COLOUR STABILITY AND LIPID OXIDISATION OF ALPACA (*VICUGNA PACOS)* MEAT

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Abstract - Little is understood about alpaca meat quality parameters including colour stability and lipid oxidisation. This study investigated these traits across a total of 50 alpaca carcasses that were evenly sampled from three ages (18, 24 and 36 month) and two genders (female and male). Animals were grazed for four months on coastal pastures of New South Wales, Australia prior to slaughter across two days. Prior to chilling one half of each carcass was electrically stimulated. After 24 hr m. *longissimus thoracis et lumborum* (LL) and the *m. adductor femoris* (AF) were removed and aged for five days prior to colour stability tests simulating retail conditions. Measurements were taken at day 0, 1, 2, and 3 prior to samples being used for lipid oxidization testing. The ratio levels (630nm/580nm) in the LL and AF did not decrease over time, thus no increase in brownness was observed as is commonly seen in other species. L* values were similar throughout the display period. a* values varied across kill day, stimulation and age of animal. There was no effect of age, gender or stimulation on lipid oxidisation of either muscle. Further research is required into the unique properties of alpaca meat in terms of colour and oxidisation.

Key Words – alpaca, colour stability, lipid oxidization, meat quality.

I. INTRODUCTION

Increasing alpaca numbers within Australia has seen the development of an alpaca meat industry [1]. It has been proposed that alpaca meat has unique fresh colour parameters [2] and is lighter in colour than other sources of red meat such as beef and lamb [2]. Meat colour is one of the main factors influencing consumer perception about freshness and quality and influences the purchase of meat products. Meat colour parameters and changes occurring during retail display have been well studied in lamb, beef and pork [3] to optimise colour parameters and reduce the impact of oxidisation and metmyoglobin reactions occurring on the meat surface [3]. These reactions cause a browning of the meat surface during retail display and have been used in the development of consumer acceptability thresholds as consumers perceive the change in colour to be associated with lower quality, unappealing meat products [3, 4]. Processing techniques, including electrical stimulation, have been shown to have minimal effects on colour stability [5].

Lipid oxidisation is also associated with meat deterioration and is affected by the lipid composition of the fat which can in turn lead to changes in meat colour, aroma and flavour [6].

However, there is a paucity of information on alpaca meat production and key meat quality parameters including colour stability and lipid oxidisation. For continued industry growth it is important to understand what potential changes this meat undergoes during retail display to ensure positive acceptance by consumers. Therefore, the aim of this study was to determine the effect of simulated retail display on colour stability and lipid oxidisation in two muscles from alpacas across three different ages and genders.

II. MATERIALS AND METHODS

The data presented in this paper formed part of a larger project and an in-depth account of experimental design and slaughter techniques can be found elsewhere [1]. Briefly, 50 huacaya alpacas evenly distributed across three age groups (14, 20, 32 months) and two genders (females and castrated males) were grazed on coastal summer pastures on the south coast of New South Wales, Australia for four months. The animals were slaughtered in two groups (n =

25/group), two weeks apart. Immediately after exsanguination the animals were immobilised (2000 mA peak current at 500 µs pulse interval and 1000 µs pulse width for 10 seconds). After dressing, each carcass was split in half down the vertebral column using a cattle brisket saw.

Prior to entering the chillers it was intended that the right side of each carcass was electrically stimulated (600 mA peak at 68 ms pulse interval and a 1000 µs pulse width for 40 seconds). This only occurred for animals slaughtered on the first day, as the stimulation unit failed on the second slaughter day preventing stimulation. After chilling (average chiller temperature 4.3˚C and humidity 90.3%) for 24 hours carcase pH and temperature were measured in each carcase half at the caudal end of the m. *longissimus thoracis et lumborum* (LL) over the lumbar-sacral junction. The pH was recorded using a meter with temperature compensation and a polypropylene spear-type gel electrode calibrated at ambient temperature. A cranial section of the m. *longissimus thoracis et lumborum* (LL) and the *m. adductor femoris* (AF) were removed from each carcase side, vacuum sealed and held at 4˚ for four days.

