EFFECT OF ELECTRICAL STIMULATION AND AGEING PERIOD ON ALPACA (*vicugna pacos*) MEAT TENDERNESS

Melanie A. Smith[1*], Russell D. Bush[1], Remy J. van de Ven[2], David L. Hopkins[3]

[1]The University of Sydney, Faculty of Veterinary Science, 425 Werombi Road, Camden, N.S.W., 2570
[2]NSW Department of Primary Industries, Orange Agricultural Institute, Forest Road, Orange, N.S.W., 2800
[3]NSW Department of Primary Industries, Centre for Red Meat and Sheep Development, PO Box 129, Cowra N.S.W., 2794
[*]melanie.smith@sydney.edu.au

Abstract – This study aimed to determine the effect of commonly used processing techniques, electrical stimulation and ageing, on alpaca meat. Fifty huacaya alpacas, evenly distributed across three ages (14, 20, 32 months) and two genders (females and castrated males) were studied. During dressing the carcasses were split in half, with the right hand side of the carcass electrically stimulated prior to the carcass entering the chillers. Carcass pH and temperature decline were recorded. After 24 hours samples from the *m. longissimus* and *m. semimembranosus* were taken, vacuum packed and aged for either 5 or 10 days, before shear force evaluation. Electrical stimulation significantly reduced *m. longissimus* shear force values by 21.6 ± 2.2 N overall and there was a further 6.6 ± 1.5 N reduction with ageing for an additional 5 days. Shear force of the *m. semimembranosus* was reduced by 5.6 ± 2.7 N due to stimulation, but increased by 5.7 ± 1.6 N for each yearly increase in animal age. It is recommended to incorporate electrical stimulation and ageing for 10 days as part of standard alpaca carcass processing to improve tenderness and overall product quality.

I. INTRODUCTION

Continued growth in the Australian alpaca herd has encouraged the development of an alpaca meat industry to provide a viable economic alternative for animals not suited to fibre production. However there is very limited information available for processors and meat producers on alpaca meat quality [1, 2].

Meat processing equipment, such as electrical stimulators, are commonly incorporated into processing plants to help improve meat quality traits such as tenderness in sheep and beef carcasses [3]. It has been well documented that electrical stimulation causes an increase in the rate of post-mortem glycolysis and prevents excessive muscle shortening during rigor in common livestock species [3]. Alpacas produce very lean carcasses with minimal fat cover [2] which makes them susceptible to cold shortening during processing. Hence, the application of electrical stimulation during processing could reduce the risk of cold shortening and have potentially favorable flow on effects to meat quality [3, 4, 5]. However, there is limited information on the effects of electrical stimulation on alpaca meat quality.

Similarly, the ageing effects and improvement in tenderness has been well documented in common livestock species [6]. One Peruvian study investigated the effect of ageing alpaca and llama meat for two and seven days. They reported lower shear force values in alpacas (59.5 ± 6.0 N) than llamas (64.3 ± 7.2 N) at two days and further reductions in shear force values at seven days for both alpacas (40.7 ± 2.3 N) and llamas (46.9 ± 3.5 N) aged meat products [7]. However, the study only looked at the effects on 25 month old entire male animals.

It has been well documented in common livestock species that shear force values increase with animal age [6]. In commercial production it is important to balance quality attributes like tenderness with quantity attributes i.e. increased yield, to obtain maximum production. However, to the best of our knowledge there is no published literature that investigates the shear force values across different age groups and between genders of alpacas.

Hence, the aims of this study were to investigate the effects of electrical stimulation on alpaca meat and determine the benefits of ageing alpaca meat from 18, 24 and 36 month old, females and castrated males. This information will assist alpaca producers and processors to enhance product tenderness and consumer acceptability.

II. MATERIALS AND METHODS

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) to prevent excess kicking during carcass dressing. Once dressed, the neck was removed at the junction of the 5th and 6th cervical vertebrae, then tagged and weighed, prior to the carcass being 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. Once the carcasses entered the chillers, carcass pH and temperature decline were measured in both carcass halves at the caudal end of the m. *longissimus thoracis et lumborum* (LL) over the lumbar- sacral junction and at the caudal end of the *m. semitendinosus* (ST) muscle. The pH was recorded using meters with temperature compensation and a polypropylene spear-type gel electrode calibrated at ambient temperature. Measurements were taken at hourly intervals from approximately 35˚C through to 18˚C and then again at 24 hours.

After chilling (average chiller temperature 4.3˚C and humidity 90.3%) for 24 hours the LL and *m. semimembranosus* (SM) were removed from each carcass side as well as the subcutaneous fat (average boning room temperature 5.0˚C and humidity 90.5%). Two blocks (64.9 ± 6.1 g) were removed from the 12/13th rib region of each LL, vacuum packed, chilled at 4˚C and aged respectively for 5 and 10 days (age duration alternated between cranial and medial position). For the SM, one block (66.4 ± 2.4 g) was removed and aged for 10 days. Following prescribed ageing, samples were frozen and later shear force (SF) was measured as described previously [8].

SM and LL shear force results were analysed separately as univariate and bivariate linear mixed models respectively. The models included ageing period, gender, animal age and stimulation as fixed effects and kill day, cook batch and cook date as random effects. The bivariate model for LL samples also included random animal effects. Temperature and pH declines for LL and ST muscles were modelled using a linear mixed model regression, including stimulation, gender and animal age as fixed effect terms and kill day as a random effect. The models were fitted using the package *asreml* [9] under R [10].

