THE EFFECT OF TIME OFF WATER PRE-SLAUGHTER ON LAMB MEAT QUALITY.

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Background

Livestock can experience dehydration during situations such as transportation, or during the time they are in holding pens at saleyards or at abattoirs. During transport, stock cannot be fed water due to the movement of the vehicle. Regulations state that transported animals must be rested at designated intervals, and have access to water. However access to water does not mean animals will drink. Stressed or hungry animals may elect not to drink during their transport stops or upon arrival at the holding pens. This may be due to differences in salinity, differing "tastes" due to the presence of algal by-products, low or high pH or the presence of heavy metals or hydrocarbons. Furthermore mixing of stock in holding pens can lead to fighting instead of drinking (Mohan Raj et al., 1992). Under hot and dry conditions, sheep without water will lose 5-7% of their body weight daily and adapt by reducing plasma volume and increasing the packed cell volume (Gregory, 1996). Normally when sheep are grazing in summer, an adult animal obtains its water requirements from pasture and in winter, when the moisture content of the grass is high, excess water is excreted in the urine. There is very little known about the effects of dehydration or time off water on meat quality. Preliminary reports from Schaefer et al. (1992) and Gregory (1996) shows that dehydration of cattle and sheep may cause a reduction in the subsequent meat quality including tenderness. Dehydration causes weight loss, and can affect blood glucose, lactate, insulin and liver glycogen concentration (Wythes and Shorthose, 1984). Dehydration is reported to have variable effects on muscle glycogen levels and hence ultimate pH of the muscle.

Objectives

The purpose of this experiment was to assess the effect of time off water pre-slaughter on the quality of the M. *semimembranosus* (SM) and M. *longissimus thoracis et lumborum* (LTL) muscles in lamb.

Methodology

Thirty-six second cross, female, eight month old lambs (Merino x border Leicester ewes and poll Dorset ram) were randomly allocated to one of two treatments within four replicates. For each of four slaughter days, nine animals were taken off pasture at 3 days pre-slaughter and placed into holding yards. The animals were weighed ('initial live weight'), blood sampled for packed cell volume ('initial PCV'), tagged, allocated to treatment within liveweight strata and returned to pasture. At two days pre-slaughter, the animals were placed in three separate pens with three animals per pen. The time off water treatment was applied to the pen as follows; (i) No water involved feed and water being withheld from all of the lambs within the pen for two days pre-slaughter, until slaughter vs (ii) Plus water which involved all lambs within the pen having access to hay until 1 day pre-slaughter and access to water throughout until slaughter. Prior to slaughter, all lambs were weighed to obtain a 'final live weight'. Animals were electrically stunned and then exanguinated and a blood sample collected for measurement of packed cell volume ('final PCV'). Carcasses were dressed conventionally, hot carcass weight and fat depth over the GR site measured at 30 min. post-slaughter and and carcasses were chilled at 2^0C overnight. Muscle samples were removed from the LTL for total glucose determination at 15 min. post-slaughter and the pH and temperature of the LTL and SM muscle was measured at 30 min. and 24 hr post-slaughter. At 24 hrs post-slaughter, the LTL and SM muscles were removed from each side of the carcass and muscles were randomly allocated to 0 or 2 days ageing in a vacuum bag ('1 Day' or '3 Days' post-slaughter). Measurements conducted included Warner Bratzler shear force, water loss during cooking (cooking loss), sarcoplasmic protein solubility and myofibrillar ATPase activity on samples processed fresh (not frozen), expressible exudate from a cut surface ('surface exudate'), total water content, water loss during suspension (drip loss), water loss during ageing (purge) and surface colour (CIE- L*, a*, b*). All methods are described in Warner et al. (1997) except the cooking method for WBSF was 80^oC in a water-bath for 60 min. All data were tested for significance with an analysis of variance (ANOVA).

Results

Tables 1 and 2 present the effects of time off water on the various animal, carcass, muscle and meat quality traits. There were no differences between treatments in live weight or carcass weight parameters or packed cell volume (PCV) measurements ($P>0.05$ for all). The lambs off water for two days tended to have a lower fat depth ($P<0.1$) then lambs with access to water. There were no differences between time off water treatments for temperature or pH measurements at 30 min. or 24 hr post-slaughter slaughter in either muscle ($P>0.05$ for all). Total muscle glucose was not different between treatments ($P>0.05$). The protein solubility of the SM muscle of the lambs with access to water tended to be lower than the lambs with no water at 1 day post-slaughter ($P<0.1$) although the myofibrillar ATPase activity was not different between treatments ($P>0.05$).

For the LTL muscle at 1 and 3 days post-slaughter and for the SM muscle at 1 day post-slaughter, the shear force tended to be lower from lambs in the no water treatment, relative to lambs with access to water ($P<0.1$ for all). The water-holding capacity traits (purge, cooking loss, surface exudate, drip loss, total water content) were not different between treatments ($P>0.05$ for all).

