More muscular carcasses have a lower incidence of dark cutting syndrome

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Abstract — **Dark cutting beef costs Australian beef producers around $7.09 per animal graded under Meat Standards Australia (MSA) due to its impact on meat quality. The objective of this experiment was to determine if carcass muscularity as determined by eye muscle area adjusted for carcass weight taken at the time of MSA grading could explain variance in ultimate pH (pH_u) due to an affect on muscle glycogen concentration. MSA beef carcass grading data was obtained from a Western Australian beef processor between February 2002 and December 2008 containing 204,072 carcass records. The effects of muscling on pH_u were analysed using a logit model within a bayesian framework. The model was adjusted for a range of production factors such as loin temperature at time of grading, season, gender, finishing system, tropical breed content and lot size along with phenotypic measures such as eye muscle area (EMA), ossification score, hot standard carcass weight, MSA marbling score and rib fat depth were also included (results not shown). Muscling had a significant impact on pH_u compliance with an increase in eye muscle area of from 40 to 80 cm^2, increasing compliance by around 14% (*P*<0.001). An increase in compliance in more muscular cattle may be the result of increased insulin responsiveness, reduced adrenaline responsiveness and more muscle glycogen in these animals at slaughter. Thus breeding more muscular cattle with an eye muscle area greater than 70 cm^2 may help alleviate the problem of dark cutting beef in Australia.**

Keywords— **Muscle glycogen, dark firm and dry beef, eye muscle area**

I. INTRODUCTION

Dark cutting beef is one of the largest problems affecting meat quality world-wide due to its darker meat colour, shorter shelf life, bland flavour, variable tenderness and its impact on degree of doneness [1-3]. In 2009, Meat Standards Australia graded 1,157,781 cattle in Australia and 5.45% had a pH_u greater than 5.7 [4]. Due to its effect on quality, beef producers are commonly penalised around $AUD0.50 per kg carcass weight for carcasses with a pH_u greater than 5.7. This penalty equates to a cost of around $7.09 per animal graded under MSA in 2009 to producers alone, calculated using the average carcass weight of 260kg. Dark cutting beef is caused by muscle glycogen levels below about 60 µmol/g at slaughter [5]. Muscle glycogen at slaughter is a function of initial muscle glycogen 'on-farm' minus the quantity of glycogen loss due to stressors during the pre-slaughter period. Thus animals with low glycogen concentrations initially, which undergo similar pre-slaughter stress, are more susceptible to dark cutting syndrome. Variations in pH_u within a herd from the same pre-slaughter environment may be attributed to intrinsic physiological differences between animals.

One cause of this physiological variability may be associated with the extent of muscle expression in individual animals and the resultant possible change in muscle fibre types. Selection for increased muscling is known to cause a shift in muscle fibre type, increasing the proportion of fast glycolytic type IIX myofibres [6]. Shift in fibre type proportions is likely to lead to metabolic changes in muscle, as has been shown by McGilchrist *et al.* [7, 8] and Martin *et al.* [9] who demonstrated that more muscular cattle and lambs are more responsive to insulin, less responsive to adrenaline and had a higher storage of muscle glycogen [7]. Therefore it was hypothesised that more muscular animals with a larger eye muscle area are likely to have increased glycogen at slaughter and a reduced incidence of dark cutting.

II. MATERIALS AND METHODS

In order to generate an individual palatability score for each carcass, carcass measurements are required for the MSA prediction model. Carcass measurements are taken by graders accredited with both MSA grading and AUS-MEAT chiller assessment [10]. The carcass measurements include: hot standard carcass weight, EMA, gender, hump height, fat colour, rib fat depth, meat colour, MSA Marbling score, ossification score, pH_u and loin temperature [10-12].

A. Statistical analysis

From February 2002 till December 2008, there were 204,071 carcasses graded at the processing plant and 8.75% had a pH_u greater than 5.7. Data was analysed to assess the impact of eye muscle area adjusted for carcass weight on carcass compliance for pH_u less than 5.7. Binomial compliance data was analysed using a logit model within a baysian framework.

For the analysis fixed terms, the model included hot standard carcass weight, EMA, ossification, MSA marbling, rib fat, loin temperature at time of grading, season (Summer, Autumn, Winter, Spring), gender (male or female), finishing system (sourced from an Australian Lot Feeders Association accredited feedlot otherwise cattle were assumed to be grass fed), tropical breed content (percentage of *bos indicus* from 0 to 100%), lot size (from 1 to 188) and the interaction between finishing system and season. Hot standard carcass weight was also divided into two groups of less than and greater than 350kg and interacted with EMA. MSA Grader, producer, year (from 2002 to 2008) and the interaction between season and year were included in the model as random terms.

III. RESULTS

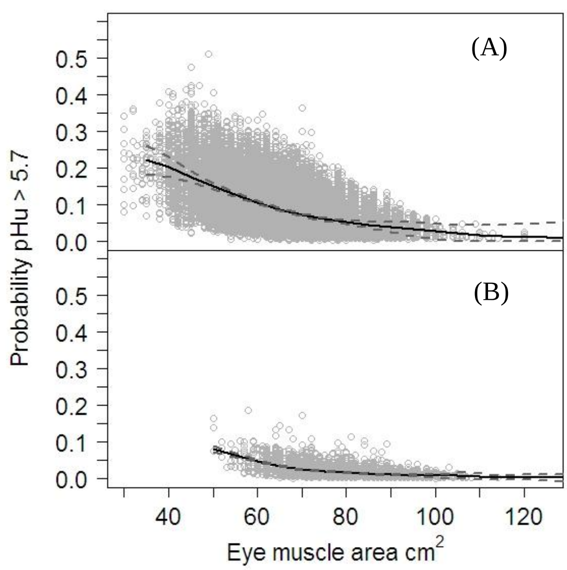

Fig. 1 Estimated mean (solid line) and standard error (dashed lines) for the effect of eye muscle area pH_u compliance in carcasses <350kg (A) and >350kg (B). Mean estimated probabilities of each raw data point are included to show the range of the data.

