EFFECT OF CHILLED STORAGE (UP TO 8 WEEKS) ON LAMB MEAT QUALITY TRAITS

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Abstract – This study evaluated the effects of chilled storage on lamb meat quality traits. Sixty *m. longissimus lumborum* (LL) muscles were randomly selected from the boning room of a commercial abattoir and assigned to one of five chilled storage durations (n = 12; 0, 2, 4, 6 or 8 weeks). At the completion of each chilled storage duration, samples were measured for shear force (SF), water loss and water activity. Samples were kept under simulated retail display conditions and colour stability measured (0, 1, 2 and 3 days) post chilled storage. SF (*P* = 0.05) decreased following 2 weeks chilled storage. Water activity (*P* = 0.05) and colour measures (redness) a* (*P* = 0.029) and (yellowness) b* (*P* = 0.026) increased with chilled storage duration. The colour traits a* (*P* = 0.039) and wavelength ratio R630/580 (*P* < 0.001) decreased under simulated retail display longer than 1 day. No other effects were observed (*P* > 0.05). These results demonstrate that chilled storage duration influences lamb meat quality traits.

Key Words – Chilled storage, Colour stability, Shear force, Water activity, Water losses.

I. INTRODUCTION

Consumers of lamb meat prioritise sensory quality and this can be categorised into the following sensorial characteristics: 1) tenderness (ease of mastication); 2) juiciness (fluid release upon mastication); 3) flavour (taste and aroma sense combination); and 4) colour (visual appeal), which if unacceptable will result in discounted prices [1]. Previous studies have indicated that chilled storage duration will affect these sensory quality traits [1, 2, 3]. One study found that lamb could be chilled for up to 12 weeks without significant sensory quality deterioration [4].

Despite these findings, there is a need to determine chilled storage duration thresholds for lamb to ensure tenderness (SF), water losses, water activity and colour stability are not compromised by chilled storage. This study aimed to determine such thresholds.

II. MATERIALS AND METHODS

At 24 h *post-mortem*, 60 lamb LL muscles were randomly sampled from the boning room of a commercial Australian abattoir. All LL were weighed, vacuum packaged and randomly allocated to five chilled storage duration treatments of 0, 2, 4, 6 and 8 weeks (*n* = 12), boxed then stored as per normal industry practice in chilled storage (1.0°C).

Following their prescribed storage duration, each LL was weighed for purge loss as per Honikel [5] and then sub-sampled for other analyses. Shear force (SF) sub-samples were prepared and analysed [6], as was water activity (a_w) [7]. Colour sub-samples were individually placed on black foam trays, overwrapped with PVC film and permitted to bloom in a chiller under simulated retail display conditions (mean 895 lux, 3-4°C) for 3 days, with CIE colorimetrics: L* (lightness), a* (redness), b* (yellowness) and R630/580 (wavelength ratio at 630 and 580 nm) measured using a calibrated HunterLab colorimeter (aperture size 25 mm, illuminant D65, 10° standard observer) [8] on days 0, 1, 2 and 3.

Data traits were analysed separately using linear mixed model (LMM) methods fitted using the *asreml* statistical package in R [9]. For cook loss and SF, chilled storage duration (2, 4, 6 and 8 weeks) was included as a fixed effect plus a separate effect for zero weeks

chilled storage. For purge loss, zero weeks storage was omitted, while for a_w, the model included random batch effects and batch water temperature as a covariate. For CIE colour traits (L*, a*, b* and R630/580), each model had linear regressions on chilled storage duration and display duration jointly plus separate effects for each zero. Random effects were separate for each chilled storage duration, display duration, chilled storage duration x display duration and random error. The level of significance of this study was set at $P < 0.05$.

III. RESULTS AND DISCUSSION

Chilled storage duration reduced SF (Table 1) in the first 2 weeks ($P < 0.05$), with no significant change thereafter, but the estimated trend ($P = 0.06$) is a declining SF with increasing chilled storage duration (0.27 N, SE 0.92 per 2 weeks). Prior studies have reported that 80% tenderisation occurs after 7.7 days [2], and that lamb SF only decreases significantly in the first 7 days of chilled storage [10]. At all chilled storage durations excluding time zero (Table 1), the mean SF was well within the upper limit of 49 N suggested previously [11].

Chilled storage duration did not affect purge or cooking losses ($P > 0.05$; Table 1), although an increasing trend was found for purge losses ($P = 0.06$). Results were comparable with previous studies on purge [3] and cook losses [11]. The latter study found water losses to be a weak predictor of sensory juiciness.

Chilled storage duration significantly influenced a_w ($P = 0.05$), values increasing with chilled storage after 2 weeks to reach a level similar to fresh meat (0 weeks aged) between 6 and 8 weeks of storage (Table 1). These values show that meat stored chilled for 2 to 4 weeks exhibits optimal preservation and reduced susceptibility to microbial proliferation as the a_w level was below 0.94 [13]. Increased a_w with an increased chilled storage duration occurs due to moisture release from within meat to the surface of the meat [14], preventing surface drying and rendering the product more susceptible to proliferation from bacteria such as Enterobacteriaceae and *Brocothrix thermospacta* [13].

