COMPARING CHILLED AND FROZEN STORAGE ON LAMB SENSORY QUALITY PARAMETERS

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Abstract – This study evaluated the effect of chilled and frozen storage, each for eight weeks, on consumer-defined lamb sensory quality traits. Twenty-four *m. longissimus lumborum* (LL) were randomly selected from the boning room of a commercial abattoir and assigned to either chilled (n = 12) or frozen (n = 6 at -12°C and n = 6 at -18°C) storage (with four freezers used, two per frozen storage temperature) for a duration of eight weeks. At the completion of the storage period, LL samples were tested using an untrained consumer sensory panel of 30 participants. Quality traits were examined by the panel (tenderness, juiciness, flavour and overall liking), as well as consumer perception of meat quality. All quality traits were found to be lower for LL that was stored frozen, regardless of temperature, than LL kept under chilled storage (P < 0.01). These results demonstrate a positive effect of chilled storage compared to frozen storage upon lamb LL sensory quality following eight weeks storage duration.

Key Words – Chilling, consumer panel, freezing.

I. INTRODUCTION

Sensory quality, as measured by consumer panels of varied levels of training, is fundamental to determining the effects of chilled and frozen storage on meat. Quality parameters such as tenderness, juiciness, flavour and overall liking, have been tested [1] and shown to be influenced by excessively long storage periods whether chilled [2] or frozen [3]. For example, storage at chilled temperatures (-2 to 7 °C) or even frozen temperatures higher than normally reported (-10 to -5 °C) can promote rancidity or warmed over flavours within 6 weeks storage of vacuum packaged lamb [3]. However, other research has reported no effect on lamb sensory quality from chilled storage up to 12 weeks [2] or from frozen storage up to 15 months [4]. Research has compared chilled and frozen storage; however, these routinely fail to compare comparable storage durations, nor for extended periods such as eight weeks [5, 6]. Furthermore, the effect of frozen storage temperature on sensory quality is often ignored. This study aimed to address these knowledge gaps, comparing chilled- and frozen-stored lamb stored for eight weeks using an untrained sensory panel.

II. MATERIALS AND METHODS

At 24 h *post-mortem*, 24 lamb *m. longissimus lumborum* (LL) were randomly sampled from the boning room of a commercial Australian abattoir. All LL were vacuum packaged and allocated to either chilled storage (n = 12 at 1-4 °C, stored as per normal industry practice) or frozen storage (n = 6 at -12°C and n = 6 at -18°C, kept in one of four freezers, two per storage temperature). At the conclusion of both eight week storage durations, LL were stored in a chiller at 3-4 °C overnight to allow frozen LL to thaw.

Each LL was sliced into 5 slices, and each slice was then halved to form 10 bite-size pieces per sample for testing, with slice and half-slice for each sample recorded. These were grilled to an internal temperature of 71°C and presented to a panel of 30 untrained participants spread across two sessions (15 testers per session, 8 samples per tester), using the protocol outlined previously [1].

Consumers also completed a survey of demographic questions pertaining to their age, smoking status, familiarity with red meat, preferred cooking level of red meat, income,

occupation and household size. All consumers received briefing prior to sensory analysis wherein they were informed of their rights as a participant and of the testing procedure. Unbeknownst to consumers, a blank sample (non-experimental, store bought) was initially provided in effort to familiarise consumers to the testing procedure and therefore limit confounding of traits, known as the halo effect [7]. Consumers ranked each sample using a sliding scale from 0 to 100 for the quality traits of tenderness, juiciness, flavour and overall liking [1]. In addition, quality levels (1-5) were recorded: 1) awful; 2) unsatisfactory; 3) good everyday quality; 4) better than everyday quality; and 5) premium [8].

Data were analysed using a linear mixed model under R [9]. Fixed effects were treatment (chilled storage, frozen storage at -12°C and frozen storage at -18°C), sensory panel session, age, gender, preferred cooking level, household size and frequency of red meat consumption. Uncorrelated random effects included individual sample, slice within sample, tester, freezer (1, 2, 3 or 4) and occupation, as well as random error. The level of significance of this study was set at $P < 0.05$.

III. RESULTS AND DISCUSSION

The untrained consumer panel in this study was able to, on average distinguish key sensory quality differences between chilled and frozen meat. Table 1 summarises the effects of chilled and frozen storage on these traits. When compared with the same storage duration of 8 weeks, frozen-stored meat resulted in significantly lower average scores than chilled meat for all quality traits tested *(P* < 0.01), with particular differences noted for tenderness and juiciness ($P < 0.001$). Frozen storage temperature (-12 and -18 °C) did not affect any sensory parameters ($P > 0.05$), and it can be concluded that storage below -12°C is not necessary for preservation of sensory quality over eight weeks of frozen storage.

The above results differed from a prior study using an untrained consumer panel to compare frozen and unfrozen lamb where no preference for frozen or unfrozen meat was reported [10]. Furthermore, no differences in sensory quality between lamb *m. semimembranosus* frozen for up to 15 months with fresh meat have been reported [4]. In the above studies, the corresponding chilled storage periods for fresh meat were 4 days or less, and this is thought to contribute to their different findings.

