MEAT QUALITY ATTRIBUTES OF BEEF CARCASES SLAUGHTERED USING DTS: DIATHERMIC SYNCOPE®

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Abstract – DTS: Diathermic Syncope®, is a system for inducing insensibility using electromagnetic energy. This study investigates meat quality indicators (pH, Warner-Bratzler shear force, drip loss and colour) at one and ten weeks post slaughter in beef produced from nine cattle slaughtered using DTS, compared with nine cattle slaughtered using captive bolt (control). In general, there was no significant difference between meat from DTS animals and from control animals. There were some slight differences in meat colour within the first week after slaughter, DTS meat being slightly yellower at quartering; and at one week DTS loins being slightly redder and slightly yellower; and DTS rounds being slightly lighter, than control samples. There was also a trend that DTS samples were more tender than control samples. However, these differences were marginal, and in light of the small sample size, should be interpreted with caution. In conclusion, DTS produces comparable meat quality captive bolt stunning. At this stage, based on this pilot study, there are no reasons to halt further development and commercialization of DTS as a stunning method for cattle.

Key Words – slaughter, pH, tenderness.

I. INTRODUCTION

Some communities require that animals processed for human consumption are healthy, uninjured and normal at the moment of carrying out the slaughter cut. As a result, many methods of stunning used in modern commercial slaughter are not acceptable. Preliminary research has shown that electromagnetic energy technology is likely to induce recoverable insensibility in animals and could result in an effective reversible stunning method that may be suitable for religious slaughter [1].

Wagstaff Food Services Pty Ltd and Advanced Microwave technologies have designed a system (trademarked as DTS: Diathermic Syncope®) for delivery of electromagnetic energy to ruminants (PCT/AU2011/000527). Research on anaesthetised sheep [2] and anaesthetised cattle [3] has indicated that the DTS system can induce the required increase in brain temperature to achieve insensibility; and induces electroencephalogram (EEG) patterns incompatible with awareness. To further develop the DTS technology for commercial use, it is important to evaluate its potential impacts on product quality. The current study evaluates the meat quality attributes of the DTS system, as compared with captive bolt stunning, in non-anaesthetized cattle, at one week post slaughter and ten weeks post slaughter.

II. MATERIALS AND METHODS

Eighteen Aberdeen Angus cross bred heifers (350-400 kg) with a quiet temperament were fed and rested in lairage for 4 days prior to the slaughter, cared for by an experienced stockperson and handled using low-stress animal handling techniques. Nine animals received DTS, and nine received captive bolt stun prior to exsanguination. Animals were processed randomly, and the treatments stratified in a pattern of 2 captive bolt; 2 DTS; 2 captive bolt; 2 DTS etc.. The carcase was then dressed according to normal practice, chilled overnight, and de-boned the following day. pH measurements were taken from the carcases at 24 hours post slaughter, prior to de-boning. At de-boning, two samples of loin (*m. longissimus lumborum*) and two of round (*m. semitendinosus*) were removed, vacuum packed and refrigerated.

One sample of each muscle was randomly assigned to a one-week storage treatment; while the other assigned to a 10-week storage treatment. These samples were transported to the laboratory by refrigerated vehicle, within the first week post slaughter, and placed in a cold room set to 0°C ± 2° for storage. At each of 1 and 10 weeks post slaughter, the muscle samples were unpacked, and sectioned into subsamples for colour, pH, shear force and drip loss evaluation.

pH was measured using a WP-80 digital pH meter (TPS instruments, Springwood, QLD), with a combination electrode for temperature compensation, calibrated using pH4 and pH 10 standards immediately before use, after every 18 measurements, and at the end of the session according to the manufacturer's instructions. The probes were inserted at least 10mm into the substance of the muscle from the cross-grain cut surface, and data recorded when the readings had stabilised. Warner-Bratzler (WB) shear force was measured on samples cooked at 70°C for 60 minutes, using a Lloyd Instruments LRX® Materials testing machine fitted with a 500 N load cell (Lloyd Instruments Ltd., Hampshire UK), according to the protocols outlined by Bouton *et al.* [4] and Bouton and Harris [5]. Meat Colour was measured using a MINOLTA CR300® colorimeter under light source D65, calibrated immediately before and after each measurement session using a standard white tile as per the manufacturer's instructions. Drip loss was measured using the method outlined by Honikel *et al.* [6] and Warner *et al.* [7]. Briefly, blocks of muscle were cut to a target weight of approximately 50g, measuring 2-3 cm thick and 3-4 cm across. Each block was weighed to the nearest 0.1g on a laboratory balance (SPE6001, Ohaus Corporation, USA), and suspended using suture material (3.5 metric braided silk, Ethicon Inc, USA) from a frame housed in a cold room set to 4°C ± 2°. After 48 h storage, the muscle blocks were removed from the frame and reweighed. Drip loss was calculated as the percentage reduction in weight over 48 hours.

