THE EFFECT OF LONG-TERM CHILLED AGEING DURATION ON LAMB MEAT WATER ACTIVITY

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Abstract – This study aimed to investigate the effect of long-term ageing duration on lamb m. *longissimus lumborum* (LL) water activity (a_w), and evaluate the relationship between a_w and moisture content (%). A total of 25 LL were sampled and equally represented in 3 ageing durations (5, 12 and 40 d) during which samples were kept refrigerated (1.6°C average)**. These were then each measured for a_w. Moisture content was also measured. Analysis using a linear mixed model demonstrated that ageing duration influenced LL a_w ($P < 0.001$) with the highest a_w found after 12 d of ageing, compared with other ageing periods. Moisture content was found to have no relationship with a_w when analysed using a simple linear regression model. These findings highlight the influence of ageing duration on the lamb a_w.**

Keywords: Water availability, spoilage potential, ageing duration, lamb

I. INTRODUCTION

Practicality dictates that lamb meat cannot be processed without some degree (albeit often non-hazardous and minor) of microbial contamination. This can have significant implications upon lamb meat susceptibility to microbial facilitated spoilage. Microbial spoilage, with regards to meat, is definable as the degradation of product quality and safety which is prompted by microbial factors to such an extent that consumer determined acceptability thresholds are breached [1]. Hence, the prevalence of microbial contamination of lamb meat can impose severe economic disadvantages on stakeholders within the lamb meat production, processing and retailing systems [1].

There already exists much effort focused towards limiting microbial spoilage in lamb meat, many of which exploit conditions which inhibit the proliferation of key spoilage microbes [1]. Packaging and storage temperatures, humidity and atmospheric composition, for example, are extrinsic means of preservation whereas, physical characteristics of meat, such as pH, redox potential and water availability, are intrinsic factors influencing microbial proliferation and a products capacity for spoilage [2, 3]. It is water availability which is the focus of this study.

Water availability can be measured objectively as water activity (a_w). This is a measure of the ratio between a sample (meat tissue) vapour pressure (or relative humidity) and its immediate environment. In essence, this provides insight into the amount of free water that is not bound within molecular structures within a sample, which is therefore available to support microbial proliferation. Previous research has reported the ideal a_w range of the proliferation of several key spoilage microbes [4, 5]. However, there remains paucity in scientific literature regarding the effect of long-term ageing on aw values for lamb meat. Investigating this knowledge gap is the aim of this study and also to identify any relationship with moisture content (%) that represents an industry norm.

II. MATERIALS AND METHODS

From 25 randomly selected lamb carcases (carcase) that were slaughtered as a single group at a commercial abattoir, a single m.

longissimus lumborum (LL) was removed at 24 h *post-mortem*. Each LL was immediately sectioned into three equal subsamples and randomly allocated ageing periods (5, 12, 40 d) while recording its site within the original LL (location). Ageing was permitted under refrigeration (1.6°C average) for all prescribed periods (duration), after which each sample was measured for aw.

Water activity was measured using a HygroPalm23-AW (HC2-AW) handheld probe (ROTRONIC Instruments Corp. N.Y., U.S.A.) with a 14 mm deep sample cup. Each LL subsample from each ageing period was measured. This entailed removing approximately 1 g of tissue which contained no visible connective or fat tissue, mincing this and placing this into the probe sample cup which was capped with the probe. Each a_w value was recorded once it stabilised. Samples were measured in duplicate (replicate).

Moisture content was measured for each LL analysed for aw, however using subsamples removed at only 24 h *post-mortem* – that is without the same ageing duration as aw. This was measured by recording each subsample of ~20 g fresh weight with visible external fat removed (fresh wt) before being freeze-dried at -50 °C using a ScanVac CoolSafe™ (LaboGene ApS., Lynge, Demark) until the weight stabilised and was then recorded (freeze-dried wt). Moisture content was then determined as a percentage using the following equation:

Moisture content (%) = (fresh wt – freeze-dried wt) / fresh wt x 100

Using the GENSTAT statistics package [6], aw data were analysed using the following linear mixed model:

aw = constant + duration + ***carcase*** + ***location*** + ***replicate***

Factors presented in bold italics were fitted as random effects, and the others as fixed effects.

This same statistics packaged [6] was used with moisture content (response variate) and aw (fitted term) data included in a simple linear regression analysis. In both these analyses, the level of significance was set at $P < 0.05$.