Trained sensory panels in prior studies focussed on lamb have also reported different results from those observed in this study – for example, six months frozen storage was not found to affect any sensory parameters in comparison to fresh meat [10]; another study only reported decreases in juiciness following one month frozen storage [11]; while a third study reported increased tenderness following 9 months frozen storage [4]. Underpinning these results is the comparison only between frozen meat and meat kept under chilled storage for 24 hours. Consequently, chilled storage for eight weeks may have improved the sensory characteristics of fresh meat, with the frozen storage preserving these original characteristics. Past research has reported the positive effects of chilled storage duration on sensory quality traits – for example beef sensory quality was found to increase between 2 and 12 weeks chilled storage [12], while lamb tenderness and juiciness increased despite an increase in off-flavour intensity between 1 and 16 days chilled storage [13]. This can be compared with past studies which have found peak lamb tenderness to occur between one and two weeks chilled storage [14].

The trait “quality” was scored, on average, as better for the chilled LL than the frozen-stored counterparts, rated as 3.6 (4: better than everyday quality) and 2.8 (3: good everyday quality), respectively ($P < 0.01$; Table 1). A relationship observed between overall liking (0-100) and quality ranking (1-5) has been reported in a prior study investigating lamb sensory quality traits [8]. That work reported an overall liking score of 56 to be the minimum overall liking score for sufficient sensory quality, and this was related to the satisfaction ranking of 3 (‘good everyday quality’). Using these benchmarks, the average frozen LL from this study (Table 1) fell below the overall liking threshold despite being considered ‘good everyday quality’, while the chilled LL exceeded both thresholds. The potential cause of this divergence could be variations contributed by demographic effects

including culture, gender, age, frequency of red meat consumption and types of red meat consumed [13].

Interestingly, consumer preferences for cooking level affected average juiciness score (P = 0.02), with consumers who reported a preference for "well done" cooking level scoring LL as less juicy. This is a personal preference of panellists and may relate to preferred cooking method, where juiciness scores decrease as internal cooking temperature and heating rate increase [15], the endpoint temperature being standardised in this study. Also, the frequency of red meat consumption affected flavour, with a predicted decrease of 3.7 points for each step decrease in red meat consumption (daily; 4-5 times per week ; 2-3 per week; weekly; fortnightly) (P = 0.04). This likely occurred due to a lack of acceptability for lamb meat in general, which was different to prior results that mentioned older consumers associated with increased lamb consumption would have more chance of negatively scoring frozen lamb meat [13]. In this study, consumer age, gender, occupation and household size did not exert any significant influence on sensory scoring (P > 0.05). This finding is similar to most other lamb sensory studies [4, 10, 16].

The findings from this study suggest that frozen storage can be considered to result in lamb of good everyday quality. Results from prior sensory studies suggest that prolonging the frozen storage duration, even for one year or more, would not significantly influence sensory quality traits compared to meat frozen for shorter durations [3, 4, 10, 11, 13, 16]. Despite the lack of influence from prolonged frozen storage, however, it is clear from these results that chilled storage yielded better sensory quality than frozen meat and may have in fact improved upon the quality of fresh meat as has been noted previously [12, 13, 14].

IV. CONCLUSIONS

Frozen storage of lamb LL was found to result in inferior sensory quality compared to chilled storage. Despite this, the lamb LL was still rated, on average, to be of good everyday quality following eight weeks frozen storage. It can be suggested that the use of prior chilled storage may prove beneficial to the sensory quality of frozen lamb LL. Furthermore, consumer demographics contribute to variations to sensory quality perceptions. This information, therefore, has application in managing lamb LL distribution.

ACKNOWLEDGEMENTS

The authors thank the Australian Meat Processor Corporation (AMPC) and the NSW Department of Primary Industries (NSW DPI) for their support.

Table 1. Mean consumer rankings (± standard error) for lamb *m. longissimus lumborum* sensory quality traits kept for eight weeks under chilled or frozen storage

Treatment	Tenderness (%)	Juiciness (%)	Flavour (%)	Overall Liking (%)	Quality (1-5)
Chilled	66.6 (4.2)***	72.4 (4.8)***	66.3 (2.6)**	67.4 (3.4)**	3.6 (0.2)**
Frozen (-12°C)	37.0 (5.7)	61.1 (5.2)	56.7 (4.6)	48.7 (4.6)	2.7 (0.2)
Frozen (-18°C)	48.4 (5.7)	64.3 (5.2)	59.5 (3.3)	54.6 (4.6)	2.9 (0.2)

Predicted means for juiciness are given for preferred cooking level of "rare". For flavour, means are adjusted at a consumer eating frequency of 2-3 times per week. Levels of significance within columns are denoted as: ** - highly significant (P < 0.01) and *** - very highly significant (P < 0.001).

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