Unlike L*, the traits a*, b* and R630/580 were altered with display and/or chilled storage duration over the respective ranges observed. However, these changes were not straightforward. Figure 1 illustrates the observed and predicted trends for average a* and shows that when the chilled storage duration and display duration are equal to or greater than 2 weeks and 1 day, respectively, a* declines due to chilled storage duration ($P = 0.03$) and display duration ($P < 0.001$).

The deviation from this linear trend at 0 weeks chilled storage duration and 0 days display duration is negative (Figure 1; $P < 0.001$). These deviations decrease with increased display duration at 0 weeks chilled storage ($P = 0.03$) and with increased chilled storage durations at 0 days display duration (Figure 1; $P < 0.001$). The a* value is a measure of redness, and therefore the basis for these observations is thought to be a delay in myoglobin oxidation. Myoglobin oxidises from deoxymyoglobin (purplish in colour) to oxymyoglobin which is responsible for the redness [1]. Past research has reported this reaction to be influenced by chilled storage conditions and bloom time following exposure to oxygen [14].

For b*, when display duration is equal to or greater than 1 day, it declines as both chilled storage duration and display duration increase, although these trends are not significant ($P > 0.05$). The deviation from this linear trend at 0 weeks chilled storage duration and 0 days display duration is negative, but progressively less negative as chilled storage duration increases ($P = 0.01$). Likewise, R630/580 declined with increased chilled storage duration and display duration when chilled storage duration was equal to or greater than 2 weeks and display duration 1 day or more. Interestingly, this decline was only significant over display duration ($P < 0.001$) which reflects a previous study [1] that also reported increased LL brownness (measured as R630/580) over display duration. This again is suggested to result from the oxidation of oxymyoglobin to metmyoglobin which infers the discolouration or browning to red meat as concentrations increase [1, 14]. The deviation from the linear trend at 0 weeks chilled storage was negative ($P < 0.001$), and as for b* it also became less negative as chilled storage

duration increased ($P < 0.001$). This could have applications in managing lamb LL colour, given an upper limit of consumer acceptability of 6.3 with 95% confidence for R630/580 [1].

Control lamb (0 weeks) exhibited colour most similar to meat stored chilled for 8 weeks and displayed under simulated retail conditions, which was similar to lamb LL stored chilled for 9 weeks in another study [15].

In this study, all lamb LL were stored chilled under vacuum packaging, which restricts the exposure of meat to oxygen and therefore prevents oxidation of lipids and myoglobin, reducing storage effects on flavour and colour, respectively. Vacuum packaging may have provided a reason for a lack of significant effect of chilled storage on R630/580 (myoglobin oxidation) without retail display.

IV. CONCLUSIONS

Within the scope of the study, it can be concluded that the optimal chilled storage duration for lamb meat based upon standard instrumental measures of quality and consumer-mediated thresholds is between 2 to 4 weeks. Chilled storage for 6 or more weeks results in a potential increased susceptibility to food safety concerns as well as consumer rejection due to more rapid meat colour deterioration, while storage beyond 2 weeks failed to improve instrumental tenderness further.

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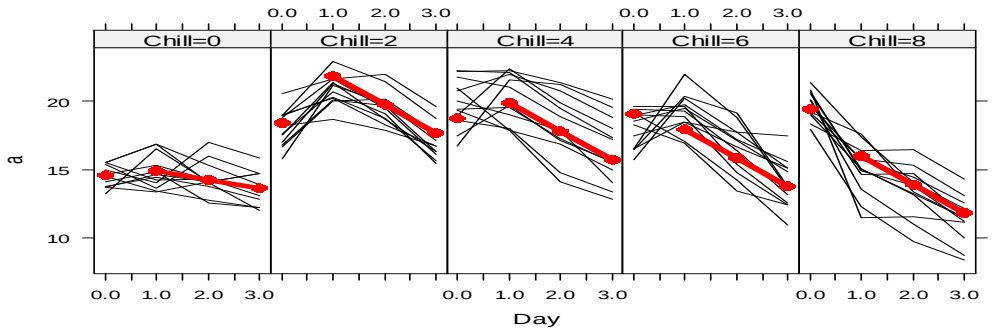

Figure 1 –CIE a* values at different display durations (0 to 3 days) for lamb LL stored chilled up to 8 weeks.

Table 1. Mean (± SE) values for meat quality attributes subjected to chilled storage

Age (w)	SF (N)	Purge Loss (%)	Cook Loss (%)	a_w
0	63.6 ± 4.09^{a}	-	25.3 ± 0.77	0.958 ± 0.008^{cd}
2	38.2 ± 3.42^{b}	2.4 ± 0.74	25.3 ± 0.64	0.909 ± 0.006^{a}
4	37.6 ± 2.24^{b}	4.0 ± 0.49	25.4 ± 0.42	0.929 ± 0.004^{b}
6	37.1 ± 2.24^{b}	5.6 ± 0.49	25.5 ± 0.42	0.944 ± 0.004^{c}
8	36.6 ± 3.42^{b}	7.2 ± 0.74	25.5 ± 0.64	0.961 ± 0.006^{d}

SE: standard error; SF: shear force; $^{a-d}$: different letters in the same column represent significant differences according to chilled storage duration ($P < 0.05$).

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