CHANGE IN COLOR STABILITY OF LAMB: FRESH vs. AGED MEAT

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Abstract –Fifty four, seven month old lambs of mixed gender, that had grazed either perennial or annual pasture, were slaughtered and at 24 h post mortem *m. longissimus lumborum* samples were collected. Half of the muscle section was sliced into three pieces, placed on a foam tray, overwrapped with 15 micron polyvinylchloride film and displayed under light (Lux = 1500) and refrigerated (~3-4°C). The redness and surface brownness were measured over 4 days post-slaughter. The rest of the sample was vacuum packed and aged for 4 weeks at 3°C, sliced and displayed for the measurement of color as for fresh samples. Ageing led to substantially greater redness and less brownness formation compared with fresh meat, over the entire four days of display. Additionally the advantage of ageing on color was sustained over the display period for lambs that had grazed perennial pasture compared with lambs that grazed annual pasture.

Key Words – Meat color, brownness formation, lamb, redness retention, shelf life.

I. INTRODUCTION

On the Australian domestic market lamb is either sold at retail fresh (within as little as 24 h post-mortem) with no previous packaging or vacuum packed or subjected to modified atmosphere packaging and then sold after a period of ageing. This latter method is known to enhance color stability [1]. Previous studies have reported that lamb that has been aged vacuum packed is redder than corresponding fresh meat for at least the first few days of retail display [2,3]. This is an important finding because meat color strongly influences a consumer's decision to purchase meat. Consumers deem color to be a visual measure of freshness and quality [4]. In support of this it has been stated that "attractiveness of the product, usually considered as redness, may have little relationship to the final assessment of the product as eaten, but it is usually the only criterion, other than cost, which influences the consumer in making a decision to purchase"[5].

As meat ages, it becomes less red as indicated by a decline in a*-values [6]. However, change in the red/green level is not the only color change that occurs on the meat surface. Consumers will reject brown meat that has high levels of metmyoglobin [7]. The brownness formation on the meat surface can be measured using the reflectance ratio at 630/580 nm (= oxy/met) [8], with lower values indicating browner meat. It appears there has been no work comparing fresh versus aged lamb for this Further, recently consumer thresholds for a*-values and the 630/580 nm ratio have been established for lamb [9] and this has allowed the impact of different marketing methods on color stability to be placed in consumer context, something not reported previously. Based on these facts a study was undertaken to investigate the surface brownness formation and stability of meat from lamb loin cuts held under simulated display as fresh or after ageing in a vacuum pack.

II. MATERIALS AND METHODS

Fifty four, seven-month old lambs of mixed gender were randomly allocated to one of four dietary treatment groups based on gender and liveweight. The initial liveweight of lambs used in this study was 28.8 – 39.6 kg. The treatments applied to lambs were: perennial pasture (PP); annual pasture with lucerne hay and oat grain pellet supplement (AP); AP and cracked flaxseed pellet supplement (APFS); AP and flaxmeal pellet supplement (APFM). The experimental period lasted for 7 weeks with one week of introduction to the supplements. Further details are provided elsewhere [10].

At the end of the feeding period, the lambs were slaughtered. At 24 h post-mortem, the entire loin muscle (*M. longissimus lumborum;* LL) was removed from the left side of the carcase. Half of each LL was cut into 3 slices (2.5 cm thickness) and these were placed on a plastic tray, over-wrapped with an oxygen permeable film (polyvinylchloride) and displayed under refrigerated conditions (~3-4°C) with fluorescent lights set at 1500 Lux. The surface color of the meat was measured at day 1, 2, 3 & 4 post-slaughter from the time samples were displayed (*i.e.*, day 1 post-slaughter measurement was taken as 0 h display), using a HunterLab color meter (Hunterlab Miniscan, TM XE Plus 45/0-L, aperture size of 25 mm, Reston, USA) with light source set at D65/10). The other half of each LL was vacuum packed and aged at 3°C for 4 weeks. After 4 weeks, vacuum packs were opened and loin slices were prepared for the color evaluation as outlined for fresh meat above. Color stability of fresh and aged meat was assessed by measuring the change in brownness on the meat surface (ratio of oxymyoglobin and metmyoglobin [oxy/met]) as determined by the reflectance ratio at 630/580 nm wavelength and the redness of meat (a*-value). The reflectance ratio of 630/580 nm is used as an indirect measure of metmyoglobin formation (brownness) on the meat surface [8]. On the day of preparation for both fresh and aged meat, color was measured after a 30 min bloom at 3^{o}C.

