TEMPERATURE-HUMIDITY INDEX HAS NO EFFECT ON THE INCIDENCE OF DARK CUTTING IN AUSTRALIAN GRAIN FED BEEF

Cameron C.Steel[1], Paula A. Gonzalez-Rivas[2], Garth. Tarr[3], Robyn D. Warner[2], Fran. Cowley[1] & Peter. McGilchrist[1]

[1] School of Environmental and Rural Science, University of New England, Armidale, New South Wales, Australia

[2] Faculty of Veterinary & Agricultural Sciences, University of Melbourne, Parkville, Vic 3010, Australia.

[3]School of Mathematics and Statistics, Faculty of Science, *University of Sydney*, Camperdown, NSW 2006, Australia

*Corresponding author email: csteel5@une.edu.au

I. INTRODUCTION

Dark cutting in Australia is defined as meat that fails to grade for Meat Standards Australia (MSA) based on pH (ultimate pH > 5.70) guidelines and also includes AUSmeat colour (colour score >3) for some processors. Dark cutting in MSA graded carcasses alone has been estimated to cost the Australian beef industry upwards of $55 million per year [1]. Dark cutting is typically a result of lower glycogen stores at slaughter which can be caused by poor nutrition, stress or muscle contraction which utilizes glycogen as an energy source. The audits of MSA data suggest a greater incidence of dark cutting in feedlot cattle during summer which is suggested to be the result of environmental impacts of during hot weather. High temperatures cause animals to gain heat load, if this load is greater than an animal can dissipate naturally it undergoes heat stress. In cattle this causes a reduction in dry matter intake, reduced metabolic rate, depressed protein deposition and increased glycogen utilization [2; 3]. The temperature-humidity index or THI uses wet and dry bulb temperatures with relative humidity as a framework for estimating heat load imposed on an animal. It is hypothesised that exposure of animals to high THI in the days or weeks prior to slaughter will increase the incidence of dark cutting.

II. MATERIALS AND METHODS

This experiment undertook a retrospective analysis of two datasets for 20 participating feedlots: Historic MSA carcass grading data and locality weather data sourced from the nearest Bureau of Meteorology (BOM) weather station. MSA data and BOM weather data was captured over a 6 year period 2012 to 2017 inclusive for 21 feedlots totaling just under 2.8 million carcasses that had been MSA graded. Weather data from the feedlot weather stations was collected from Katestone varying from 3 years to as short as 6 months in hour increments. Following an extensive data integration and variable creation process, DFD percentage per lot was regressed on the weather predictors of a certain lag, as well as certain lot attributes, such as feedlot, processor, sex and HGP status. A stepwise model selection procedure was performed starting at the full model and progressing both backwards and forwards through the model space using the Akaike information criterion to evaluate competing models and stopping when a minimum is reached. Data integration and modelling was performed using the R statistical program.

III. RESULTS AND DISCUSSION

Table 1. Statistical output for the effect of weather terms at 24 hours, 2, 3, 7, 14 and 28 days prior to slaughter plus sex, HGP, feedlot and processor on the incidence of dark cutting per lot.

Variable	1	2	3	7	14	28
THI sd		*0.001*******		*-0.001*		
Rain	*-0.0002****	*-0.0001****				
THI max			*0.0004****	*0.001****	*0.0004****	*0.0003****
THI min			*-0.0003****	*-0.0005****	*-0.0002***	
THI range sd					*0.001**	*0.002****
Observations	19,563	18,852	18,224	15,637	12,782	9,167
R^2	0.202	0.204	0.202	0.199	0.205	0.242

[1] **p<0.1; **p<0.05; ****p<0.01, Table has variables sex, plant, HGP and processor removed.

THI max and min had no significant effect within 48hr period although a 10 point increase in THI max between 3 and 28 days prior increased DFD by between 1 and 0.3 %. An explanation for this might be that there is a delay in body temperature responses to a heat challenge during the first 3-4 days of exposure, the animal will only enter a chronic response stage after 3 days[4]. Long term heat acclimation only occurs after multiple days to weeks, this involves the release of heat shock proteins that enable reprogrammed gene expression and altered endocrine systems to decrease metabolic heat production [5]. This long term response may have a higher impact on DFD % than the more immediate homeostatic responses.

An increase of 10 points of min THI had a reduction in DFD by 0.2-0.5 %. This shows that low temperatures and humidity also have a negative effect on dark cutting. This may be due to increasing metabolism to maintain normal body temperature, physical responses such as shivering and muscle contractions, or stress may utilize more muscle glycogen.

Wind speed was not significant in the model, although air movement aids in evaporative cooling from the skin and respiratory tract [4] [6]the same effect on evaporation could be explained by humidity. A 1mm increase in rainfall had a 0.01% reduction in DFD if it occurred in the first 48 hours out from slaughter. This suggests that 10mm rain in the two days before kill could reduce DFD by 0.1%.

Although THI was significant in the prediction of DFD; when compared across years to producer and processor effect it has little to no effect on the incidence of DFD. When comparing producer effects chosen at 2 days out, the DFD could increase by 4.1 %, while another producer could reduce it by 6.7%. This was a far greater effect than any of the THI variables included in the model.

Comparing the base model without weather variables at 28 days, produced an R^2 of .241 compared to .242 in the THI model with weather variables included. This demonstrates that across lots from all producers over the 6 years of grading data, THI could only explain a further 0.01% of the variation in DFD carcasses than sex, producer, processor and HGP status alone.

IV. CONCLUSION

The retrospective analysis over 6 years has shown that the effect of temperature-humidity index (THI) in the days or weeks prior to slaughter although significant, explains only .01% more of the variation in dark cutting carcasses when compared to the base model; sex, producer, processor and HGP status alone. Within 48 hours before slaughter THI had no effect, while a THI max increase of 10 occurring between 3 and 28 days prior increased DFD by between 0.1 and 0.4 %. An increase of 10 points of min THI had a reduction in DFD by 0.2-0.5 %. This suggests that although THI was significant in the model, when applied across multiple years, producers and processors overall it has little to no effect on the incidence of DFD. This may be largely due to the fact that producers and processors have management systems in place to negate a majority of the negative effects of heat and humidity on cattle.

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REFERENCES

1. Jose, C., McGilchrist, P., Perovic, J. L., Gardner, G. E., & Pethick, D. W. (2015). The economic impact of dark cutting beef in Australia. Paper presented at the International Congress of Meat Science and Technology, Clermont-Ferrand, France.
2. O'Brien, M. D., Rhoads, R. P., Sanders, S. R., Duff, G. C., & Baumgard, L. H. (2010). Metabolic adaptations to heat stress in growing cattle. Domestic Animal Endocrinology, 38(2), 86-94.
3. Miova, B., Dinevska-Kjovkarovska, S., Cvetkovska, F., Mitev, S., Dzimervska, A., & Dimitrovska, M. (2013). Liver Carbohydrate Metabolism in Rats in the Period of Recovery after Acute Heat Stress. Macedonian journal of medical sciences, 6(1), 16-23.
4. Gaughan, J., Lacetera, N., E. Valtorta, S., Khalifa, H., Hahn, L., & Mader, T. (2009). Response of Domestic Animals to Climate Challenges.
5. Bernabucci, U., Lacetera, N., Baumgard, L. H., Rhoads, R. P., Ronchi, B., & Nardone, A. (2010). Metabolic and hormonal acclimation to heat stress in domesticated ruminants. Animal, 4(7), 1167-1183.
6. Vermunt, J., & P. Tranter, B. (2011). Heat stress in dairy cattle – a review, and some of the potential risks associated with the nutritional management of this condition.