# THE EFFECT OF FORAGE TYPE ON THE MEAT QUALITY OF WHITE DORPER LAMBS

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**Abstract - The aim of this study was to evaluate the effect of different types of forage on the meat quality of White Dorper lambs. White Dorper mixed sex lambs (62) were grazed on five different forages: Bladder clover, Hybrid forage brassica (Rape Kale X), Chicory + Arrowleaf clover, Lucerne + Phalaris and Lucerne. Samples of *longissimus lumborum* (LL) muscle were collected 24 h post-mortem, and were sliced into three equal sub-samples which were vacuum packaged and assigned to ageing periods of 5, 12 or 40 days. The *semimembranosus* muscle from the right side was also aged for 40 days. Lambs fed Chicory + Arrowleaf clover or Lucerne produced the fattest carcases with those fed Bladder clover or Lucerne + Phalaris producing the leanest carcases. The pH in the LL at 24 hours was lowest in lambs fed Chicory + Arrowleaf clover or Lucerne and this caused some of the differences in meat colour measures.**

**Keywords:** Carcase characteristics, Colour, pH

## I. INTRODUCTION

Lamb production systems often require alternative feeds to pasture due to seasonal fluctuations in pasture quantity and quality. There is a range of alternative feeds already available [1], but a number of newer forages have emerged for which there are limited comparisons in terms of lamb meat quality traits. The colour of meat is an important factor for consumers whom apply this as a visual marker of freshness and quality. Routinely, lamb with discoloration is rejected by consumers and therefore the premature browning of retail-displayed meat is an important economic consideration [2]. Thus it is important to quantify the effect that forages have on colour. Other objective characteristics applied to evaluate lamb meat quality include: pH, water-holding capacity, tenderness, and the health and nutritional aspects. In developing new production systems based on alternative forages it is important that the impact on meat quality is determined, to avoid deleterious effects which may arise [3]. The aim of this study was to evaluate the effect of several different types of forage on the meat quality of White Dorper lambs.

## II. MATERIALS AND METHODS

Sixty-two (62) White Dorper lambs were grazed on five different forages: Bladder clover ($n$ = 12), Hybrid forage brassica (Rape Kale X ) ($n$ = 12), Chicory + Arrowleaf clover ($n$ = 15), Lucerne + Phalaris ($n$ = 11) and Lucerne ($n$ = 12). All animal procedures were approved by the Charles Sturt University Animal Care and Ethics Committee (Protocol No. 12/101). These lambs were initially weighed and allocated into plots with other lambs at a stocking rate of 32.5 lambs per hectare (3 plots per forage type), where they were kept for 49 days. The lambs were weighed two days prior to slaughter following an overnight curfew (44.1 ± 6.4kg) and returned to the plots. Lambs were transported to a commercial abattoir (400 km), where they were held in lairage overnight and slaughtered the following day. The lambs were slaughtered following head only stunning. As a part of this process carcases were exposed to a number of electrical inputs routinely used by the cooperating abattoir including a high frequency immobilisation unit, applied for 25-35 secs (2000 Hz, 400 volts, and a maximum current of 9 amps over 7 animals, pulse width of 150 microseconds), moderate frequency immobilisation (800 Hz, 300 peak volts, a constant current of 1.7 amps, pulse width 150 microseconds) applied for 5-7secs, low voltage electronic bleed (15 Hz, 550 peak volts,

