BEEF SARCOMERE LENGTH AFTER APPLYING TWO "IDEAL" SLAUGHTER PROCEDURES

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Abstract – Two "ideal" post-slaughter treatments namely, ES (short high voltage electrical stimulation, 20 sec, 400 V peak, 5ms pulses at 15 pulses/sec) followed by chilling within 1 hour at 4°C and NS (no electrical stimulation with step-wise chilling, six hours at 10°C followed by chilling at 4°C) were tested on steers consisting of Bos indicus (Brahman), Sanga type (Nguni), British Bos taurus (Angus), European Bos taurus (Charolais) and the composite (Bonsmara), 10 animals per genotype, n=50. Both treatments resulted in sarcomere lengths of larger than 1.9 µm – therefore no negative muscle contraction effects. Nevertheless significant differences (P < 0.001) were found for sarcomere length and carcass characteristics such as warm and cold carcass mass, percentage mass loss, eye muscle area, pH and temperature decline profiles. Breed effects were minimal.

Key Words – Short high voltage electrical stimulation, step-wise chilling, sarcomere length.

I. INTRODUCTION

The control of post-slaughter conditions such as electrical stimulation and temperature is very critical to achieve relaxed muscle meat and the resulting optimal tenderness. For instance it is found that minimal shortening of muscle occurs at muscle temperatures of 14 – 19°C [1]. The risk of chilling carcasses too fast or too slow and over stimulating with electrical stimulation is high. This paper describes how sarcomere length can be helpful in indicating if optimal post-slaughter procedures were applied. Two "optimal" post-slaughter treatments were applied to 50 steers from five different genotypes with the aim of achieving an ideal sarcomere length.

II. MATERIALS AND METHODS

The five genotypes studied were Brahman, Nguni, Angus, Charolais and the composite Bonsmara. Ten steers per genotype were purchased (n=50). The animals were fed on a feedlot diet for a period of between 90-110 days. All animals were slaughtered, processed and sampled at the abattoir of the Agricultural Research Council, Irene, Gauteng, South Africa. The carcasses were halved and the right sides were electrically stimulated for 20sec (400 V peak, 5ms pulses at 15 pulses/sec) and chilled in the cold rooms (± 4°C) within 60 min after killing (**ES treatment)**. The left sides were placed in a room with a controlled temperature of 10°C for 6 hours, after which they were placed in the cold rooms at ± 4°C (**NS treatment)**. Warm and cold carcass masses were recorded. Carcasses were classified according to the official South African classification standards for age and fatness (visual appraisal).

pH and temperature of the M. longissimus lumborum (LL) was recorded at 1, 3, 6, and 21h *post mortem* at the last lumbar vertebra of the left and right sides of the carcass with a digital handheld meat pH meter. The *M. longissimus lumborum* (LL) of both carcass sides were sampled between the third last rib and last lumbar vertebra on the day after slaughter. Samples for sarcomere length were collected near the area where pH and temperature measurements were measured. Sarcomere lengths (SL) of fresh LL samples (24 h *post mortem*), were prepared [1; 2] by using distilled water instead of Ringer–Locke solution [3]. Fifty sarcomeres per sample were measured by means of VIA, using an Olympus B340 system microscope at a 31000 magnification equipped with a CC12 video camera (Olympus, Tokyo, Japan). AnalySIS Life Science software package (Soft Imageing Systems Gmbh, Münster, Germany) was used to process and quantify measurements.

The data were subjected to one-way ANOVA [4] to determine breed effects, treatment effects and breed x treatment effects. Means for the interactions were separated using Fisher's

protected t-test least significant difference (LSD) at the 5% level of probability [5] Correlation coefficients were determined between sarcomere length and other carcass characteristics.

III. RESULTS AND DISCUSSION

The rate of temperature decline early *post mortem* can initiate two tenderness restricting mechanisms, i.e. cold shortening and a change in proteolytic rates (cold toughening) [6]. The effects of breed and two post- slaughter treatments, ES and NS on beef carcass characteristics are shown in Table 1. Although carcass mass (warm and cold) differed significantly between the breeds, temperature decline did not show a significant breed effect (data not shown). Nguni carcasses tended to have the lowest carcass temperature overall, but the differences were not significant in this study compared to a previous study by Strydom et al. [7]. Due to their small size, Nguni carcasses chill very quickly and are more prone to cold shortening and/or cold toughening (proteolytic delay) [8]. The ES carcasses had a significantly higher chilling rate than that of the NS treated carcasses that shows the effect of ES and NS post-slaughter treatments on temperature and pH decline profiles of the breeds (Figure 1). The pH/temperature decline rate differed significantly ($p < 0.001$) between ES and NS treated carcasses, but only showed some differences as a result of breed at pH 3 h ($P = 0.035$) and 6 h ($P = 0.105$) and only within the NS treated carcasses (Figure 2).

