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## BRIEF COMMUNICATION: Factors affecting colour stability of fresh chilled lamb meat

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**Key words:** colour stability; chilled lamb; retail display life.

### INTRODUCTION

An increasing proportion of New Zealand lamb meat is shipped to the European Union market as chilled rather than frozen product, with 29% exported as chilled product in 2005/06 (Anon, 2006). Once chilled lamb reaches this market it is further processed, with the lamb meat entering the retail market approximately eight weeks after slaughter. A major selection criterion for retail purchasers is the colour of the meat on display. Most consumers prefer bright red coloured meat versus darkened meat as they associate a bright red colour with freshness (Killinger *et al.*, 2004; Savell *et al.*, 1989). Colour stability of meat significantly affects its retail display life. Previous research into colour stability of chilled lamb investigated the effects of electrical stimulation and packaging type in comparisons with frozen lamb (Moore & Young, 1991). This paper looks into the colour stability of chilled pasture-fed lamb in more detail and investigates the role that sex and genetics play. These factors have not previously been considered.

### MATERIALS AND METHODS

Colour stability data was collected in 2004, 2006 and 2007 on the *M. longissimus dorsi* (loin cut) of 5,734 lambs from a progeny test of composite breed sires of the Suffolk, White Suffolk and Poll Dorset breeds. The lambs were slaughtered in commercial plants with the carcasses electrically stimulated and aged following accelerated conditioning and aging criteria (Chrystall *et al.*, 1989). The same plant was used in 2004 and 2006 with a different plant used in 2007. Within each year all the lambs were slaughtered on the same day. During the day following slaughter boneless loins were collected, vacuum packed and stored at -1°C for eight weeks. At eight weeks, ultimate pH was measured using a Sensorex spear-tip pH probe calibrated to pH 4 and pH 7 using buffer standards. Three 2 cm thick transverse slices of loin were cut, avoiding the end pieces, and placed on small plastic trays, which were wrapped using a semi permeable, standard supermarket cling wrap, film and stored at 4°C. Colour was measured using the CIE L\*, a\*, b\* scale at 2, 24, 48, 72, 96, 120, 144, 168, 192 and 216 hours with a Minolta Chromameter. Only the CIE a\* readings are considered in this paper. At

each time point colour was measured on each of the three slices from each lamb and the values averaged.

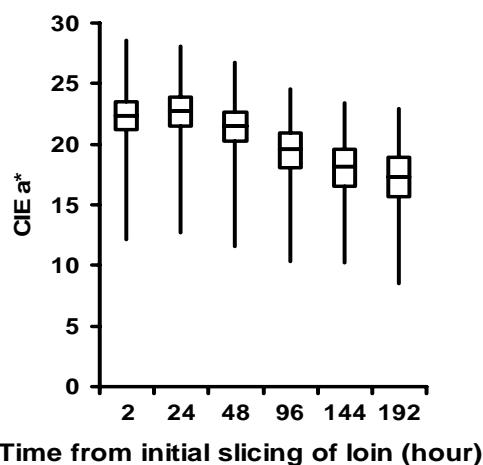
The regression procedure in SAS (SAS, 2004) was used to generate a linear model to describe the decline in CIE a\* for each animal between 24 hours and 216 hours. This provided information on the initial maximal bloom as the CIE a\* value at 24 hours, rate of decline in CIE a\*, and an R<sup>2</sup> value to indicate how well a linear model described the data. This model was used to estimate the time taken for CIE a\* to decline to 16 units, a proxy of the maximal length of time the loins could be on retail display before they would have to be removed or discounted due to poor colour as an indication of their potential retail display life. The general linear model procedure in SAS (2004) was used to determine factors affecting the CIE a\* value at 24 hours, rate of decline in CIE a\* and estimated retail display life. Only individuals with a model R<sup>2</sup> greater than 0.75 were included in the analysis as estimates of retail display life from low R<sup>2</sup> models was poor. Factors fitted in the models included fixed effects of sex, year and sire nested with year, and covariates of carcass weight and pH fitted as a quadratic.

### RESULTS AND DISCUSSION

This paper only considers the CIE a\* values which represents the degree of redness of the meat as this is the value most correlated with consumers' subjective measurement of colour acceptability (Moore & Young, 1991). Figure 1 shows the distribution of CIE a\* values for a subset of time points. From 2 to 24 hours post slaughter the CIE a\* values increased indicating a brighter red colour, while from 24 hours on the CIE a\* values declined indicating a gradual darkening of the colour of the meat.

A linear model fitted across the time points accurately explained the decline in an individual carcasses CIE a\* values with an average R<sup>2</sup> of 0.94. Both maximal CIE a\* and decline in CIE a\* varied between individuals, resulting in variation in estimated retail display life. The overall average estimated retail display life was 156 hours with a standard deviation of 71 hours for individual loins with model R<sup>2</sup> values greater than 0.75. The total amount of variation explained by factors considered was 36%, 60% and 44% for maximal CIE a\*, rate of

**FIGURE 1:** Box and whisker plot for colour CIE a\* values measured over time on slices of *M. longissimus* muscle cut after 8 weeks chilled storage of the whole muscle. Vertical lines represent the full range of values; the horizontal lines represent the 25th, 50th and 75th quartile values respectively.



decline in CIE a\* and retail display life, respectively. When fitted as a quadratic, pH explained the largest proportion (14.7%) of variation in the maximal CIE a\* value, with sire explaining the next largest proportion (9.2%). Year explained the largest proportion of variation in the rate of decline in CIE a\* (42.8%), with carcass weight explaining the next largest proportion (10%). Year also explained the largest proportion of variation in estimated retail display life (34.4%), with sire explaining the next largest proportion (7%).

The general trend of an initial increase, or bloom, in CIE a\* values for up to 24 hours followed by a decline is consistent with changes in Hunter "a" values reported by Moore and Young (1991). This trend is due to the initial exposure of the cut meat surface to oxygen which results in the oxygenation of myoglobin, which has a purple colouration, to oxymyoglobin, which has a bright cherry red colouration. Over time oxymyoglobin oxidises to ferric metmyoglobin, which has a brown colouration (MacDougall, 1986). Conversion of the Hunter values reported by Moore and Young (1991) to the CIE scale showed the bloom values reported by these workers to be considerably lower than those recorded in this study. As a result, their reported display lives were considerably shorter at three days than the nine days estimated in this experiment, despite one of their treatments being similar to the regime imposed in this study.

Fitting a linear model to CIE a\* values from 24 to 216 hours explained their decline well. This suggested that rather than regular monitoring to record when CIE a\* declined below 16 units, fewer measurements could be taken and the time predicted via regression with little loss of accuracy. In some

instances the fit was poor with a low R<sup>2</sup> value, probably due to the meat being inconsistent in appearance resulting in large day to day variation.

Some of the variation in these traits was accounted for by carcass weight, quadratic of pH, sex, year and sire nested within year. Other factors are also likely to influence colour stability. The significant effect of year indicates that differences in pre-slaughter treatment and subsequent processing of the carcasses play an important role in the subsequent colour stability of lamb. Achieving consistent colour between years will require further investigation as to how best minimise this variation. That there were some between-sire differences indicates that genetic variation does exist and selection could be used to improve the colour stability of New Zealand chilled lamb.

Retail display life of lamb loins chill stored can be accurately predicted using a linear model of the colour measure CIE a\*, with the model consisting of colour CIE a\* at 24 hours and rate of decline. Sire significantly impacted retail display life. Between-year variation was significant. Targeting both genetic and processing control, both pre and post slaughter, for improving colour stability will lead to New Zealand lamb with improved display life.

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