constant current of 0.8 amps, pulse width 500 microseconds) applied for 20 seconds and post dressing medium voltage electrical stimulation (MVS) with a constant current 1.0 amp and pulse width of 2500 microseconds, but variable frequency across the 6 electrodes (the frequency for electrodes 1 & 2 was set at 25 Hz, 3 & 4 at 15 Hz and 5 & 6 at 10 Hz, with 300 peak volts) applied for 30-35 seconds. All carcasses were trimmed according to AUS-MEAT specifications [4] weighed hot (HCW) and the depth of tissue at the GR site (the depth of muscle and fat tissue from the surface of the carcase to the lateral surface of the twelfth rib 110-mm from the midline) was measured using a GR knife (GR). At 24 h *post-mortem*, the M. *longissimus lumborum* (LL) was removed (Product identification number HAM 4910 [4]) from the right side loin, between the 6th lumbar vertebrae and the 12$^{th}$ rib. Measures of subcutaneous fat depth (Fat C) and muscle depth and width (EMD and EMW; LL) were taken at the 12$^{th}$ rib by experienced personnel using a metal ruler and these values multiplied by 0.008 to give a cross sectional area estimate (EMA) as applied previously [5]. The cut surface of the LL was bloomed at ambient temperature for 30-40 min and the meat colour measured using a Minolta Chroma meter (Model CR-400) set on the CIE *L**, *a**, *b** system (whereby *L** measures relative lightness, *a** relative redness and *b** relative yellowness), with D65 illuminant and 10° standard observer. The chromameter was calibrated with a white tile (Y = 92.8, x = 0.3160, y = 03323). Three replicate measurements were taken at different positions upon the measured surface with the average value used for analysis. The boned LL section was transported (at 4°C) in a portable chiller to the Centre for Red Meat and Sheep Development. All LL were sliced into three equal samples vacuum packaged and assigned randomly to ageing periods of 5, 12 and 40 days, so that each LL was represented in each period and the ageing occurred under refrigeration (1.6°C average). Following their prescribed ageing period, a cutting guide was used to section the LL samples to a uniform 3 cm thickness with the myofibres on the measurement surface perpendicular to the chroma meter [6]. These sections were then individually placed on black foam trays and overwrapped with PVC food film wrap (15 µm) and permitted to bloom for 45 min before colorimetric analysis. Colorimetric measurements were taken over four display time intervals (0, 24, 48, 72 h) between which all samples were displayed under simulated retail lighting (851 lux average) and refrigeration (1.6°C average). A HunterLab colorimeter (Miniscan Model 45/0-L: Reston, VA, USA) with a 25 mm aperture was calibrated (X = 80.4, Y = 85.3, Z = 91.5). This was set to illuminant D65 and viewing angle 10°. The instrument was calibrated on a black glass then a white enamel tile following the manufacturer's specifications. At each reading the measurement was replicated after rotating the spectrophotometer 90° in the horizontal plane. The oxy/met ratio was estimated by dividing the captured light reflectance at wavelength 630 nm, by the percentage of light reflectance at wavelength 580 nm. The SM (Product identification number HAM 5073 [4]) was weighed prior to vacuum packaging and held (1.6°C average) for 40 days then removed from the bag and patted dry and reweighed to determine purge loss. A sample from the medial section of the SM (mean 72 g) was removed and frozen at -22°C. These samples were cooked from frozen for 35 min in plastic bags at 71°C in a water bath to determine shear force [7]. These samples were weighed prior to and after cooking to determine cooking loss (CL). The traits were analysed by analyses of variance with replicate blocked and fixed effects for forage treatment and gender, using GENSTAT [8], and the means were compared by the least significant difference (LSD) at the 5% level. For carcase traits HCW was used as a covariate.

## III. RESULTS AND DISCUSSION

The results for the carcase traits are given in Table 1. There were minimal treatment effects, however lambs fed Chicory + Arrowleaf clover or Lucerne had a higher deposition of fat in the carcase ($P < 0.05$), but were not different from the lambs fed the forage brassica. Lambs fed on Chicory + Arrowleaf clover or Lucerne had the lowest LL pH values at 24 hours suggesting that they had higher glycogen reserves pre-slaughter a direct reflection of these having the fattest carcases.

Table 1. Predicted means for carcase traits of White Dorper lambs feed different forages.

| Traits | Treatment | | | | | |
|---|---|---|---|---|---|---|
| | Bladder | Brassica | Chic / Arrow[1] | Luc / Phal[2] | Lucerne | LSD values |
| Hot carcase weight - HCW (kg) | 21.6 | 23.5 | 24.6 | 21.7 | 24.6 | 3.23 |
| Dressing percentage - DP (%) | 49.0 | 43.0 | 51.1 | 46.6 | 36.7 | 14.67 |
| Fat measure – GR (mm) | 8.8a | 11.8bc | 13.5c | 10.0ab | 13.6c | 2.98 |
| Subcutaneous fat - FatC (mm) | 2.4 | 3.5 | 3.5 | 2.7 | 3.9 | 1.23 |
| Eye muscle area - EMA ($cm^2$) | 17.7 | 17.3 | 17.8 | 16.8 | 17.8 | 0.85 |
| Eye muscle depth - EMD (mm) | 33.6 | 33.0 | 35.1 | 31.7 | 33.9 | 1.38 |
| Eye muscle width - EMW (mm) | 65.7 | 65.5 | 63.3 | 65.6 | 65.7 | 1.39 |
| pH 24 hour - LL | 5.63a | 5.62a | 5.57b | 5.63a | 5.59b | 0.03 |