Eye muscle area when adjusted for HSCW had an effect on mean pH_u and carcass pH_u compliance (P<.0001). In lighter carcasses (<350kg) the effect of EMA was greater than in heavy carcasses, as shown by the significant interaction between the two terms in the model (P<0.0001, Figure 1). In the light carcasses (<350kg), as EMA increased from 40 to 80cm^2, the proportion of non-compliant carcasses with a pH_u >5.7 decreased from around 22% to 6%, while in heavy carcasses the non-compliance level dropped from around 8% to 3% as EMA increased from 50 to 80cm^2. There were minimal improvements in pH_u compliance in both light and heavy carcasses as EMA increased above around 85 cm^2.

IV. DISCUSSION

More muscular cattle with larger EMA's had a lower incidence of darkcutting, supporting our initial hypothesis. A reduction in the incidence of dark cutting syndrome in high muscled cattle complements the other advantages of muscular cattle like increased retail beef yield [13] and processing efficiency. This is a very important finding for the beef industry as it demonstrates that beef producers can actively select for more muscular cattle with the knowledge that it will help to reduce the incidence of dark cutting carcasses in their herd. This analysis suggests that producers should breed animals to have an EMA greater than 70 cm^2, if carcass weights average 250kg, to help reduce the incidence of dark cutting syndrome. This value of 70 cm^2 is around 5cm^2 larger than the average EMA measured in this data set, thus it is an achievable goal if producers utilise sires that have an estimated breeding value for EMA higher than the average. Producers can also evaluate their current position by viewing MSA feedback sheets which give EMA measurements, which will allow appropriate breeding decisions to be made.

This result suggests that more muscular cattle have higher muscle glycogen content at the time of slaughter resulting from either greater muscle glycogen concentration prior to the pre-slaughter period or less mobilisation of glycogen during the pre-slaughter period. McGilchrist *et al.* [8] has shown that Angus cattle selected for high muscling had increased whole body insulin responsiveness. This may enhance the uptake of glucose into muscle tissue in the post-prandial period and allow for an increased rate of glycogenesis, allowing these animals to have higher resting concentrations of muscle glycogen [7]. More muscular cattle may also mobilise less glycogen during the pre-slaughter period. The level of glycogenolysis during mustering, transport and lairage is largely due to the catabolic hormone adrenaline. Alternatively, McGilchrist *et al.* [7] and Martin *et al.* [9] have shown that cattle and lambs selected for high muscling had muscle tissue that was less responsive to exogenous adrenaline, indicating that more muscular cattle may mobilise less glycogen during the stressful pre-slaughter period. Therefore both of these mechanisms may have contributed to the positive phenotypic association between EMA and muscle glycogen concentration.

ACKNOWLEDGMENT

The authors wish to thank the Cooperative Research Centre for Beef Genetic Technologies for funding this study and to Meat Standards Australia and Harvey Beef for collecting and providing the data.

REFERENCES

1. Ferguson, D.M., et al., *Factors affecting beef palatability - Farmgate to chilled carcass.* Aust. J. Exp. Agric., 2001. **41**: p. 879 - 91.
2. Purchas, R.W. and R. Aungsupakorn, *Further investigations into the relationship between ulitate pH and tenderness in beef samples from bulls and steers.* Meat Sci., 1993. **34**: p. 163 - 78.
3. Thompson, J.M., *Managing meat tenderness.* Meat Science, 2002. **62**(3): p. 295-308.
4. MSA. *Meat Standards Australia feedback and benchmarking system*. pH Report 2010 [cited 2010; Available from: https://www.msagrading.com.au/FBS/.
5. Tarrant, P.V., *Animal behaviour and environment in the dark-cutting condition*, in *Dark cutting in sheep and cattle*, S.U. Fabiansson, W.R. Shorthose, and R.D. Warner, Editors. 1989, Australian Meat and Livestock Research and Development Corporation: Sydney. p. 8 - 18.
6. Wegner, J., et al., *Growth- and breed-related changes of muscle fiber characteristics in cattle.* J. Anim. Sci., 2000. **78**(6): p. 1485-96.
7. McGilchrist, P., et al., *Beef cattle selected for increased muscularity have a reduced muscle response and increased adipose tissue response to adrenaline.* animal, 2011. **5**: p. 875 - 84.
8. McGilchrist, P., et al., *Whole body insulin responsiveness is higher in beef steers selected for increased muscling.* animal, 2011. **FirstView**: p. 1-8.
9. Martin, K.M., et al., *Progeny of high muscling sires have reduced muscle response to adrenaline in sheep.* animal, 2011. **FirstView**: p. 1-11.
10. MLA, *Module 6: Meat Standards Australia Grading*. 2006, Meat & Livestock Australia: Sydney. p. 1 - 111.
11. Romans, J.R., et al., *The meat we eat*. 1994, Danville, Ill.: Interstate Publishers Inc.
12. AUS-MEAT, *Handbook of Australian Meat*. International Red Meat Manual. Vol. 7th Edition. 2005, Brisbane: AUS-MEAT Ltd.
13. O'Rourke, B.A., et al., *Quantitative analysis of performance, carcass and meat quality traits in cattle from two Australian beef herds in which a null myostatin allele is segregating.* Ani. Prod. Sci., 2009. **49**(4): p. 297-305.