MEAT QUALITY IN MERINO RAM HOGGETS

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SUMMARY

Genetic, environmental and management effects on meat pH and colour and their relationship with other production traits were estimated from pooled data based on carcase measurements from 5870 Merino hogget rams from New South Wales, South Australia and Western Australia. Principal component analyses failed to generate a trait which would be superior to the direct use of meat pH and colour as criteria in selection against dark cutting meat. No genetic or environmental links were found between dark cutting and production traits that could provide a causative effect or potential for indirect selection. In addition to parameter estimates, the contribution of various sources of variation for meat pH and colour have been quantified and the implications of the findings are discussed.

INTRODUCTION

Australia's sheep industry differs from most other countries in that the majority of sheep are either purebred or derived from the Merino, a specialist wool breed. Currently, 33% of lambs slaughtered for human consumption are second cross (25% Merino), 42% first cross (50% Merino) and 22% are purebred Merino. The Merino has a greater prevalence of high pH meat compared to more traditional meat breeds (Hopkins and Fogarty 1998; Gardner *et al.* 1999), so high pH is an important meat quality issue in Australia, as it is a predisposing factor in dark cutting meat.

There are two major hypotheses for the increased prevalence of dark cutting meat in Merinos. The first is associated with the Merino's greater response to stressors. It suggests this heightened response occurs from the farm to slaughter and especially during lairage, resulting in greater glycogen depletion, a lower level of lactic acid produced and a higher pH (Gardner *et al.* 1999; Warner *et al.* 2006). The second theory is that breeding for a specialist wool producing animal has unintentionally resulted in a decline in meat based traits and that this has lead to an increase in dark cutting meat (Warner *et al*. 2006).

The aim of this study was to obtain a better understanding of the high pH condition within the Merino breed. The first objective was to test if the pH and colour traits could be combined into a single trait that provides a stronger association with the high pH condition. The second objective was to quantify sources of variation within meat quality traits; how much of this variation can be accounted for and therefore what are the driving forces behind the high pH condition.

METHODS

Recently, Greeff *et al.* (2008) reported on the largest meat quality data set analysed to date in Merino flocks within Australia. This same data set was utilised in the current study. The data source comprised 5870 animals from three research locations in southern Australia. The Merino hogget rams slaughtered were approximately 18 months of age. A total of 543 sires and 4284 dams were used across 3 research flocks which each had their own selection guidelines (Safari *et al.* 2007). No sires were used across flocks. The research flocks were based at Trangie (New South Wales), Turretfield (South Australia) and Katanning (Western Australia).

Ultimate pH was measured 24hrs post mortem on the loin at the 12th rib. In South Australia this measurement was taken at 48hrs as there was no electrical stimulation. Meat colour was measured on the cut surface of the loin muscle at the 12th rib after 30 minutes of exposure to air allowing the meat to 'bloom'. Measurements were taken with a Minolta Colorimeter (Konica Minolta Sensing Inc., Osaka, Japan) using the Commission Internationale deÉclairage laboratory colour system; CIELAB. Brightness (L*) is a measure of white light reflected from the meat surface whilst redness (a*) and yellowness (b*) refer to the ratios of red to blue light and yellow to green light respectively (Warner *et al.* 2006).

Principal Component (PC) Analysis. PC analysis was used with the aim of producing an independent descriptor trait of the relationship between pH and meat colour. This method uses the correlation matrices between variables to deduce the latent variables describing the relationships in a more economical way. The new components are then described by the loadings of the feeder traits, in this case pH and meat colour (Jobson 1992). The loading values describe the proportion that each trait accounts for and the direction they are acting within the PC. The benefit of this process is observed in highly correlated traits which cluster together and are affected by common factors which can therefore be described by a single trait. For a more in-depth discussion of PC analysis see Jobson (1992) and Forkman *et al.* (1995). The data were analysed using ASREML (Gilmour *et al.* 2006) with location, year and breeding line within location and year fitted as random effects. Effects for type of birth and rearing, age of dam and date of birth accounted for zero variance in meat colour and were removed from the model. Hot carcass weight and GR fat at the 12 rib were also fitted as covariates but accounted for zero variance and were removed for both pH and colour.