The surface brownness (RF 630/580 = oxy/met) and redness (a*-value) values of meat over days 1, 2, 3 and 4 were analysed as repeated measures analyses of variance with Greenhouse-Geisser correction with animal as a blocking effect. Factorial and nested treatment effects involving treatment (fresh versus aged) and display time (days) are reported in Table 1. These analyses allow comparison between fresh and aged meat color, over time, for the four feeding management treatments.

III. RESULTS AND DISCUSSION

There was no indication that supplement (within the annual pasture treatment) had any interaction with packaging or time of display for either a*-value or RF630/580 ($P > 0.1$; Table 1), and thus the results for the three supplements in annual pasture treatment are not presented separately. However, there was evidence of interactions between pasture types (annual versus perennial), and thus results are separately presented for annual and perennial pasture treatments.

At initial display (day 1), the a*-value was 5.8 (se = 0.27) units greater after ageing than when fresh for the annual pasture (Figure 1A). For perennial pasture the response was almost identical, being 5.7 (se = 0.60, Figure 1B). Similarly, the difference between aged and fresh for RF630/580 was similar for annual (0.8, se = 0.10, Figure 2A) and perennial pasture treatments (0.7, se = 0.23, Figure 2B).

With ageing, there was a marked decline in both a*-value and RF630/580 over the 4 days of display. The decline in a*-value over the 4 days was greater in annual pasture (5.7, se = 0.21) than in perennial pasture (4.3, se = 0.47). Similarly the decline in RF630/580 was greater in annual pasture (2.6, se = 0.08) than in perennial pasture (1.9, se = 0.19). With fresh lamb, there was a much smaller decline in a*-value, but by day 4 the a*-value of the aged meat was still clearly greater than fresh for both annual (1.5, se = 0.27) and perennial pasture (3.2, se = 0.60). Over the four days, there were substantial declines in RF630/580 for all treatments, but by day 4 the RF630/580 ratio of the aged meat was still greater than fresh for both annual (0.3, se = 0.10) and perennial pasture (0.8, se = 0.23).

Thus ageing the meat for 4 weeks led to substantially greater redness and less brownness development, than occurred in fresh meat, over the entire four days of simulated retail display. However, the advantage of ageing was more sustained over the display period for lambs that had grazed perennial pasture than lambs that had grazed annual pasture.

The importance of these findings must be considered in relation to likely consumer perception of the meat displayed as either fresh or aged. Based on previous data [9] consumers typically assessed displayed lamb meat as unacceptable when the a*-value fell below 14.8 and when the RF630/580 ratio was less than 3.3. Using these cut-offs the fresh meat was on average unacceptable for both traits after 2 days on display, whereas the aged meat was acceptable for 3 days of display. This difference is of real economic importance given retailers will discount meat that is visually unacceptable [7]. With many retailers moving towards the storage of meat prior to retail display the results of this study suggest this will have positive consequences for color stability and thus consumer acceptability.

Table 1. Levels of significance (P values) for effects, involving treatment or time of display (main effects and interactions), on meat redness or surface brownness measurements.

