and in these cases ossification criteria may provide additional information.

Conclusions

The results of the present study confirm that production system and growth promotants affect ossification. Use of growth implants in a calf-fed production system accelerated the ossification process in mo of age based on physiological maturity evaluation. A compendium of descriptors based on dentition and ossification processes at the thoracic, lumbar and sacral vertebrae should be taken into consideration in order to ensure accurate estimation of chronological age of cattle when birth date documentation is not available.

Acknowledgements

The authors gratefully acknowledge funding support from Alberta Livestock and Meat Agency Ltd., Alberta Agriculture and Rural Development (AARD), Alberta Environment, Agriculture and Agri-Food Canada (AAFC) Matching Industry Initiatives program, Elanco Animal Health and Pioneer Hybrid International, and the in-kind contribution in animals, facilities and people received from AAFC-Lacombe Research Centre (LRC), AB, Canada. Drs. N. Prieto and Ó. López-Campos thank the Alberta Crop Industry Development Fund (ACIDF) and Livestock Gentec and the Canadian Beef Grading Agency (CBGA) for their funding support, respectively. We also wish to acknowledge the significant contribution of Wayne Robertson (retired LRC-AAFC). Special thanks are extended to Cletus Sehn, Ken Grimson, and their staff at the Beef Unit, for animal care and management and to Chuck Pimm and his staff at the Meat Centre for slaughter and processing of the cattle (LRC-AAFC).

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