The effect of farmyard stress on meat quality: a model enabling the search for predictive biomarkers of meat pH

Hannah Lee [1], Alastair B Ross [2], Reshan Jayawardena [1], Elizabeth Ham [1], Kelly-Anne Bentley [1], Alan Tsai [1], Kevin Taukiri [2], Evelyne Maes [2], Stefan Clerens [2], James D Morton [1]

[1] Faculty of Agriculture and Life Sciences, Lincoln University, Lincoln 7647, New Zealand, [2] Proteins and Metabolites, AgResearch, Lincoln, New Zealand

Objectives: High pH meat is frequently associated with poor shelf-life and eating quality, and pH is a commonly used marker for meat quality. Early detection of high pH lamb is desirable and can improve meat quality control. Due to the variability in the occurrence of high pH at meat processing plants in New Zealand, there is a need for reproducible models that allow the study of abnormal pH in meat. We devised a pilot trial using standardised farmyard stress to produce high pH meat. To confirm the impact of the model on meat we measured biochemical features in the meat samples that can be related to meat pH. In future, biomarkers of high pH in the meat could be used for enhancing animal welfare and confirm the relationship between minimising pre-slaughter stress and improving the consistency of meat quality.

Materials and Methods: This experiment compared lambs exposed to some of the normal pre-slaughter stress factors within a New Zealand pastoral system with a control group with minimal pre-slaughter stress. It used two groups of 10 lambs (Coopworth, 6 month-old), held in the pasture paddock next to the abattoir. The 10 "low stress" animals were kept quietly in pens prior to slaughter and slaughtered first (Non-exercised/control group). The second group of 10 animals were exercised by moving with a dog for 30 minutes every hour for 4 hours prior to slaughter, replicating mustering prior to going to the freezing works (Exercised/stress group, "moderate stress"). Lambs were stunned using captive-bolt and slaughtered by throat cutting. Each carcass was dressed and ten different muscles were removed within 30 min of slaughter, and snap frozen in liquid nitrogen for glycogen and lactic acid analysis. Those 10 muscles represented different muscle fibre types: fast/glycolytic: longissimus lumborum/thoracis (LL, LT), semitendinosus (ST); slow/oxidative: supraspinatus (SS), infraspinatus (IS); intermediate: semimembranosus (SM), psoas major, glute- us medius (GM), gracilis (G); unknown muscle fibre type: sternomandibulous. The remainder of the carcasses were aged and meat quality measurements were taken at different post mortem time points: pH (at 1.5 h, 24 h), colour (at 4 days), cooking loss and shear force (at 7/8 days). Glucose and lactic acid kits were used to determine the glycogen and lactic acid content in four muscles representing two different muscle fibre types: fast/glycolytic (LT, ST) and slow/oxidative (IS, SS).

Results and Discussion: The pH declined significantly over the 24 h post-slaughter in all muscles. There was no significant differ- ence in the average pH of muscles among non-exercised (pH 6.650, N=100) and exercised groups (pH 6.683, N=99). At 1.5 h post- mortem, the pH of two different fibre types was compared as an early sign of pH response to pre-slaughter exercise stress, the slow/ oxidative muscle types (SS+SI) had significantly higher pH than the same muscle types from non-exercised group (p=0.011). This was not seen in fast/glycolytic fibre muscles (LT, LL, ST). At 24 h post-mortem muscles, the pH of the muscles from exercised group (N=99, pH 6.14) was significantly higher in comparison to the muscles from non-exercised (N=100, pH 5.85, p=0.000). For one of the ten muscles, GM, the pH did not differ between the exercise stress and control groups, while the pH of the other nine was significantly higher at 24 h post-mortem. Four muscles (LT, ST, IS, SS) from stressed lambs had a significantly lower average glycogen content compared to muscles from non-stressed lambs. These results indicated that exercise had an effect on glycolysis in these four muscles, which resulted in higher pH after 24 h post mortem. It was also found that in the lambs exposed to exercise stress conditions, their fast/glycolytic (LT, ST) muscles had a significantly higher lactic acid content compared to the slow/oxida- tive muscles (IS, SS). Exercise stress also resulted in differences in other meat quality measurements. Meat from LL, IS, SS, GM and SM muscles were darker (lower L value) in the exercise stress group compared to control. Cooking loss in LT, LL, IS and G muscles was lower and shear force was lower in LT, LL, IS and SS, but increased in G after exercise stress.

Conclusion: We have developed a model for generating high pH lamb based on farmyard pre-slaughter stress. This resulted in changes to several important meat quality markers. Samples from this trial have been used for fingerprinting mass spectrometry to identify new potential predictive markers of high ultimate pH (Ross *et al*, ICoMST 2022). This simple farmyard stress model is a useful tool for research on high pH meat under controlled yet realistic conditions, and follow up validation trials are underway to confirm the reproducibility of this model.

Acknowledgements: This work was funded through the New Zealand Ministry of Business, Industry and Employment Catalyst programme. We thank Frank Zhang, Lekshmy Jayakumari, Yukiyo Muto and Ines Homewood for assistance.

Key words: Pre-slaughter stress, Exercise, pH, Glycogen, Lactic acid