III. RESULTS AND DISCUSSION

Ageing period was shown to influence lamb meat a_w values ($P < 0.001$), within the constraints of this study. Figure 1 illustrates that aw values were highest after

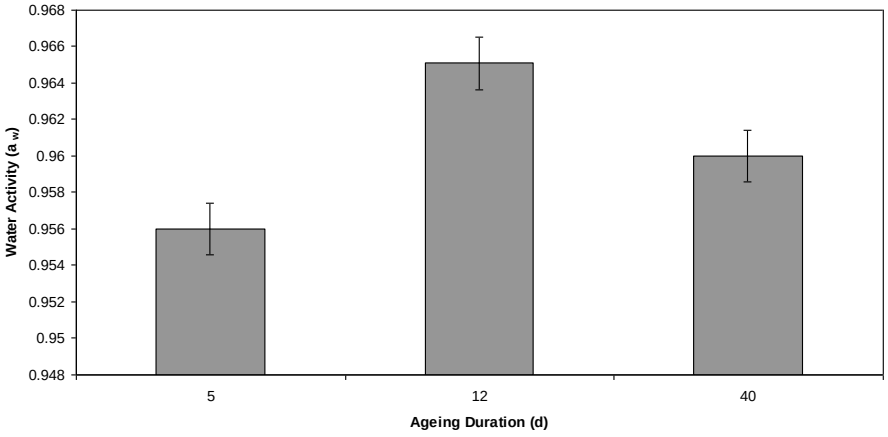

Figure 1. Mean water activity (a_w) from aged (5, 12, 40 d) lamb m. *longissimus lumborum*. Standard error difference between means is shown as error bars.

12 days of ageing, whereas 5 d ageing resulted in the lowest aw values.

Fresh meat has been previously reported as having a_w values of approximately 0.990 [7], which is higher than the results observed in this study. These lower levels are still, however, within the ideal ranges for several hazardous (to either safety or spoilage) microbial contaminants. For example, *Listeria monocytogenes* is inhibited when a_w is below 0.92, *Staphylococcus aureus* when a_w is below 0.87 and *Enterobacteriaceae* sp. when aw is below 0.94 [5]. Therefore, ageing duration does not alter aw sufficiently to restrict all microbial contaminant proliferation.

Ageing duration has already been associated with increases in purge and drip loss for lamb and other red meats [8]. This indicates that ageing will reduce the water content of an aged meat product, an effect that should be evident with a_w measurements. However, the samples analysed in this study were aged while vacuum packaged, which has been reported to protect against desiccation and therefore promote water retention within a product [3]. This influence could further be promoted by the observed increase in a_w when 5 d ageing was compared to other ageing durations, as molecular 'trapped' water that is released by protein degradation arising from the ageing process is kept as free water. However, this comparison is complicated by the observed absence of a significant relationship between moisture content and aw.

This study found moisture content (%) did not affect a_w ($P = 0.090$); only accounting for 3.9 % ± 0.854 (standard error) of variation. This is thought to be based upon moisture content being measured from each sample prior to ageing duration (at 24 h *post-mortem*) and therefore still susceptible to shifts in water availability prior to the initial a_w measurement. To better understand this relationship, additional complementary research which investigates the relationship between a_w and other measures of moisture availability, such as drip, thaw and purge loss, and water holding capacity, is advisable.

CONCLUSION

This study demonstrated that long-term ageing (including 40 d) duration does influence lamb LL a_w values, and moisture content has no significant relationship with a_w values.

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REFERENCES

1. Borch, E., Kant-Muermans, M. L., & Blixt, Y. (1996). Bacterial spoilage of meat and cured meat products. International Journal of Food Microbiology 33:103-120.
2. Vermeiren, L., Devlieghere, F., Van Beest, M., De Kruijf, N., & Debevere, J. (1999). Developments in the active packaging of foods. Trends in Food Science and Technology 10:77-86.
3. Quintavalla, S. & Vicini, L. (2002). Antimicrobial food packaging in meat industry. Meat Science 62:373-380.
4. Boylston, T., Chen, F., Coggins, P., Hydlig, G., McKee, L. H., Kerth, C., & Nollet, L. M. L. (2012). Handbook of meat, poultry and seafood quality. John Wiley & Sons:
5. Mills, J., Donnison, A., & Brightwell, G. (2014). Factors affecting microbial spoilage and shelf-life of chilled vacuum-packed lamb transported to distant markets: A review. Meat Science 98:71-80.
6. Genstat (2014). Release for 16.1. VSN International: Clarendon Press Oxford.

7. Hill, M. J. (1996). Nitrates and nitrites in food and water. CRC Press:
8. Pearce, K. L., Rosenvold, K., Andersen, H. J., & Hopkins, D. L. (2011). Water distribution and mobility in meat during the conversion of muscle to meat and ageing and the impacts on fresh meat quality attributes— A review. Meat Science 89:111-124.