Effect	Redness (a*-value)	Brownness (RF 630/580)
Storage time (fresh vs. aged) = treatment	0.001	0.001
Treatment x pasture type	0.015	0.038
Treatment x supplement (in annual pastures)	NS	NS
Display time	0.001	0.001
Pasture x display time	NS	0.048
Treatment x display time	0.001	0.001
Treatment x pasture type x display time	0.043	NS
Supplement x display time	NS	NS
Treatment x supplement x display time	NS	NS

NS = not significant

Previous work using a chromameter to measure color in lamb found evidence that muscle samples vacuum packaged and aged for 4 weeks when placed under simulated retail display had greater color stability (color retention) based on a*-values compared with fresh meat counterparts [2,3]. The results presented here confirm previous findings, but also extend our understanding to the effects of ageing in a vacuum pack on surface brownness formation given the use of the Hunterlab Miniscan. There could be several reasons for aged meat being more color stable compared to fresh meat. We propose some possibilities. Firstly, the anaerobic condition with 4 weeks of vacuum packaging might have changed the initial biochemical reaction associated with heme pigment (heme iron) and oxygen in the meat surface; secondly, the oxygen consumption of meat and/or the oxygen diffusion into the muscle surface may have been altered due to changes in the physical properties of meat (structural changes with tenderization of meat) or thirdly, the antioxidant status of meat may have had an effect on the lipid oxidation when aged for a longer duration under vacuum packaging. Further investigation is warranted.

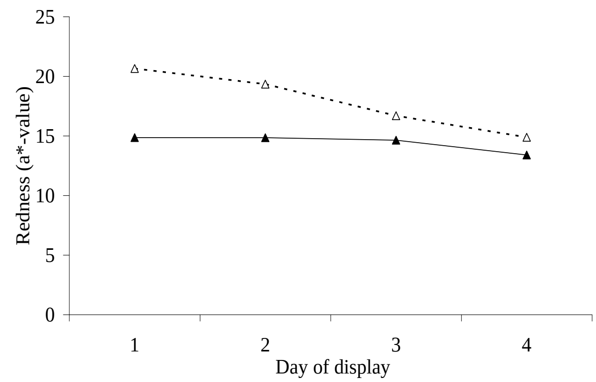

Figure 1A. Redness (a*-value) over the 4 days of display in lambs grazing annual pasture for fresh (▲) and aged (Δ) meat.

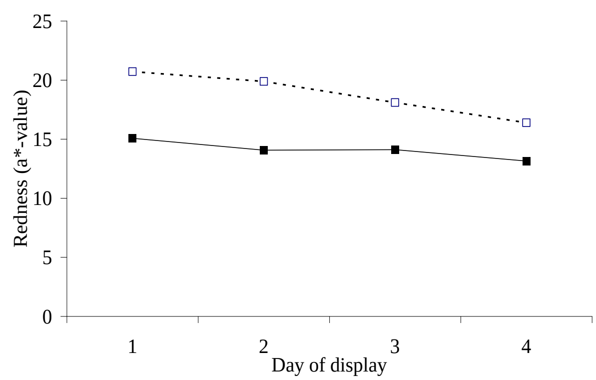

Figure 1B. Redness (a*-value) over the 4 days of display in lambs grazing perennial pasture for fresh (■) and aged (□) meat.

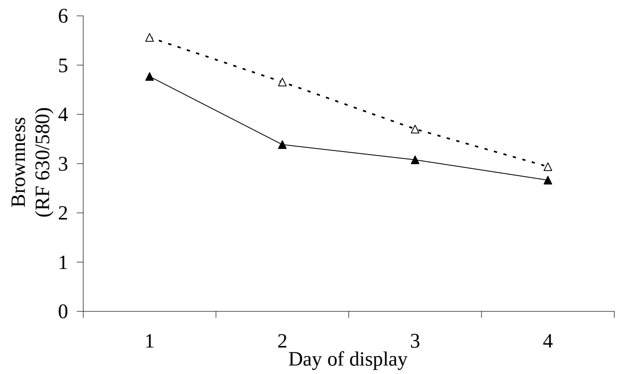

Figure 2A. Surface brownness (RF 630/580 nm = oxy/met) over the 4 days of display in lambs grazing annual pasture for fresh (▲) and aged (Δ) meat. The decreasing ratio on the y axis indicates increasing brownness formation.