Means followed by different letters in rows differ ($P < 0.05$) based on an LSD. [1]Chic/Arrow - Chicory + Arrowleaf clover and [2]Luc/Phal - Lucerne + Phalaris.

There was no effect of feeding type on shear force or cooking loss of the SM (Table 2), but there was an effect on purge loss ($P < 0.05$), such that lambs fed forage brassica or Lucerne lost less purge during ageing.

Differences in lightness ($L^*$) of the LL between treatments disappeared when pH was used as a covariate. Khliji et al [2] studying the acceptability of consumers for fresh meat and for displayed meat related with objectively measured parameters of colour, reported that the when $L^*$ value is equal to or exceeds 34 the consumers consider meat colour acceptable. On this basis the fresh meat was on average acceptable from each treatment group.

Table 2. Predicted means for purge, shear force and cooking loss for the *semimembranosus* (SM) and colour traits (L* lightness, a* redness, b* yellowness and brownness (ratio 630/580) of *longissimus lumborum* muscle from White Dorper lambs feed on different forages.

| Traits | Treatment | | | | | |
|---|---|---|---|---|---|---|
| | Bladder | Brassica | Chic/Arrow[1] | Luc/Phal[2] | Lucerne | LSD values |
| Purge loss – PL (%) - SM | 8.0a | 5.8b | 6.7ab | 8.1a | 5.8b | 1.91 |
| Shear force – (N) - SM | 34.6 | 36.1 | 34.1 | 36.1 | 37.3 | 3.34 |
| Cooking Loss - CL (%) –SM | 20.6 | 20.4 | 21.1 | 21.5 | 21.2 | 1.08 |
| $L^*$ fresh colour | 37.9ab | 37.2a | 38.8b | 38.1ab | 38.5b | 1.07 |
| $L^*$ fresh colour[†] | 38.0 | 37.2 | 38.6 | 38.2 | 38.5 | 1.14 |
| $a^*$ fresh colour[†] | 15.5 | 15.9 | 15.7 | 15.9 | 15.2 | 0.89 |
| $b^*$ fresh colour[†] | 1.1ab | 1.2ab | 1.5ab | 1.5a | 1.1b | 0.42 |
| L* day4 5 day aged | 36.2a | 36.5a | 39.2b | 37.5a | 37.7ab | 1.56 |
| L* day4 12 day aged | 35.1a | 35.3a | 38.3c | 36.1ab | 36.6b | 1.27 |
| L* day4 40 day aged | 39.1a | 39.3a | 42.2b | 40.3a | 40.6a | 1.57 |
| a* day4 5 day aged | 16.5 | 17.8 | 16.9 | 16.5 | 17.2 | 1.17 |
| a* day4 12 day aged | 18.2 | 19.8 | 17.9 | 18.2 | 17.9 | 1.42 |
| a* day4 40 day aged | 13.9 | 14.9 | 13.9 | 14.9 | 13.7 | 1.39 |
| Ratio630/580 day4 5 day aged | 3.3a | 3.8b | 3.5ab | 3.3a | 3.6ab | 0.38 |
| Ratio630/580 day4 12 day aged | 4.3a | 4.8b | 4.1a | 4.3a | 4.1a | 0.54 |
| Ratio630/580 day4 40 day aged | 2.6 | 2.9 | 2.6 | 2.8 | 2.5 | 0.34 |

Means followed by different letters in rows differ ($P < 0.05$) based on an LSD. [1]Chic/Arrow - Chicory + Arrowleaf clover and [2]Luc/Phal - Lucerne + Phalaris. [†]Adjusted for pH.