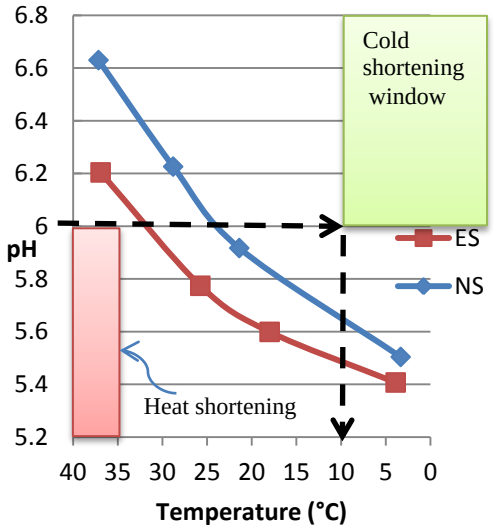

Figure 1. Effect of ES and NS post-slaughter treatments on temperature and pH decline profiles of the five breeds tested.

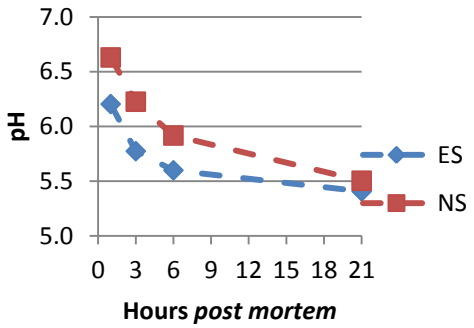

Figure 2. Effect of short electrical stimulation and stepwise chilling on pH decline. P value = 0.05 and less.

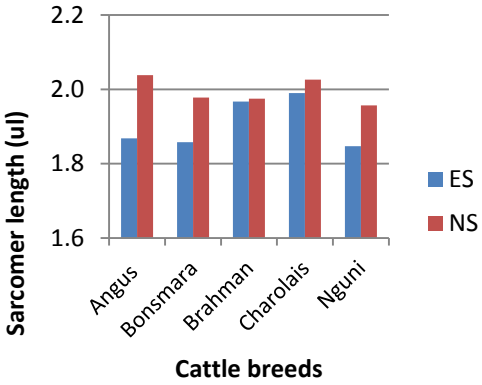

Figure 3. Effect of ES and NS post-slaughter treatments on sarcomere length of LL in the five breeds tested.

Figure 3 shows the effect of ES and NS treatments on SL in Angus, Bonsmara, Brahman, Charolais and Nguni. The SLs of all the breeds slaughtered in this study were exceptionally longer than those measured in recent studies. This could be due to the different chilling temperature and chilling rates of the carcasses (placed directly into chiller after electrical stimulation or , or step-wise chilling for no stimulation.) Overall SLs were longer than 1.8 µm, which is advantageous as it usually leads to a good quality meat and a relaxed myosin-actomyosin interaction. Nonetheless the SLs of ES treated carcasses (1.9 µm) were still significantly shorter than that of the NS treated carcasses (2.00 µm) (Table 2). SLs of this study were similar to a

Table 1. The effects of breed and two post-slaughter treatments, ES and NS, on beef carcass characteristics

	Cattle breeds						
	Angus	Bonsmara	Brahman	Charolais	Nguni	SEM[1]	P-Value
Live animal (kg)							
Carcass side mass (kg)							
Warm average	110.95[c]	107.84[c]	97.65[b]	120.92[d]	85.02[a]	3.146	<0.001
ES (right sides)	110.71	107.63	97.48	120.45	84.89	3.158	
NS (left sides)	111.20	108.05	97.82	121.38	85.14		
Cold average	108.22[c]	105.14[c]	95.16[b]	117.94[d]	82.79[a]	3.078	<0.001
ES (right sides)	107.87	104.94	94.91	117.43	82.58	3.090	
NS (left sides)	108.57	105.35	195.40	118.44	83.00		
% mass loss/carcass side							
Average	2.483[a]	2.492[b]	2.553[b]	2.466[a]	2.615[a]	0.0692	0.010
ES (right sides)	2.598	2.491	2.636	2.507	2.491	0.0895	
NS (left sides)	2.369	2.493	2.470	2.424	2.511		
Eye muscle area							
Average	5543[a]	6499[b]	5702[a]	6932[b]	5366[a]	189.6	<0.001
ES (right sides)	5747	6525	5737	7095	5527	225.3	
NS (left sides)	5338	6473	5668	6768	5206		

