# RELATIONSHIP BETWEEN FRESH COLOUR (AT GRADING) AND COLOUR STABILITY MEASURES FOR DISPLAYED DARK OR NON-DARK CUTTING BEEF

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## I. INTRODUCTION

Dark cutting (DC) is problematic to the Australian beef industry, and in an effort to discourage its prevalence; processors will discount and downgrade the value of any such carcasses. This action is based on the consumers' preference for beef that presents a bright red appearance – DC beef colour is unfavourably received as it is considered less fresh and of lower quality [1]. It is also important that beef colour is consistent (stable) across a display period so as to assure its retail-potential. Fresh colour assessments made at ~24 h post-slaughter are often used to grade beef and determine whether or not it is DC. Convention then dictates that this same beef is then aged for an additional 2 weeks (sometimes longer) to improve its tenderness and eating quality prior to retail. This prompted us to consider the relationship between fresh and retail colour of DC and non-DC (nDC) beef. In this preliminary study, we aimed to compare beef colorimetrics recorded at grading (fresh) and again across 3 d of retail display.

## II. MATERIALS AND METHODS

From a commercial Australian abattoir, beef carcasses graded [2] as DC ($n$ = 16; mean: 149.0 kg HCW; grading pH 5.96 at 9.4°C) and nDC ($n$ = 14; mean: 145.2 kg HCW; grading pH 5.48 at 9.7°C) were selected. At this same point, colour measurements were recorded on their bloomed (~1.5 h, at 2-3°C) *M. longissimus lumborum* (LL) surfaces– exposed between the 12-13$^{th}$ ribs [2]. Temperature and pH were also recorded at this same time point using calibrated probes (smartCHEC-CP, TSP Pty, Ltd, Queensland, AUS) inserted ~ 2 cm into the exposed LL surface. At boning, each LL was then removed, vacuum-packaged and aged for an additional 2 weeks (1-2 °C). When sectioned, LL slices were prepared (2-3 cm thick), overwrapped using 15 µm PVC film, and then placed under continuous fluorescent lighting (58 W NEC tubes delivering ~ 1000 lx to the measured surface) and held at 2-3 °C to proxy retail-display conditions. Colour measurements were recorded after an initial blooming period (~ 45 min) and again at 1 d measurement intervals (0-3 days: 4 in total) throughout retail-display. All colour measurements were made using the same NIX colorimeter (aperture size: 15 mm; Nix Pro Color Sensor™, Nix Sensor Ltd., Ontario, CAN) set to Illuminant D65 and 10° standard observer. The results from 7 technical replicates were averaged, and data were reported as CIE values (L*, a*, and b*) which were used to calculate chroma and hue [3].

Data were evaluated in Genstat (18$^{th}$ Edition, VSN International Ltd., www.vsni.co.uk) using multiple linear regression analyses with carcass grade (DC or nDC) fitted as groups; all fresh colorimetrics as explanatory terms; and each display colorimetric as the response variate. Colorimetric data were again analysed using individual linear mixed models with carcass fitted as a random effect; carcass grade, colour measurement interval, and their interactions as fixed effects. Level of significance was set at $P < 0.05$.

**Table 1 Fresh beef colorimetric account of variance (% = $R^2$) for retail-display beef colorimetrics assessed over 3 days. Shown in parentheses are: the standard error of observations. *** $P < 0.001$ and $^{ns}$ $P > 0.05$.**

| | Display period (d) | | | |
|---|---|---|---|---|
| | 0 | 1 | 2 | 3 |
| L* | 65.2 (3.3)*** | 50.0 (3.5)*** | 51.7 (3.1)*** | 59.2 (3.4)*** |
| a* | 65.4 (2.2)*** | 77.8 (1.8)*** | 63.5 (2.1)*** | 65.9 (2.0)*** |
| b* | 60.4 (1.9)*** | 73.0 (1.3)*** | 49.2 (1.8)*** | 64.8 (1.4)*** |
| Chroma | 65.8 (2.7)*** | 77.3 (2.2)*** | 60.3 (2.7)*** | 66.7 (2.3)*** |
| Hue (radians) | 19.9 (3.8)$^{ns}$ | 18.9 (1.5)$^{ns}$ | 20.8 (2.1)$^{ns}$ | 20.3 (1.6)$^{ns}$ |