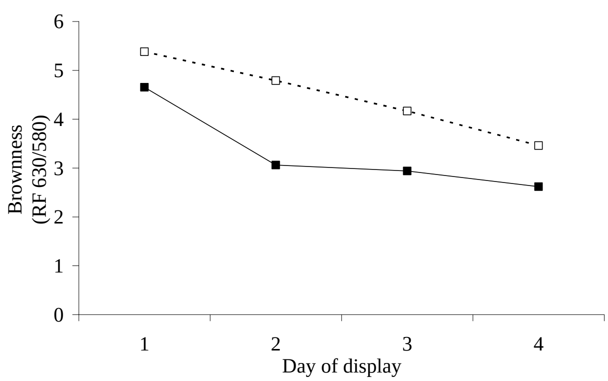

Figure 2B. Surface brownness (RF 630/580 nm = oxy/met) over the 4 days of display in lambs grazing perennial pasture for fresh (■) and aged (□) meat. The decreasing ratio on the y axis indicates increasing brownness formation.

IV. CONCLUSION

The initial meat color, formation of brownness and retention of redness during four days of retail display were superior for aged meat compared with fresh meat. This improvement will significantly enhance the visual acceptability of lamb at retail display and requires further investigation.

ACKNOWLEDGEMENTS

The funding for this work was provided by the Department of Primary Industries, Victoria, Australia. The authors would like to thank Victorian Department of Primary Industry staff Greg Seymour, for the management of animals in paddocks and Matthew Kerr, Athula Natharampatta and Wayne Brown for the slaughter of lambs, muscle sample collection and color measurement of the meat.

REFERENCES

1. McMillin, K.W. (2008). Where is MAP going? A review and future potential of modified atmosphere packaging for meat. Meat Science 80: 43-65.
2. Moore, V. J. & Young, O. A. (1991). The effects of electrical stimulation, thawing, ageing and packaging on the colour and display life of lamb chops. Meat Science 30: 131-145.
3. Ponnampalam, E. N., Trout, G. R., Sinclair, A. J., Egan, A. R. & Leury, B. J. (2001). Comparison of the color stability and lipid oxidative stability of fresh and vacuum packaged lamb muscle containing elevated omega-3 and omega-6 fatty acid levels from dietary manipulation. Meat Science 58: 151-161.
4. Faustman, C. & Cassens, R.G. (1990). The biochemical basis for discoloration in fresh meat: a review. Journal of Muscle Foods 1**:** 217-243.
5. MacDougall, D.B. (1982). Changes in the colour and opacity of meat. Food Chemistry, 9: 75-88.
6. Renerre, M., Dumont, F. & Gatellier, P. (1996). Antioxidant enzyme activities in beef in relation to oxidation of lipid and myoglobin. Meat Science 43: 111-121.
7. Hood, D.E. & Riordan, E.B. (1973). Discolouration in pre-packaged beef measured by reflectance spectrophotometery and shopper discrimination. Journal of Food Technology 8: 333-343.
8. Strange, E.D., Benedict, R.C., Gugger, R.E., Metzger, V.G. & Swift, C.E. (1974). Simplified methodology for measuring meat color. Journal of Food Science 39: 988-992.
9. Khliji, S., van de Ven, R., Lamb, T.A., Lanza, M. & Hopkins, D.L. (2010). Relationship between consumer ranking of lamb colour and objective measures of colour. Meat Science 85: 224-229.
10. Burnett, V.F., Seymour, G.R., Norng, S., Jacobs, J.L. & Ponnampalam, E.N. (2012). Lamb growth performance and carcase yield from perennial or annual pasture systems with supplements. Animal Production Science 52: 248-254.