Discussion and conclusion

As there was no effect of time off water on live weight, carcass weight or plasma packed cell volume it is probable that the lambs were not dehydrated. Usually dehydration leads to a decreased blood volume and increased osmolality of the blood, which can be measured by packed cell volume. The only evidence of dehydration is the reduced fat depth for the lambs with no access to water for two days. This reduction in fat depth is unlikely to be due to fat mobilisation but is more likely due to tissue shrinkage in response to a lack of water. But this is not supported by a reduction in total water content of the muscle tissue thus possibly only the fat tissue underwent shrinkage. Certainly sheep are known to be extremely tolerant of water deprivation and they are physiologically adapted to conserve moisture in dry conditions. This fact is supported by an interesting story of a farm in Australia where a paddock mistakenly contained no water source and for a number of years a mob of sheep survived in the paddock. The sheep could be seen licking the moisture off the fencing wire early in the morning. Dehydration causes the release of ACTH from the pituitary gland causing vasoconstriction and potentially interacts with or causes the release of catecholamines, thus causing muscle glycogen depletion (McCance and Heuther, 1994). There was no evidence of an effect of two days off water on muscle glycogen content at slaughter. Gregory (1996) stated that dehydration causes sticky, darker meat but there was no evidence of an effect of time off water on meat colour or ultimate pH in our study. Lambs off water for two days tended to exhibit an increased tenderness, as measured by shear force, in the LTL and SM muscles. As there was no evidence that the lambs were dehydrated,

the mechanism for this increase in tenderness is not clear. The tendency for an increase in tenderness was associated with a higher sarcoplasmic protein solubility for the SM muscle which suggests that time off water pre-slaughter protects against protein denaturation which may explain the trend for tender meat. Alternatively, it is possible that the trend for increased meat tenderness in lambs off water for two days pre-slaughter can be explained by increased proteolysis associated with muscle cell shrinkage as described by Lang et al (1993). In conclusion, in this study, lambs did not appear to become dehydrated by two days off water pre-slaughter and the effects on meat quality were minimal with a tendency for improved tenderness.

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Table 1: Effect of time off water (no water vs water) on animal, carcass and meat quality traits over time post-slaughter (15 min, 30 min, 24 hr).

	No Water	Water	SED
Initial liveweight (kg)	39.7	38.9	1.19
Final liveweight (kg)	36.1	36.8	0.88
Hot carcass weight (kg)	19.1	19.8	0.67
Fat depth (mm)	10.2x	11.6y	0.66
Initial PCV (%)	36.1	37.3	1.56
Final PCV(%)	39.8	39.7	1.31
M. *Longissimus thoracis et lumborum*			
Temp (^{0}C), 30 min	35.5	35.2	0.41
pH, 30 min	6.41	6.43	0.049
pH, 24 hr	5.77	5.74	0.075
Total glucose (mg/g), 15 min	8.37	9.47	1.08
Sarcoplasmic protein solubility (mg/g)	71.0	69.5	1.93
Myofibrillar ATPase activity (umol/min/mg)	0.134	0.139	0.0056
M. *semimembranosus*			
Temp (^{0}C), 30 min	38.7	38.5	0.27
PH, 30 min	6.32	6.29	0.042
PH, 24 hr	5.74	5.71	0.086
Sarcoplasmic protein solubility (mg/g)	71.3x	67.1y	1.94
Myofibrillar ATPase activity (umol/min/mg)	0.115	0.129	0.0089

Table 2: Effect of time off water (no water vs water) on meat quality traits at one and three days post-slaughter (Day 1, Day 3).

	No Water	Water	SED
M. *Longissimus thoracis et lumborum*			
Purge (%)	2.6	2.8	0.59
Cooking Loss (%), Day 1	36.6	37.2	0.69
Cooking Loss (%), Day 3	36.3	37.0	0.85
Surface exudate (mg)	20.4	22.5	2.27
Drip Loss (%)	1.21	1.20	0.263
Total water content (%)	75.2	75.4	0.33
Shear Force (kg), Day 1	6.4x	7.5y	0.55
Shear force (kg), Day 3	4.5x	5.3y	0.35
CIE- L*, Day 1	33.2	32.7	0.70
CIE- a*, Day 1	16.9	16.8	0.60
CIE- b*, Day 1	5.75	5.75	0.356
M. *semimembranosus*			
Purge (%)	1.3	1.7	0.30
Cooking Loss (%), Day 1	33.7	33.7	0.73
Cooking Loss (%), Day 3	34.3	34.7	1.18
Surface exudate (mg)	18.2	18.4	1.66
Total water content (%)	76.8	76.8	0.14
Shear Force (kg), Day 1	7.9x	9.0y	0.47
Shear Force (kg), Day 3	6.6	6.9	0.60
CIE- L*, Day 1	33.8	33.6	0.75
CIE- a*, Day 1	17.8	17.4	0.67
CIE- b*, Day 1	6.28	6.27	0.466

ab, means with different superscripts are different, P>0.05,
xy, means with different superscripts tend to be different, P<0.1.