Colour stability samples for the LL and AF were taken at day five of ageing following methods described previously [7]. In brief a 3 cm slice with a fresh surface was cut from both the LL and the AF and placed on black styrofoam trays (one sample per tray) and overwrapped with 15 µm polyvinyl chloride (PVC) film. The samples were allowed to bloom for 40 mins at 4˚C prior to the initial colour measurement being taken and displayed for three days under fluorescent lights set at ~ 1000 lx. Light reflectance was measured on a Hunter Lab Mini Scan ™ XE Plus (Cat. No. 6352, model No. 45/0-L, reading head diameter of 37mm) and calibrated with a white enamel tile and black glass. The light source was set at "D65" with the 10˚ standard observer. Each reading was conducted at the same time across the four time points (day 0, 1, 2, and 3) with each measurement replicated after rotating the spectrophotometer 90˚ for each sample. Measurements for L*, a*, b* (where L* measures lightness, a* measures redness, b* measures yellowness), chroma, hue and oxy/met ratio were taken. A proxy for the oxy/met ratio was calculated by the percentage of light reflectance at wavelength 630 nm divided by the percentage of light reflectance at wavelength 580 nm.

After retail display a 25 g sample of the LL and AF were retained, and frozen at - 20˚C for later determination of lipid oxidisation. This was measured using the thiobarbituric acid reactive substances (TBARS) procedure described previously [7] and expressed in mg of malondialdehyde (MDA) per kg of muscle. In brief 1 gram sample of thawed meat was suspended in 5 ml saline prior to being analysed with the OXltek TBAR assay kit. Sample concentrations of MDA were determined through the supernatant being read on a spectrophotometer at 540 nm.

The colour stability data was analysed for each muscle and trait (L*, a*, b*, chroma, hue and ratio) separately using linear mixed models (LMM) analysis. The model for each muscle by trait included the fixed terms: level of stimulation (Stimulation versus Control); slaughter day effect (Kill Day 2 versus Kill Day 1); a linear trend for day of measurement; separate linear trends with day of measurement across levels of stimulation; animal gender; linear animal age (in years); and 24 hour pH. Random effects included deviations associated with day of measurement, stimulation x day of measurement, slaughter day x day of measurement; random regressions on day across samples and correlated random errors within each sample across day of measurement. The above full model was fitted using the package *asreml* [8] under R [9]. This model was then simplified by removing fixed effects not significant at the 0.05 level. The lipid oxidisation data was analysed using LMM with fixed effects of animal age, gender and stimulation, with the random effect of slaughter day and random error. This model was fitted using Genstat 14th edition [10].

III. RESULTS AND DISCUSSION

Interestingly, Measurement day (retail display time) was not significant in either the LL or AF for lightness (L*) or ratio measurements. During LL and AF retail display, L* remained relatively constant across the four day period. Slaughter day two samples had consistent reductions in lightness values in both LL and AF muscles (Table 1 and 2), with stimulated samples having further reductions in the LL (Table 1).

Table 1 Coefficients and standard errors (s.e.) for lightness (L*), redness (a*) and 680/580 ratio of m. *longissimus thoracis et lumborum* (LL) during simulated retail display of alpaca meat.

Trait	Coefficients	s. e.	P – Value
LL – L*:			
Intercept	41.25	0.59	
Slaughter day	-3.00	0.72	< 0.001
Stimulation	-1.52	0.27	< 0.001
LL – a*:			
Intercept	15.13	1.58	
Stimulation (Day 0)	0.26	0.20	> 0.05
Measurement Day (Control samples)	1.26	0.84	> 0.05
Measurement Day (Increase in rate for Stim samples)	0.26	0.10	0.043
LL – Ratio:			
Intercept	4.22	0.18	
Slaughter day	0.67	0.24	0.016
Stimulation	0.32	0.05	< 0.001

For LL samples, there was a significant trend across Measurement day (retail display time) in average difference for a* between Stimulated and Control samples, with the difference (Stim – Ctrl) increasing by 0.26 (± 0.10) units for each extra day of display. The difference at Day 0 was not significant. For neither Controls nor Stimulated samples were the average linear trends with Measurement day significantly different to zero. (Aside: an alternative analysis, not reported here, which allowed for separate fixed Day effects, indictates that the a* values at Day 0 were significantly less than those at Days 1, 2 and 3 for both Stimulated and Control samples.) The results in this current study are different to previous literature in lamb showing that a* values decrease over time [6]. This difference may be due to species differences.