The $L^*$ and $a^*$ fresh colour were not significantly different when 24 hour pH was added as a covariate. Only $b^*$ values were different between treatments with the highest values for Chicory + Arrowleaf clover or Lucerne + Phalaris fed lambs, but since $b^*$ values are not considered important by consumers [2] these differences are of no practical consequence.

For lamb meat under simulated retail display there was a treatment difference for L* values with Chicory + Arrowleaf clover fed lambs having the highest values (lightest) irrespective of ageing period prior to display. By contrast there was no effect on a* values whether measured fresh or after display for any of the ageing times studied. Previous research [3] reported no effect on a* values when lambs were fed on Brassica (forage rape) compared to lambs grazed on irrigated perennial grass/clover pasture. In the current study, a* values were higher than those reported previously [9]. For all ageing times, these authors reported that the red intensity values decreased over the ageing period,

whereas in our study, a* values were observed to increase from measurement in fresh meat to 12 days of ageing and then decreased after 40 days of ageing.

The ratio values (R630/580) were higher for forage brassica fed lambs after ageing for 5 and 12 days, but by 40 days of ageing there were no treatment differences. Additionally the absolute ratio values were much lower after the long ageing a result supported by others [10, 11] and indicative of meat that would be visually unacceptable to consumers [2]. This is an important finding in itself, because it has implications for product long aged on route to overseas markets.

## IV. CONCLUSION

White Dorper lambs fed Chicory + Arrowleaf clover or Lucerne produced fatter carcases than those fed Bladder clover or Lucerne + Phalaris. The lambs fed on Chicory + Arrowleaf clover or Lucerne also produced loin meat with the lowest pH as well as meat from the former group having higher luminosity values.

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## REFERENCES

1. Howes, N. L. Bekhit, A. A., Burritt, D.J. & Campbell, A.W. (2015). Opportunities and implications of pasture-based lamb fattening to enhance the long-chain fatty acid composition in meat. Comprehensive Reviews in Food Science and Food Safety 14:22-36.
2. 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.
3. Hopkins, D.L., Beattie, A.S. & Pirlot, K.L. (1995). The meat quality, carcass fatness and growth of short scrotum lambs grazing either forage rape or irrigated perennial pasture. Australian Journal of Experimental Agriculture 35:453-459.
4. Anonymous (2005) *Handbook of Australian Meat* (7th ed.) Brisbane, Australia: AUS-MEAT Limited. ISBN 0957879369.
5. Hopkins, D. L., Gilbert, K. D., Pirlot, K. L. & Roberts, A. H. K. (1992). Elliottdale and crossbred lambs: growth rate, wool production, fat depth, saleable meat yield, carcass composition and muscle content of selected cuts. Australian Journal of Experimental Agriculture 32:429-434.
6. Holman, B. W. B., Alvarenga, T. I. R. C., Van de Ven, R. J. & Hopkins, D. L. (2014). Influence of myofibril orientation on lamb colour measurement and colour stability. In Proceedings 60th International Congress of Meat Science and Technology, (Paper 87, pp. 1-4), 17-22 August 2014, Punta Del Este, Uruguay.
7. Hopkins, D. L., Toohey, E. S., Warner, R. D., Kerr, M. J. & van de Ven, R. (2010). Measuring the shear force of lamb meat cooked from frozen samples: a comparison of 2 laboratories. Animal Production Science 50:382-385.
8. GENSTAT (2014). Release 16.1. Clarendon Press. Oxford. VSN International.
9. Luciano, G., Monahan, F. J., Vasta, V. Pennisi, P., Bella, M. & Priolo, A. (2009). Lipid and colour stability of meat from lambs fed fresh herbage or concentrate. Meat Science 82:193-199.
10. Hopkins, D. L., Lamb, T. A., Kerr, M. J., van de Ven, R. J. & Ponnampalam, E. N. (2013). Examination of the effect of ageing and temperature at rigor on colour stability of lamb meat. Meat Science 95:311-316.
11. Holman, B.W.B., Ponnampalam, E.N., van de Ven, R.J., Kerr, M.G. & Hopkins, D.L. (2015). Lamb meat colour values (Hunter Lab CIE and reflectance) are influenced by aperture size. Meat Science 100:202-208.