The Effect of Electrical Stimulation, Hanging Method and Ageing Period on the Eating Quality of Grilled Beef

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Abstract –The aim of this study was to investigate the effect of heat shortening conditions on the eating quality of beef in the context of the Meat Standards Australia (MSA) pH/temperature window. The effects of carcase suspension method and ageing period on beef eating quality were investigated. Thirty two Charolais x Limousin cross heifers were assigned to two treatment groups using a split carcase alternate side design. High voltage electrical stimulation (HVES) was applied for 30s to the left hand sides of 16 carcases, the right hand sides of these carcases acting as non-stimulated controls. The left hand sides of the other 16 carcases received 60s of HVES, the right hand sides of these carcases also acting as non-stimulated controls. pH/temperature declines were recorded post slaughter in the striploin muscle of every carcase side. Consumer taste panels were used to assess beef eating quality of striploin and topside cuts aged 7 and 21 days. Heat shortening conditions were achieved with both HVES treatments. Control sides fell mostly within the MSA window. Although the eating quality of seven day aged beef was little affected by the rapid pH temperature decline, there was negligible improvement with subsequent ageing compared to unstimulated beef.

I. INTRODUCTION

The measurement of the rate of decline in muscle pH post-mortem is a feature of the Meat Standards Australia (MSA) grading system for beef [1, 2]. If rigor (at ~ pH 6.0) is achieved at high temperatures (> 35.0 ^{o}C) heat shortening may occur resulting in diminished meat quality and excessive drip. If muscle pH is still above 6.0 at low temperatures (< 12.0 ^{o}C), then cold shortening resulting in meat toughening can occur. Avoiding the risk of heat and cold shortening is the basis of the MSA window whereby processors manipulate their stimulation/chilling regime to ensure carcases enter rigor between 12.0 and 35.0 ^{o}C. Electrical stimulation of carcases accelerates glycolysis, thereby decreasing the risk of cold-shortening [3]. Although many studies report a positive effect of electrical stimulation on beef tenderness, over stimulation of carcases may contribute to heat induced toughness. Tenderness improvement can be achieved by employing various post-mortem treatments including ageing and aitch bone hanging (tenderstretch) [4].

The objective of this study was to determine the effect of electrical stimulation on pH/temperature decline in the context of the MSA window and how this might affect the eating quality of beef subjected to heat shortening conditions. This was tested for three different meat cuts taken from carcase sides hung by the Achilles and Tenderstretch methods and aged for 7 and 21 days.

II. MATERIALS AND METHODS

The 32 animals chosen for this experiment were selected by the abattoir and comprised predominantly of 14 to 28 month old Charolais x Limousin continental crossbred heifers. Animals were not kept in lairage overnight and were clipped before slaughter. After captive bolt stunning and exsanguination, the primary treatments comprised assigning the sides of each carcase to either HVES or no HVES. Two HVES treatments, 800V for either 30s or 60s, were used on the stimulated sides of the two groups of 16 heifers. The right and left sides of the split carcase were then alternatively suspended from the Achilles tendon (AT) or Tenderstretched (TS) before chilling using the plant's normal chilling regime. The pH and temperature of the centre of the *M. longissimus dorsi* (between the 2nd and 5th lumbar vertebrae) of both sides of each carcase were measured on entering the chill room using a calibrated polypropylene spear-type gel electrode (Inonode IJ 44). Subsequent measurements were taken every hour for 5 hours and finally at 24 hours post mortem (ultimate pH). Labelled primal joints were

boned out, vacuum packed, stored under chill conditions for 7 or 21 days, and prepared for sensory analysis by consumer panels. Muscles assessed were the posterior (Post) and anterior (Ant) sections of the striploin (STR) and the topside (TOP). Steaks from each muscle/cut were grilled to a well done state and each sampled by 10 consumers. Consumers scored portions for tenderness (TE), juiciness (JU), flavour liking (FL), and overall liking (OL), by placing a mark on a 100mm line scale [5]. Additionally, they were asked to assign a quality rating to each sample: "unsatisfactory, "satisfactory everyday quality", "better than everyday quality" or "premium quality". A combined score (CMQ4) was obtained for each muscle and position within each muscle using the equation, CMQ4 = 0.4*TE + 0.1*JU + 0.2*FL + 0.3*OL.

III. RESULTS AND DISCUSSION

The mean pH/temperature profiles within the striploins of the carcase sides (Fig.1) show that 60s and 30s HVES electrical stimulation increased the rate of pH fall with respect to temperature and placed all of these carcase sides outside the MSA window and at risk of heat shortening.