III. RESULTS AND DISCUSSION

In ST muscle, the pH declined significantly faster immediately after slaughter ($P < 0.01$) for the electrically stimulated carcass halves, such that at 36˚C stimulated carcass halves had on average a pH value equal to 6.69 ± 0.04 compared to non-stimulated halves with an average pH of 6.83 ± 0.04. This lower pH for stimulated halves continued until carcass halves reached approximately 12˚C when pH values from both stimulated and non-stimulated were statistically equivalent ($P > 0.05$) with a pH of 6.32 ± 0.03. The pH levels for ST muscle were also similar at 24 hours for both stimulated and non-stimulated carcass halves, with the average pH then equal to 5.98 ± 0.03. The average pH at 24 hours for LL muscle was 5.83 ± 0.02 which was significantly less ($P < 0.05$) than for the ST muscle. These results are consistent with previous reports on 24 hour pH results for alpacas [3].

This difference in pH decline is to be expected as electrical stimulation has been found to increase the rate of post-mortem glycolysis, resulting in an accumulation of lactic acid and subsequently leading to a quicker initial decline in pH as previously observed [6]. There were no differences ($P > 0.05$) in the pH decline of the LL between electrically stimulated and non-stimulated carcass halves. This finding was unexpected as previous studies conducted on lamb show significant difference in initial pH values of stimulated (pH 6.3 ± 0.0) and non-stimulated (pH 6.8 ± 0.0) LL [5]. There was no statistically significant animal age or gender effect ($P > 0.05$).

Electrical stimulation reduced shear force values ($P < 0.001$) of the LL by 21.6 ± 2.2 N overall and there was a 6.6 ± 1.5 N ($P < 0.001$) reduction with an additional 5 days ageing. There was no animal age or gender effect ($P > 0.05$) on the shear force of the LL. The predicted means for the four combinations are given in Table 1. Electrical stimulation has been found to reduce the susceptibility of cold induced shortening by speeding up the rate of post-mortem glycolysis [6]. Cold induced shortening results in increased shear force values due to shortening of the muscle fibres prior to the carcass entering rigour [6].

Table 1. Effect of stimulation and ageing period on the shear force (Newtons) of alpaca *longissimus* (LL) muscle.

Ageing period (d)	Stimulation	Mean ± s.e.	LSD rank
5	Yes	61.1 ± 2.4	d
5	No	82.7 ± 1.9	a
10	Yes	54.5 ± 2.6	c
10	No	76.1 ± 2.1	b

Different letters in the LSD column indicate significant differences ($P < 0.05$)

The average shear force value observed from the non-stimulated LL samples at five days (82.7 ± 1.9 N) was higher than previous Peruvian studies, two of which reported shear force values for two day aged samples of 45.8 ± 0.8 N [3] and 59.4 ± 6.0 N [7]. The difference between these findings could be due to multiple factors including the average age of the animals and the high susceptibility of cold induced shortening occurring in lean alpaca carcasses.

In addition to electrical stimulation, further reductions in shear force values were obtained through ageing the LL an additional 5 days. These findings support previous studies conducted in Peru where ageing meat samples for seven days significantly improved two day shear force values from 59.4 ± 6.0 N to 40.7 ± 2.3 N [7].

There was a reduction in the shear force of the SM by 5.6 ± 2.7 N ($P < 0.05$) due to stimulation and also an effect of animal age such that shear force increased by 5.7 ± 1.6 N ($P < 0.001$) for each yearly increase in animal age. The gender difference was not significant ($P > 0.05$). Predicted means for control and stimulated samples at age 18, 24 and 36 months are given in Table 2.

Table 2. Effect of electrical stimulation (ES) on shear force (Newtons) of *m. semimembranosus* muscle from 18, 24 and 36 month old alpacas after 10 days of ageing.

Stimulation	Age (months)	Mean ± s.e.	LSD rank
No	18	46.7 ± 2.6	bc
No	24	52.1 ± 1.8	d
No	36	57.5 ± 2.5	e
Yes	18	40.8 ± 3.0	a
Yes	24	46.2 ± 2.4	b
Yes	36	51.6 ± 2.9	cd

Different letters in the LSD column indicate significant differences ($P < 0.05$)

This increase in shear force with age has been well documented in other livestock species [6]. It is primarily due to the biochemical maturing of collagen, which results in increased strength and rigidity of connective tissue in the muscle as the animal gets older [6]. Hence, this information will be important to producers and processors who are aiming to optimize the balance between younger, tenderer animals and increased carcass yields generated by generally older animals.

This study presents the first information on shear force values of hind leg muscles of alpacas and shows that in younger animals the levels are

more likely to be acceptable for the retailing of high quality meat.

IV. CONCLUSION

Electrical stimulation of alpaca carcasses is recommended at processing as it significantly improves meat tenderness and reduces the incidence of lean alpaca carcasses experiencing cold induced shortening. Furthermore, ageing alpaca meat for up to 10 days is recommended to further improve tenderness. These recommendations are designed to improve product quality and increase consumer acceptability by improving tenderness.

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