RELATIONSHIP OF DARK CUTTING WITH ANIMAL AND CARCASS PHENOTYPE IN HEIFERS

S. Mahmood[1], J. A. Basarab[2], W. Dixon[1], H. L. Bruce[1]

[1]Department of Agricultural, Food and Nutritional Science, 410 Agriculture/Forestry Building, University of Alberta, Edmonton, Alberta, T6G 2P5; [2]Alberta Agriculture and Rural Development, 6000 C & E Trail, Lacombe, Canada, T4L 1W1.

Abstract – Recent research has suggested that cattle predisposed to dark cutting can be predicted from live animal or carcass characteristics. This hypothesis was tested using production and phenotype data from an existing data set collected from heifers (n = 467) on study at three different farms. Carcasses in the data set graded Canada A (n = 14), AA (n = 296), AAA (n = 136) and B4 (dark cutting) (n = 21). Generalized logit modeling with the CATMOD procedure, analysis of variance and logistic regression were used to establish phenotypic relationships with carcass grades and farm of origin. Results indicated that farm of origin affected incidence of dark cutting and was confounded with breed and related to differences in cattle weight. Finishing heavy heifers for a short time appeared to increase the likelihood of dark cutting. Heifers at risk of dark cutting had reduced weaning weight, live weight and carcass weight. The probability of dark cutting declined with increased growth rate and at slaughter weight greater than 550kg.

Key Words – average daily gain, dark cutting, slaughter weight, marbling score.

I. INTRODUCTION

Carcasses from cattle under 30 months of age that have a purple or dark red rib eye muscle (m. *longissimus thoracis*, LT) at the 12^{th}-13^{th} rib grading site are considered dark cutting. Such carcasses usually have an ultimate pH greater than 5.8 and are undesirable to consumers because of their appearance. In compliance with the Canadian Beef Carcass Grading Regulations, dark cutting carcasses are graded Canada B4 and their price discounted relative to the normal Canada A grades, resulting in CAD$1.4 million per annum loss to producers. Dark-cutting continues to occur and its incidence has increased in Canada within the last 10 years from 0.8 to 1.3% [1] while in the United States of America (US), the proportion of dark-cutting increased to 3.2% in 2012 [2]. Moreover, the frequency is higher in heifer than in steer carcasses [3]. This persistence justifies continued research into the factors contributing to dark cutting.

Insufficient muscle glycogen to fuel post mortem anaerobic glycolysis and reduce muscle pH is the accepted cause of dark cutting. Relationships between animal and carcass phenotypes and dark cutting incidence are unclear because increased carcass weight and rib eye area either decreased [4] or increased carcass pH and dark cutting [5, 6, and 7]. The relationship between dark cutting and marbling score is also unclear, with increased marbling score either unrelated [4] or linked to reduced dark cutting frequency [5]. The purpose of this study was to relate carcass conformation and animal phenotypic characteristics to the occurrence of dark cutting in beef heifers to test the hypothesis that the likelihood of a heifer producing a dark cutting carcass is related to specific live animal and carcass characteristics.

II. MATERIALS AND METHODS

An existing data set of heifers (n = 467) collected from cattle on study from 2003 to 2011 in the province of Alberta, Canada, was used in this study. Heifers included in the data set were from three farms, designated A, B and C, which contributed n = 44, n = 267, and n = 156 heifers, respectively. Cattle within the database were Hereford-Angus and Charolaise at farm A and crossbred composite (BeefBooster®, Calgary, Alberta) at farms B and C. The carcasses in the data set graded Canada A (n = 14), AA (n = 296), AAA (n = 136) and B4 or dark cutting (n = 21). Production and carcass phenotype included dry matter intake (DMI, kg DM day^{-1}), average daily gain (ADG, kg gain day^{-1}), feed conversion ratio

(FCR, kg DMI kg^{-1} gain), residual feed intake (RFI, kg DMI day^{-1}), ultrasound rib eye area (uREA, cm^2), ultrasound subcutaneous fat depth (uFD, mm), ultrasound marbling score (uMS), carcass weight (CarWt, kg), grade fat depth (gFD, mm), grade rib eye area (gREA, cm^2), and grade marbling score (gMS).