Data were analysed using R Studio [8]. Data were checked for normality using the Shapiro-Wilkes test; differences between stun treatments were assessed using ANOVA, and considered significant at the $P<0.05$ level.

III. RESULTS AND DISCUSSION

The mean pHu of DTS carcases was 5.68±0.06. This was not significantly different from captive bolt carcases (5.69±0.05). Similarly there were no significant differences in pH between DTS and captive bolt samples of round and loin at week 1 and week 10 post slaughter (Table 1). pHu in both groups was below pH 5.8, indicating that DFD was not induced, and pH values of loin and round at weeks 1 and 10 of storage lay within normal ranges (pH4 – pH 6).

Table 1: pH measurements

Analysis		Captive Bolt	DTS
Ultimate pH 24 h	Mean	5.69	5.68
post slaughter	St Dev	±0.05	±0.06
Week 1 loin pH	Mean	5.50	5.50
	St Dev	±0.03	±0.04
Week 1 round pH	Mean	5.45	5.48
	St Dev	±0.02	±0.02
Week 10 loin pH	Mean	5.51	5.51
	St Dev	±0.03	±0.04
Week 10 round	Mean	5.44	5.48
pH	St Dev	±0.02	±0.03

Shear force in both loin and in round did not differ significantly between stun treatments at either week 1 or week 10 (

). There was a non-significant trend that DTS samples were more tender than control samples, but this trend should be interpreted with caution in light of the small sample size. Shear force values for loins at one week post slaughter in the current study were 4.62 ± 0.34 kg and 4.01 ± 0.45 kg in control and DTS respectively; while at 10 weeks post slaughter these values were 3.45 ± 0.29 kg and 3.28 ± 0.39 respectively. These results lie within normal ranges: Warner *et al.* [9] report values of 7.0 kg at 6 days post slaughter, and 4.8 kg at 21 days post slaughter; Gruber *et al.* [10] report a range of 3.5 to 5.11 kg measured over a range of ageing periods from 3 to 28 days; while Sazili *et al.* [11] report 9.19 ± 0.97 to 9.96 ± 0.72 kg at one week post slaughter. For rounds, the current study measured 5.54 ± 0.25 kg for control and 4.84 ± 0.33 kg for DTS at one week post slaughter, and 5.46 ± 0.26 and 4.71 ± 0.36 kg respectively at week 10. These values again align with previously published ranges, for example 4 – 18 kg [12], 4.12 ± 0.16– 6.63 ± 0.2 kg [13] and 4.6 – 9.5 kg [14].

Table 2: Warner-Bratzler Shear Force measurements at weeks 1 and 10 post slaughter

Analysis		Captive Bolt	DTS
Week 1 loin	Mean	4.62	4.01
Shear Force (kg)	St Dev	±0.34	±0.45
Week 1 round	Mean	5.45	4.84
Shear Force (kg)	St Dev	±0.25	±0.33
Week 10 loin	Mean	3.54	3.28
Shear Force (kg)	St Dev	±0.29	±0.39
Week 10 round	Mean	5.46	4.71
Shear Force (kg)	St Dev	±0.26	±0.36

There were no significant treatment differences in drip loss from either round or loin at week 1 or week 10 of storage (Table 3).