## III. RESULTS AND DISCUSSION

With the exception of hue, DC colorimetric results were significantly lower than for nDC beef (Figure 1). These results reflect previous research and are thought to be pH-mediated - as pH can affect meat oxygen consumption rates, therefore the susceptibility of myoglobin to oxidation and its dominant redox state [1]; likewise, pH can affect meat's water-holding capacities which underpin myoglobin structure and their light scattering properties [4]. It was noteworthy that DC samples did not breach the threshold (a* < 14.5) for consumer acceptance of beef colour [5] – but this outcome should be considered with reference to the colorimetric instrument used (NIX) as the colour threshold is based on HunterLab MiniScan measures; these remain to be compared.

Independent to carcass grade, measurement interval resulted in higher ($P$ < 0.05) fresh a* and chroma values than observed at retail-display 0 d. This was thought to be a consequence of ageing effects on mitochondrial oxygen consumption rates, protein oxidation and degradation, and their contributions to myoglobin redox status – which is most obvious in the relative redness and intensity of colour [6]. No significant interaction between carcass grade and measurement interval was apparent.

Colorimetric regression models based on fresh colour measures accounted for variation in retail-display colorimetrics across the 3 d of display (again, with the exception of hue; Table 1). Moreover, the variation accounted for was increased when carcass grade (DC or nDC) was included in the model along with fresh colorimetrics. This suggests pH contributions to this relationship as important to understanding retail-display potential, as carcass grade was solely based on LD pH levels [2]. Within the context of this study, improvements were marginal (typically ~2%), but this could arise from instances of carcass grade misclassification [1] – that said, carcass grade here was based on industry appraisal.

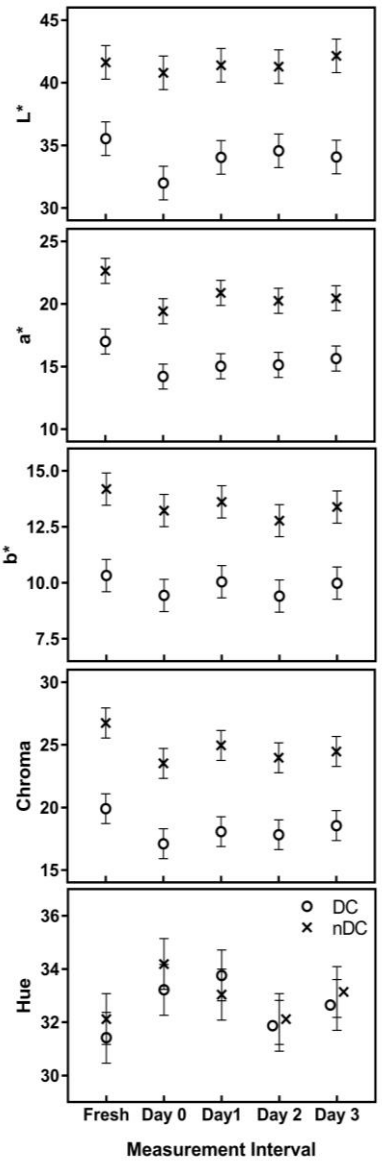


Figure 1. Predicted mean (± standard error) fresh and retail-display beef colorimetrics measured on beef graded as dark cutting (DC) and non-dark cutting (nDC)

## IV. CONCLUSION

These findings demonstrate the usefulness of colorimetric fresh carcass assessment using the NIX, to understanding the retail-potential and scope for value-adding to conventional subjective appraisals of DC and nDC beef.

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