Production and phenotypic measurements were performed similarly to that described by López-Campos et al. [8]. RFI was calculated as the deviation of actual feed intake from expected feed intake [9]. Cattle from each farm were slaughtered separately in two lots and each lot had data from at least one animal/carcass from each grade. Both ultrasound and post mortem rib eye marbling scores were categorized using the United States Department of Agriculture (USDA) scoring system where Canada A, AA, AAA and Prime quality grade marbling corresponded with traces (Standard, 300-399), slight (Select, 400-499), small to moderate (Choice, 500-799), and greater than or equal to slightly abundant (Prime, 800-1099), respectively.

The statistical analyses were performed using the Statistical Analysis Software (SAS) system (Version 9.3, SAS Institute Inc., Cary, NC). A generalized logit model was applied using the CATMOD procedure to compute the frequency of dark cutting in three farms while animal and carcass parameters were tested as covariates. Analyses performed on phenotypic and carcass data included analysis of variance, Pearson correlations, and binomial and multinomial logistic regression. Data were used to examine the effects of farm (A, B, C) and grade (A, AA, AAA and B4) on live animal and carcass characteristics using the MIXED procedure with farm, grade and their interaction as fixed sources of variation and slaughter lot within farm was included as a random term that served as the error term for farm. Kenward-Roger approximation was used to compute the denominator degrees of freedom while differences between means were identified using least square means differences, with significance at $P < 0.05$.

Binomial and multinomial logit regression models were applied separately to animal and carcass measurements, which were tested as covariates in their respective analyses. Farm was the sole source of variation used to test the effect of the covariates (animal or carcass measurements) on the probability of dark cutting. For binomial logit regression, data of cattle that produced A, AA and AAA grade carcasses were combined into one category (NORMAL) and compared to the data of cattle that produced dark cutting carcasses (DARK) and the probability of being dark (yes or no) was modeled. In multinomial logistic regression, the response variables were the four grades (A, AA, AAA and B4). Graphs for predicted probabilities were obtained in SAS after selecting the covariates with the largest R^2 values that were uncorrelated with each other.

III. RESULTS AND DISCUSSION

Farm was identified as significant ($P = 0.0268$) in Catmod analysis where dark cutting incidence was $11.4 \pm 4.8\%$, $5.2 \pm 1.4\%$ and $1.3 \pm 0.9\%$ respectively for farms A, B and C. The effect of farm was confounded with breed as farm A had Hereford-Angus and Charolaise cattle while both farms B and C had breed Composite (BeefBooster®), and breed may have contributed to the differences observed between farms [3]. Effect of farm was insignificant, however, once animal weight at slaughter or carcass weight were included in the analysis, suggesting that the difference between farms was driven by animal live or carcass weight.

Canada A, AA and AAA carcasses are carcasses with normal colored muscle that are differentiated by intramuscular fat, which increases as the letter A is added to the grade. Results from the analysis of variance indicated no differences ($P > 0.05$) in mean ADG and FCR due to grade. Grade had a significant effect ($P < 0.05$) on mean values of RFI, uFD, gFD and gREA (Table 1). Results indicated that heifers that produced dark cutting carcasses (Canada B4) were similar to Canada AA and AAA heifers for RFI, and Canada A and AA heifers for uFD and gFD. Notably, dark cutting heifer carcasses had a mean gREA similar to that of Canada AA and AAA heifer carcasses, which was significantly less than the large gREA of the Canada A carcasses. The latter result supported the findings of McGilchrist et al. [4], who noted that reduced fat depth and muscling scores collectively predisposed heifer carcasses to cut dark.

Table 1. Least square means (± standard error) of grades for animal and carcass characteristics.