Table 3: Drip loss from meat samples at weeks 1 and 10 post slaughter

Analysis		Captive Bolt	DTS
Week 1 loin	Mean	15.08	16.33
drip lost (%)	St Dev	±0.79	±1.06
Week 1 round	Mean	13.38	12.91
drip lost (%)	St Dev	±0.34	±0.45
Week 10 loin	Mean	21.43	21.95
drip lost (%)	St Dev	±0.80	±1.07
Week 10 round	Mean	19.60	21.00
drip lost (%)	St Dev	±1.00	±1.35

Meat colour measurements are shown in Table 4. DTS meat was slightly yellower at quartering (MINOLTA b* 2.71 ± 0.59 DTS; 1.06 ± 0.44 control); DTS loins were slightly redder (MINOLTA a* 23.22 ± 0.92 DTS; 20.89 ± 0.69 control) and slightly yellower (MINOLTA b* 2.79 ± 0.93 DTS; 0.77 ± 0.70 control); and DTS rounds were slightly lighter (MINOLTA L* 43.32 ± 1.05 DTS; 40.94 ± 0.78 control) at week 1, than control samples ($P<0.05$). These values in turn affected the Hue and Chroma results at these time points; Hue and Chroma being calculated from the MINOLTA a* and b* values. However, these differences were marginal, and the values align with published data on MINOLTA colour attributes of loin (*m. longissimus lumborum*) and round (*m. semitendinosus*) [9, 11, 15]. In light of the small sample size (n=9 in each treatment group), the observed differences should be interpreted with caution.

Table 4: Meat colour measurements

Analysis		Captive Bolt	DTS
MINOLTA L*	Mean	33.45	33.71
at quartering	St Dev	±0.50	±0.67
MINOLTA a*	Mean	23.16	23.74
at quartering	St Dev	±1.39	±1.86
MINOLTA b*	Mean	1.06[a]	2.71[b]
at quartering	St Dev	±0.44	±0.59
Hue at	Mean	0.045[a]	0.11[b]
quartering	St Dev	±0.02	±0.02
Chroma at	Mean	24.10[a]	38.27[b]
quartering	St Dev	±4.38	±5.87
Week 1 loin	Mean	34.73	36.05
MINOLTA L*	St Dev	±0.82	±1.11
Week 1 loin	Mean	20.89[a]	23.22[b]
MINOLTA a*	St Dev	±0.69	±0.92
Week 1 loin	Mean	0.77[a]	2.79[b]
MINOLTA b*	St Dev	±0.70	±0.93
Week 1 loin	Mean	0 03	0.113
Hue	St Dev	±0.03	±0.04
Week 1 loin	Mean	22.51[a]	40.29[b]
Chroma	St Dev	±4.71	±6.31
Week 1 round	Mean	40.94[a]	43.32[b]
MINOLTA L*	St Dev	±0.78	±1.05
Week 1 round	Mean	21.93	22.47
MINOLTA a*	St Dev	±0.49	±0.65
Week 1 round	Mean	4.12	5.25
MINOLTA b*	St Dev	±0.56	±0.75
Week 1 round	Mean	0.19	0.23
Hue	St Dev	±0.02	±0.03
Week 1 round	Mean	48.21	57.08
Chroma	St Dev	±4.56	±6.12
Week 10 loin	Mean	35.14	36.06
MINOLTA L*	St Dev	±0.67	±0.90
Week 10 loin	Mean	22.16	23.14
MINOLTA a*	St Dev	±0.52	±0.69
Week 10 loin	Mean	2.00	2.77
MINOLTA b*	St Dev	±0.33	±0.44
Week 10 loin	Mean	0.09	0.12
Hue	St Dev	±0.01	±1.57
Week 10 loin	Mean	32.59	40.27
Chroma	St Dev	±3.18	±4.26
Week 10	Mean	41.04	42.75
round MINOLTA L*	St Dev	±0.89	±1.19
Week 10	Mean	21.92	22.31
round MINOLTA a*	St Dev	±0.46	±0.61
Week 10	Mean	5.85	6.47
round	St Dev	±0.39	±0.52

MINOLTA b*			
Week 10	Mean	0.26	0.28
round Hue	St Dev	±0.02	±0.02
Week 10	Mean	59.49	64.45
round Chroma	St Dev	±2.90	±3.89

Means across rows with differing superscripts differ significantly ($P<0.05$)

IV. CONCLUSION

The objective of the study was to determine whether DTS would lead to adverse effects on meat quality as compared to conventional stunning. In general, there were no significant differences between meat from DTS animals and meat from control (captive bolt stun) animals. This is in agreement with other authors who have identified little difference in meat quality parameters from cattle processed using different slaughter techniques: electrical stunning, penetrative and non-penetrative mechanical stunning and unstunned slaughter [11, 15].

At this stage, based on this pilot study, there are no reasons to halt further development and commercialization of DTS as a stunning method for cattle.

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