RESULTS

At all 3 locations, a high proportion of animals produced high pH meat characterised by a pH of 5.8 or higher (NSW 63%; SA 90%; WA 74%).

Principal Component Analysis. Initially PCs were formed from four traits; pH, brightness (L*), redness (a*) and yellowness (b*). The first PC accounted for 67% of the variation but the secondary colour traits a* and b* had a large influence on the latter PCs despite being of relatively low importance in actually quantifying the problem of high pH meat. Meat brightness was the key driving factor in tonal changes within the meat colour chips used in beef meat quality analysis (Walkom, unpublished). Thus, it was decided to form a PC solely on pH and brightness. The PC analysis was possible because pH and brightness were moderately correlated ($r_P = -0.41$). The first PC was significant (latent root 1.41) and accounted for 70% of the variation in the two traits. The PC in this case described meat colour with positive values associated with brighter, low pH meat. By chance, the colour threshold measurement of 34 (Hopkins and Fogarty 1998) corresponded to a PC value of zero.

Fixed Effects. The PC was influenced by location, year and genetic line nested within years. This was also the case for pH and brightness although the influence of line on the PC appears to be mainly driven by the brightness value. The model was only able to account for 36-45% of the variation within pH, brightness and the PC with the genetic variation accounting for less than 20% of the total variation (Figure 1), leaving approximately 60% of the variation unaccounted for. Variation within location, year and breeding lines did not coincide with any trends in prime lamb production traits.

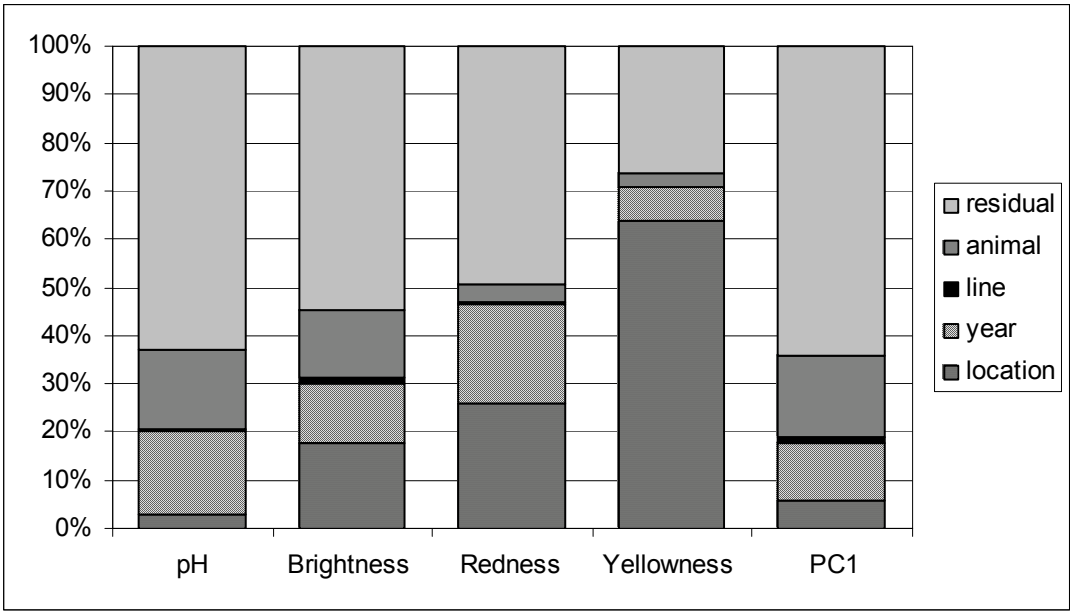

Figure 1. Analysis of sources of variation on meat quality. The proportion accounted for is shown on the vertical axis in percentage from. The traits analysed were, ultimate pH, the meat colour traits brightness (L*), redness (a*) and yellowness (b*) and the principal component combining pH and brightness (PC1).