Measurements	Grades			
	A (n=14)	AA (n=296)	AAA (n=136)	B4 (n=21)
Residual Feed Intake (kg feed day^{-1})	-0.393^{b} (0.13)	0.0038^{a} (0.034)	0.0589^{a} (0.050)	0.069^{a} (0.129)
Ultrasound fat depth (mm)	5.82^{c} (0.68)	6.99^{b} (0.29)	7.92^{a} (0.34)	6.46^{bc} (0.66)
Grade fat depth (mm)	6.33^{c} (1.19)	8.92^{b} (0.28)	11.08^{a} (0.42)	8.02^{bc} (1.06)
Grade rib eye area (cm^{2})	96.59^{a} (3.48)	86.53^{b} (1.35)	81.79^{c} (1.60)	82.64^{bc} (3.13)

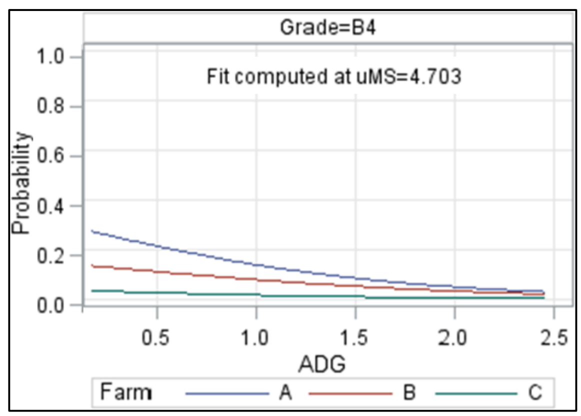
The interaction between farm and grade was significant (P < 0.05) for days to finish the cattle, age at slaughter, DMI, weaning weight, weight at slaughter, uREA, carcass weight, uMS and gMS. Results indicated that dark cutting heifers finished in the same mean days and at the same mean age as Canada AA or A heifers depending upon the farm and that dark cutting heifers were either younger than or the same age as heifers that produced normal carcasses. Mean slaughter age and days to finishing of dark cutting heifers from farm C were less than that of heifers that produced a normal carcass from that farm, which may have made animals susceptible to cut dark. Muscle glycogen level increases with age and finishing period [10], therefore, heavy cattle exclusively fed for a short period were susceptible to cutting dark. For farm A, dark cutting heifers were the lightest at weaning and slaughter, had the lowest DMI intake, and produced the lightest carcasses compared to heifers that produced the other grades, whereas for farms B and C, dark cutting heifers were not different from heifers that produced Canada AAA and AA carcasses. The carcass results of the present study support those of Lorenzen *et al*. [3] who found that dark cutting carcasses were similar to USDA Choice-Select carcasses, which are equivalent to Canada AAA-AA carcasses.

Other analysis of variance results indicated no relationship between rib eye marbling and dark cutting, which opposes previous findings [5]. Further, there was a trend (P = 0.14) toward reduced ADG in dark cutting (Canada B4) heifers from Farm A and B, but not from Farm C.

Multinomial logistic regression indicated that uMS, ADG and farm had significant effects (P < 0.05) on the probability of dark cutting and realizing a Canada B4 grade (Figure 1). The probability of dark cutting (Canada B4) declined with an increase in ADG both at Farm A and B but there was no relationship with ADG and dark cutting at Farm C.

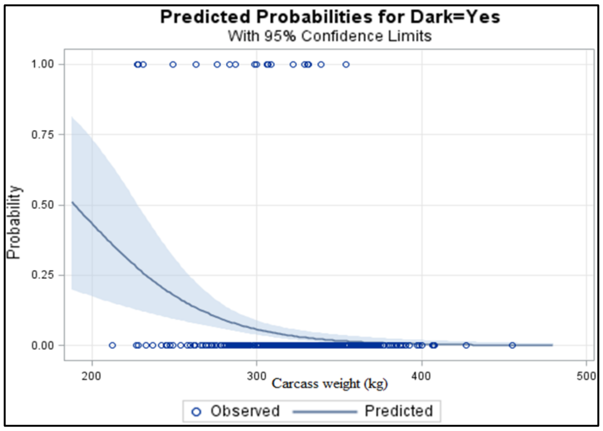
Binomial regression identified carcass weight as significant (P<.0001) and there was a substantial decline in the probability of dark cutting at carcass weights greater than 325 kg (Figure 2).

Figure 1. Relationship of B4 grade probability with ADG (kg. day^{-1}) at three farms (A, B and C) identified in multinomial logistic regression.