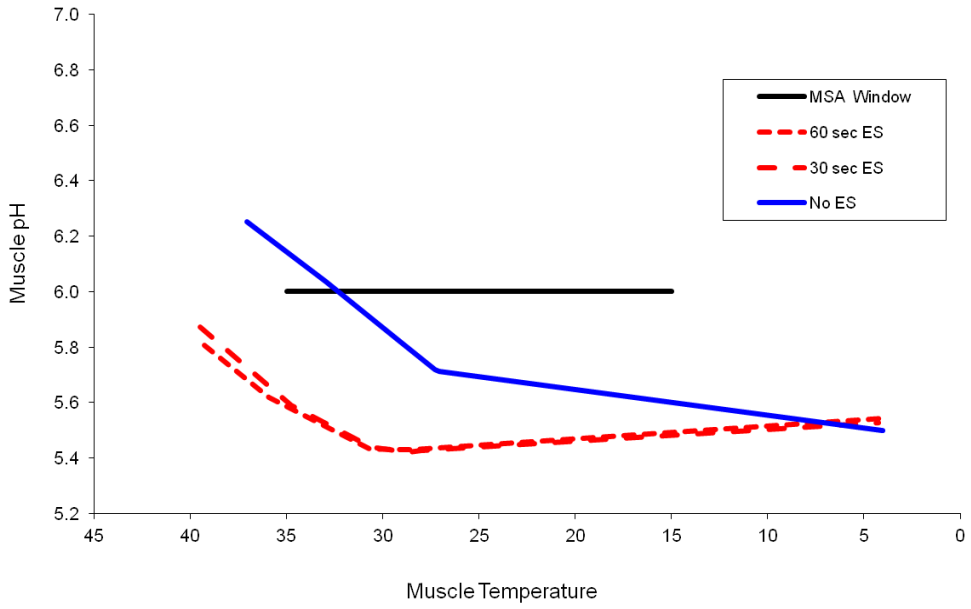

Fig. 1. Mean pH/temperature profiles of alternate carcase sides. 60s and 30s ES and No ES.

Table 1 shows that there were highly significant (P<0.001) differences in all eating quality attributes for muscle type (STR Ant > STR Post > TOP); hanging method (TS > AT) and ageing period (21d > 7d). Less significant differences were found for ES treatments (0s > 30s > 60s) where ES for 30 or 60 seconds significantly and progressively decreased eating quality compared to controls. Interactions (P < 0.05) were found between stimulation and ageing period for tenderness and CMQ4 score. In effect, tenderness and CMQ4 scores for 7 day aged controls were similar to 21 day aged 60s ES beef (Table 2).

Table 1. Effect of cut, hanging method, electrical stimulation and ageing time on consumer evaluation of grilled beef.

Treatment		Tender	Juicy	Flavour	Overall	Satisfaction	CMQ4
Cut	STR Ant	58.8	56.5	57.7	57.9	3.48	58.1
	STR Post	52.2	50.1	53.4	52.8	3.27	52.4
	TOP	33.9	38.4	41.5	39.6	2.83	37.5
	sig	***	***	***	***	***	***
	sed	1.42	1.41	1.26	1.22	1.232	0.44
Hang	AT	44.5	46.4	48.4	47.1	3.10	46.2
	TS	52.1	50.3	53.3	53.1	3.28	52.4
	sig	***	***	***	***	***	***
	sed	1.64	1.40	1.13	1.28	0.443	1.33
ES	0s	51.3	50.9	52.7	52.4	3.27	51.9
	30s	48.1	47.4	50.7	49.8	3.19	49.0
	60s	45.6	46.7	49.3	48.1	3.12	47.1
	sig	**	**	*	*	**	**
	sed	1.77	1.49	1.39	1.54	1.525	0.05
Ageing	7d	44.7	46.0	48.4	47.4	3.09	46.3
	21d	52.0	50.7	53.4	52.8	3.29	52.3
	sig	***	***	***	***	***	***
	sed	0.99	1.01	0.96	0.95	0.036	0.89
Stim1.Aged1		*	ns	ns	ns	ns	*

Table 2. Interactions between electrical stimulation and ageing on consumer evaluation of grilled beef.

Treatment	Tender		Juicy		Flavour		Overall		Satisfaction		CMQ4	
Stim1.Aged1	7d	21d	7d	21d	7d	21d	7d	21d	7d	21d	7d	21d
0s	46.5	56.2	47.4	54.4	49.2	56.2	48.7	56.1	3.11	3.42	47.8	56.0
30s	43.6	52.5	45.1	49.6	48.4	53.0	46.8	52.8	3.09	3.28	45.7	52.3
60s	43.9	47.2	45.3	48.1	47.6	50.9	46.7	49.5	3.07	3.17	45.4	48.7
sig	*		ns		ns		ns		ns		*	
sed	2.05		1.90		1.78		1.86		0.064		1.80	

IV CONCLUSIONS

Although HVES had little effect on eating quality of beef aged for 7 days, HVES had an adverse effect on consumer scores after prolonged ageing. A possible explanation for the adverse effect of HVES electrical stimulation on eating quality is its apparent inhibitory effect on eating quality improvement during ageing compared to the controls. This may be due to partial denaturation of the enzymes involved in proteolysis and ageing due to the rapid pH decline at high temperatures, but further research would be needed to confirm this. The rationale behind the upper limit of the MSA pH / temperature window is therefore justified in that exceeding this is progressively detrimental to the normal improvement of eating quality during ageing.

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