Table 2 Coefficients and standard errors (s.e.) for lightness (L*), redness (a*) and 680/580 ratio of *m. adductor femoris* (AF) during simulated retail display of alpaca meat.

Trait	Coefficients	s. e.	P - Value
AF – L*:			
Intercept	36.85	0.61	
Slaughter day	-3.59	0.84	< 0.001
AF – a*:			
Intercept	16.21	1.45	
Age	1.43	0.48	0.005
Stimulation	-0.84	0.36	0.031
pH – 5.5	-7.38	2.22	0.002
AF – Ratio:			
Intercept	3.38	0.53	
Age	0.75	0.21	< 0.001
Slaughter day	1.22	0.35	0.002

Animal age impacted on AF a* values such that a* values increased by 1.43 (± 0.48) for each year's increase in age. This is to be expected as myoglobin content in the muscle increases with age resulting in older animals having darker/ redder coloured meat [3]. In addition, a* values in the AF had the opposite reaction to the LL muscle and decreased with stimulation. These differences between muscles could be attributed to differences in muscle fibre composition. pH also had a negative effect in the AF such that a* decreased by -7.38 (± 2.22) units for a unit increase in pH (Table 2).

The oxy/met ratio 630/580 on Slaughter day two was consistently higher in both LL and AF. The ratio increased with animal age, in the AF as expected [11]. In addition, the LL stimulated samples had higher ratio values (Table 1). Interestingly, ratio levels in both the LL and AF were consistent throughout retail display which is quite unique as ratio levels generally decline with increasing retail display in other species indicating oxidation of myoglobin [3]. This finding may be unique to alpacas and favourable for retail packaging of alpaca meat as it will lead to reduced wastage during retail display. Further investigation into the reason for this is required.

There were no effects of age or gender on lipid oxidisation of the LL or AF muscles ($P < 0.001$; Table 3). The AF had higher levels (2.15) of lipid oxidisation compared to the loin (1.58; Table 3).

However, both fall within acceptable ranges previous reported on red meat [7, 12].

Table 3: Lipid oxidisation (TBARs method) predicted means and standard error (s.e.) of m. *longissimus thoracis et lumborum* (LL) and *m. adductor femoris* (AF) muscles from alpaca meat.

Muscle	Predicted Mean (MDA/kg meat)	s.e.
LL	1.58	0.07
AF	2.15	0.11

It should be noted that only one time point at the end of stimulated retail display was examined and the levels observed suggest that some lipid oxidisation may have occurred prior to this observation. In future it is recommended that two time points be used for reference pre- and post- retail display to determine levels of lipid oxidisation and degradation of alpaca meat.

IV. CONCLUSION

Alpaca meat has unique colour stability properties that make it favourable for retail display. Day of retail display only impacted on a* values of the LL, with a* values at day 0 being significantly less then day 1, 2 and 3 of retail display, unlike other species. Stimulation increased redness (a* values) in the LL and decreased redness in the AF muscle compared to control samples. Meat colour redness increased with age, as expected in the AF muscle. Interestingly, the oxy/met ratio did not change during retail display unlike other species, indicating favourable packaging benefits of alpaca meat. There was no effect of age or gender on lipid oxidisation in the LL and AF muscles of alpaca meat.

ACKNOWLEDGEMENTS

This project was funded by RIRDC and Illawarra Prime Alpaca. The authors of this paper would like to thank Dr. Evelyn Hall from the University of Sydney for her statistical assistance, NSW DPI technical staff (Matthew Kerr, Tracy Lamb and Kristy Bailes) for their assistance; the staff of the cooperating abattoir and butchery and Chris Mudford (StimTech, QLD, Australia) for the supply of the immobilisation and stimulation equipment.

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