Overall study results indicated that animals at risk of dark cutting were slow growing, in contrast to previous findings [6]. That increased weight at slaughter lowered the muscle lightness score of bull carcasses [7] contradicted the findings of the current study in heifers. Reduction in the likelihood of dark cutting with an increase in slaughter weight and carcass weight, however, agreed with the findings of McGilchrist et al [4].

Figure 2. Relationship of dark cutting probability with carcass weight (kg).



IV. CONCLUSION

Selecting cattle for increased growth rate and live weight may reduce frequency of dark cutting. Slow growing cattle may have an increased potential to cut dark and such animals should be sorted and managed adequately to decrease this risk. The results indicated that potential dark cutting heifers were those most likely to have produced Canada AA carcasses. Moreover, ultrasound measurement of rib eye area, fat depth and marbling score will assist with predicting carcass grades in live cattle and identifying those most at risk of dark cutting.

ACKNOWLEDGEMENTS

The authors thank the Alberta Agriculture and Rural Development for providing access to the data used in this study. The authors wish to thank Agriculture and Agri-Food Canada, the Beef Cattle Research Council (BCRC), the Alberta Beef Producers and the Alberta Livestock and Meat Agency Ltd (ALMA) for their financial support.

REFERENCES

1. Canadian Cattlemen's Association (2013). National beef quality audit 2010/11 plant carcass audit (pp. 13).
2. Moore, M. C., Gray, G. D., Hale, D. S., Kerth, C. R., Griffin, D. B., Savell, J. W., Raines, C. R., Belk, K. E., Woerner, D. R., Tatum, J. D., Igo, J. L., VanOverbeke, D. L., Mafi, G. G., Lawrence, T. E., Delmore, R. J., Christensen, J. L. M., Shackelford, S. D., King, D. A., Wheeler, T. L., Meadows, L. R. & O'Connor, M. E. (2012). National Beef Quality Audit 2011: In-plant survey of targeted carcass characteristics related to quality, quantity, value, and marketing of fed steers and heifers. Journal of Animal Science 90: 5143-5151.
3. Lorenzen, C. L., Hale, D. S., Griffin, D. B., Savell, J. W., Belk, K. E., Frederick, T. L., Miller, M. F., Montgomery, T. H. & Smith, G. C. (1993). National Beef quality Audit: survey of producer-related defects and carcass quality and quantity attributes. Journal of Animal Science 71: 1495-1502.
4. McGilchrist, P., Alston, C. L., Gardner, G. E., Thomson, K. L. & Pethick, D. W. (2012). Beef carcasses with larger eye muscle areas, lower ossification scores and improved nutrition have a lower incidence of dark cutting. Meat Science 92: 474-480.
5. Janloo, S. M., Dolezal, H. G., Gargner, B. A., Owens, F. N., Peterson, J. & Moldenhauer, M. 1998. Characteristics of dark cutting steer carcasses. Animal Science Research Report, 28-31.
6. Młynek, K. & Guliński, P. (2007). The effect of growth rate and age at slaughter on dressing percentage and colour, pH48 and microstructure of longissimus dorsi muscle in Black-and-White (BW) bulls vs commercial crossbreds of BW with beef breeds. Animal Science Papers and Reports 25: 65-71.
7. Vestergaard, M., Oksbjerg, N. & Henckel, P. (2000). Influence of feeding intensity, grazing and finishing feeding on muscle fibre characteristics and meat colour of semitendinosus, longissimus dorsi and supraspinatus muscles of young bulls. Meat Science 54: 177-185.
8. López-Campos, O., Basarab, J. A., Baron, V. S., Aalhus, J. L. & Juárez, M. (2012). Reduced age at slaughter in youthful beef cattle: effects on carcass merit traits. Canadian Journal of Animal Science 92: 449-463.
9. Basarab, J. A., Price, M. A., Aalhus, J. L., Okine, E. K., Snelling, W. M. & Lyle, K. L. (2003). Residual feed intake and body composition in young growing cattle. Canadian Journal of Animal Science 83: 189-204.
10. Miller, M. F., Cross, H. R., Buyck, M. J. & Crouse, J. D. (1987). Bovine longissimus-dorsi muscle glycogen and color response as affected by dietary regimen and postmortem electrical-stimulation in young bulls. Meat Science 19: 253-263.