DISCUSSION

Principal component. Whilst the PC was of value to the analysis and provided an ideal description of the relationship between the original traits, it was not as useful as a stand alone trait. Selection on the PC threshold within industry would be difficult due to its dependence on the size of the data source and level of error within the source. The heritabilities of pH and brightness were low to moderate (0.20 and 0.21 respectively, Greeff *et al.* (2008) with the heritability of the PC no better at 0.22. The moderate heritability suggests potential for improvement by selection directly for pH or colour. A genetic correlation of -0.57 between pH and brightness (Greeff *et al.* 2008) will assist with improving the meats appearance along with the selection against high pH meat. With a selection intensity of 1 and a generation interval of 3 years and single trait selection against dark cutting for 10 years, ultimate pH ($h^2 = 0.21$, $\sigma_P = 0.38$) could be improved by 0.26 units (from 6.05 to 5.79) or brightness ($h^2 = 0.20$, $\sigma_P = 3.35$) could be improved by 2.2 units (from 33.9 to 36.1). These calculations suggest the majority of animals could be within the acceptable industry threshold after focussed selection for approximately 10 years. Due to the need to include other traits within the breeding system and that meat quality traits are measured on the carcass, selection against high pH meat would take far longer than the direct selection calculation suggests.

Factors. The statistical model only accounted for 37% (pH) and 45% (brightness) of total observed variation within the flocks and the level of genetic variation was small in both key traits, so approximately 60% of the variation was unaccounted for. This residual variation would include non-additive genetic effects, technical error within machine measurements as well as other biological variation such as behaviour associated with stress response and the physiological

differences between animals associated with glycogen storage and breakdown; these factors were not measured in this study. A higher proportion of high pH meat is expected in Merino hogget rams although there are some reports of high levels (68%) in wethers (Ferguson *et al.* 2008).

The major factors accounting for variation were location and year effects. There are a number of variables that are confounded with location and year effects that can not be explained within the data available; the largest of these being genotypic strain and nutrition. The genetic background of the flocks at each site varied greatly although the influence of line on high pH levels is unknown.

Variation in animal nutrition between sites and years was quite large, however long term nutrition (as defined by fat depth) did not affect high pH within the flocks. This is supported by Sañudo *et al.* (2000) where fat covering of commercial lambs had no significant influence on pH or brightness and is probably expected for ruminants. The period prior to haulage and slaughter may provide the greatest opportunity to prevent high pH in Merinos, as the animals can not mobilize fat fast enough during these times to restore glycogen stores. The month prior to slaughter appears to be the most critical phase of the animals' nutritional regime for ensuring meat quality, as Ferguson *et al.* (2008) found that Merino wethers fed a concentrate diet of 11.4 ME/kg over a 34 day period prior to slaughter only had a 9% incidence of dark cutting compared to 68% for animals feed a roughage diet of 8 ME/kg. Animals at Trangie were fed pellets before slaughter and Katanning animals were slaughtered off green pasture in an attempt to lift muscle glycogen levels however the influence of this is unknown.

Genetic improvement through selection against high pH in Merinos provides some hope to improve meat quality due to a moderate heritability. However, other studies (Ferguson *et al.* 2008) indicate a greater potential for improvement by maintaining high muscle glycogen concentration through better nutrition prior to lairage and slaughter.

ACKNOWLEDGEMENTS

Funding for this study was provided by the Commonwealth Government through the Australian Sheep Industry Cooperative Research Centre and by Meat and Livestock Australia. We thank the many other scientists, technical and support staff from the NSW Department of Primary Industries, the South Australian Research and Development Institute and the Department of Agriculture and Food Western Australia, who have contributed to flock management and data collection over several years. Contributions from sheep breeders and Australian Wool Innovation Ltd for their support in the establishment of the research flocks is also gratefully acknowledged.

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