[1] Standard error of means

[a,b,c,d] Means within a row with different superscripts differ significantly (P<0.05)

previous study done at ARC-Irene under similar post-slaughter procedures [9], involving the same breeds electrically stimulated and rapidly placed into chilling at 4°C [Strydom et al. [7]. Frylinck et al. [10] reported SLs ranging from 1.71 to 1.77 µm for Brahman-crosses and 1.66 to 1.71 µm for Simmentaler-crosses. On the other hand, the Nguni breed tended to have longer SL under controlled slower chilling conditions (1.83 µm) or when electrically stimulated (1.75 – 1.89 µm).

According to Pearson and Young [11] cold shortening occurs when the muscle pH is greater than 6.0 at a temperature of less than 10°C with ATP still available. In this study the cold shortening phenomena can definitely not be considered, although delayed chilling should benefit tenderization when processing smaller carcasses such as the Nguni. On the other hand care must be taken that the pH does not drop too quickly while the carcass temperature is too high as this causes heat shortening, high protein denaturation and high drip loss. Although care was taken not to over-stimulate, it is apparent from the data in Table 1 and 2 that ES treated carcasses had a higher % mass loss because of drip compared to the NS treated carcasses. As a result of electrical stimulation, commencement of rigor (pH 5.6) occurred within 2 h *post mortem* when muscle temperature was still above 30°C.

The correlations in Table 3 show that carcass size could influence sarcomere lengths under conditions of ES. Also percent mass loss showed some correlation with ES muscle sarcomere length than muscle sarcomere length than that of the NS muscle. It is known that electrically stimulated carcasses have a higher % drip than that of non-stimulated carcasses.

Table 2. The effects of two post-slaughter treatments. ES and NS on beef carcass characteristics and sarcomere length

	Treatment			
	ES	NS	SEM	P-Value
Carcass side mass (kg)				
Warm	104.23[a]	104.72[b]	0.177	0.059
Cold	101.55[a]	102.15[b]	0.171	0.016
% Mass loss	2.590[b]	2.453[a]	0.0359	0.010
Eye muscle area	6126[b]	5891[a]	77.0	0.036
Sarcomere length	1.906[a]	1.995[b]	0.0202	0.003

[1] Standard error of means

[a,b] Means within a row with different superscripts differ significantly (P<0.05)

Table 3. Correlations showing the relationship between sarcomere length and carcass characteristics.

	Sarcomere lengths		
Treatments	All	ES	NS
Carcass mass			
Warm	0.164	**0.243**	0.079
Cold	0.162	**0.234**	0.083
% loss	0.025	**0.286**	-0.212
Eye muscle area	0.218	**0.291**	0.216
Muscle pH			
1 h *post mortem*	0.231	-0.108	0.239
3 h *post mortem*	0.196	-0.098	0.131
6 h *post mortem*	0.186	-0.181	**0.249**
21 h *post mortem*	0.188	-0.079	**0.294**
Muscle temperature			
1 h *post mortem*	0.022	-0.022	0.181
3 h *post mortem*	0.164	0.243	0.097
6 h *post mortem*	**0.314**	0.122	**0.303**
21 h *post mortem*	0.187	0.169	**0.275**

This is also reflected in the results of this project (Table 2). Eye muscle area, which is also a function of carcass size also seems to correlate to some extent with ES muscle sarcomere length. On the other hand it seems as if pH and temperature at 6 hours *post mortem* and ultimate pH and temperature affect sarcomere length of NS muscle samples more than that of ES muscle sarcomere lengths. Temperature of muscle at 6 h *post mortem* correlates best with sarcomere length (R=0.300).

IV. CONCLUSION

Both post-slaughter treatments as defined above as ES and NS can achieve ideal relaxed sarcomere lengths of 1.9 µm and longer. The NS treatment seems to give still more advantageous SL characteristics and other advantages such as a lower % carcass mass loss. The advantages of the higher pH and temperature at early *post mortem* on other tenderness characteristics can at this stage just be speculated. The value of using sarcomere length to predict ideal slaughter procedures and meat tenderness is under estimated.

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