LAMB LOIN TENDERNESS IS ASSOCIATED WITH KILL ORDER

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Abstract – The purpose of this study was to test if associations exist between plasma indicators of acute stress and lamb loin shear force. Blood was collected at exsanguination from 1436 lambs of the Meat and Livestock Australia genetic resource flock and analysed for glucose, lactate and NEFA concentrations. Loin samples were collected and analysed for Warner-Bratzler Shear Force (WBSF). No association was found between plasma indicators and shear force. However, an increase in WBSF was associated with increasing kill order. Further work is required to understand if acute stress is reflected by kill order and what immediate pre-slaughter factors drive this effect.

Key Words – Lamb, shear force, stress

I. INTRODUCTION

Tenderness is a key driver of consumer eating quality of lamb [1]. Currently there is a large amount of variation in lamb loin (*m. longissimus lumborum)* tenderness. Recent work has shown that approximately 40% of lamb loins rated as good every day (3 star) or lower by consumers under the Meat Standards Australia grading system with a significant proportion (7%) rated as unsatisfactory [1].

Previous research in beef has indicated that acute stress prior to slaughter is linked with a reduction in tenderness. This was shown by Warner *et al* [2] who simulated acute stress by subjecting cattle to electric prodders, resulting in decreased consumer tenderness scores for the grilled loin. This treatment was also associated with elevated plasma lactate concentrations, suggesting that plasma indicators of acute stress could potentially indicate reduced tenderness.

The association between acute stress and tenderness has yet to be explored in lamb. Alternatively, plasma indicators of acute stress are well established. Most recently work by Stewart *et al.* [3] showed that lambs have elevated plasma glucose, lactate and NEFA concentrations at slaughter, reflecting adrenergic stress resulting in increased glycogenolysis and lipolysis [4]. Tenderness can be measured objectively by Warner Bratzler Shear Force (WBSF). Therefore, we hypothesised that increasing plasma lactate, glucose and NEFA concentrations at slaughter will be associated with increased WBSF values in lamb loin.

II. MATERIALS AND METHODS

Data was collected from 1,436 lambs (mean age 298 ± 57 days old) from two sites of the Meat and Livestock Australia genetic resource flocks; Katanning (WA, Australia) and Armidale (NSW, Australia). Prior to slaughter, lambs were subjected to approximately 6 hours of feed curfew on farm and then transported for 0.5-2 hours to commercial abattoirs. They were held in lairage overnight, with access to water only, and slaughtered the following morning using electrical stunning and exsanguination.

A. Blood collection and analysis

Following exsanguination, blood was collected into lithium heparin tubes (Vacuette®, Greiner bio-one, Austria). Following collection, tubes were stored on ice and then centrifuged at 3000 rpm for 15 minutes. Plasma was pipetted into two aliquots and stored at -80°C until analysis. Plasma was analysed for lactate, glucose (Beckman Coulter Inc., Brea, USA) and NEFA (WAKO Pure Chemical Industries Ltd, Osaka, Japan) concentrations.

B. Carcass measurements

Carcasses (mean carcass weight 23.5±2.7 kg) were subjected to medium voltage electrical stimulation about 30 minutes post-mortem before being chilled overnight at 3-4ºC. Ultimate pH was measured in the loin at 24 hours post slaughter (ph24LL). Loin samples were then removed from the carcass, vacuum packed, aged for 5 days at 1ºC and then frozen at −20 °C. Frozen samples were defrosted, then cooked to an internal temperature of 71°C and then cooled in running water for 30 minutes. Shear force was measured on 6 replicate samples using a Lloyd texture analyser with a Warner–Bratzler shear blade fitted.

C. *Statistical analysis*

The WBSF was analysed using a linear mixed effects model. Initially a base model was established with fixed effects for site, sex and dam breed within sire type, kill group within site, and birth type-rear type, with sire identification included as a random term. Covariates were then individually included in the base model. These included kill-order, lactate, glucose and NEFA. All models were corrected for pH24LL which had no impact on the significance of any of the fixed or covariate terms.

III. RESULTS AND DISCUSSION

There was no association between WBSF and plasma lactate, glucose or NEFA at slaughter which is contrary to the initial hypothesis. This may suggest that there is no association between acute stress and tenderness, contradicting the earlier study of Warner *et al* [2] in beef cattle. Alternatively, the plasma indicators themselves may be poor indicators of acute stress. For example, plasma lactate concentrations can be elevated due to exercise which causes a contraction-linked increase in the rate of muscle glycogenolysis [5]. This is likely to have occurred immediately pre-slaughter as lambs are moved from the yards to the stunning restrainer. Likewise, feed deprivation can lead to lower plasma glucose concentrations (due to reduced feed intake), and elevated plasma NEFA concentrations due to a glucagon induced increase in the rate of adipose tissue lipolysis [6]. Thus the multiple confounding factors that impact on these metabolites during the pre-slaughter period may have reduced their accuracy as indicators of immediate pre-slaughter stress.

One unexpected finding was the association between WBSF and kill-order. Increasing kill-order from 0 to 300 led to a 19% increase in WBSF (Fig. 1) from 32.3 to 38.7 N ($P < 0.01$, $F = 12.29$). The kill-order term within our model describes the order that lambs were slaughtered within each kill group. Thus, it reflects the duration of exposure to immediate pre-slaughter processes during the lead up to the stunning restrainer, which are likely to cause high levels of stress. Therefore lambs that are killed later within a kill group may have a greater exposure to stress underpinning the link between kill-order, acute stress and the resulting impact on tenderness. This suggests that kill order may more accurately reflect the acute stress response at slaughter in contrast to plasma indicators.

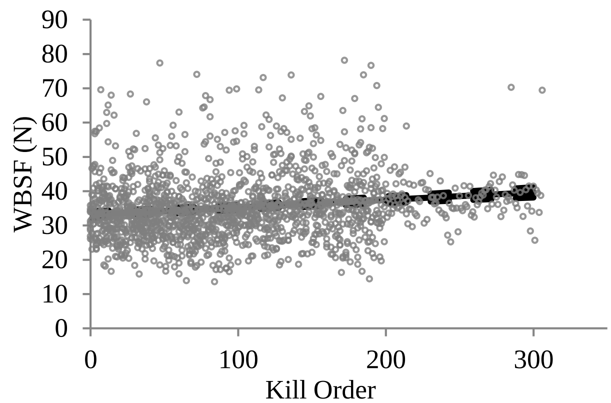

Figure 1. Association between loin Warner Bratzler Shear Force (WBSF) (N) and kill order. Solid line represents the least square means and dashed lines are the standard error ○ denotes residuals from response line.

Importantly, the WBSF values found in this study were higher than 27 N, which is associated with a 10% failure rate for lamb eating quality [7]. Likewise the mean concentrations for plasma lactate and NEFA were above basal levels, while the mean concentration for glucose was normal [8]. However, for all plasma indicators there was a large range in concentrations (Table 1).

Table 1 Mean ± SD, minimum and maximum values for plasma indicators

Variable (units)	Mean	SD	Minimum	Maximum
NEFA (mmol/L)	1.14	0.54	0.17	2.85
Glucose (mmol/L)	4.87	0.92	2.59	10.50
Lactate (mmol/L)	4.13	2.50	0.60	21.22

IV. CONCLUSION

There was no association found between plasma lactate, glucose and NEFA as indicators of stress and lamb loin shear force. However, further work is required to understand the immediate pre-slaughter factors, reflected by kill-order, that are impacting on tenderness as this may provide some insight to improve consumer acceptability of Australian lamb.

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