EFFECT OF NEW GENERATION MEDIUM VOLTAGE ELECTRICAL STIMULATION ON THE MEAT QUALITY OF BEEF SLAUGHTERED IN A CHINESE ABATTOIR

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I. INTRODUCTION

Electrical stimulation (ES) is a classical and widely used technology to reduce meat toughness in the red meat industry. However, ES should be used carefully, because some studies have found that early (immediately after stunning) application of stimulation, can result in a very rapid pH decline, and early reduction in µ-calpain level, which negatively affects meat tenderness and other eating quality traits [1]. Some have also reported that stimulated beef carcasses missed the “ideal” pH-temperature window established by Meat Standards Australia (MSA) [2, 3]. Recently, a new generation medium voltage (~300V) stimulation system designed in Australia was examined in the context of beef slaughtered and processed in China after studies revealed a high percentage of beef carcasses miss the MSA window for pH decline [4]. Therefore, the objective of this study was to evaluate the effect of three electrical parameter combinations (current, pulse width, time of application) on the quality of beef *longissimuss lumborum* muscle from cattle slaughtered in a Chinese abattoir compared to muscle from unstimulated carcasses.

II. MATERIALS AND METHODS

Chinese crossbred yellow cattle (22~24 months old) half carcasses were randomly selected on the slaughter line in a local abattoir. The carcasses were subjected to the following stimulation (A: 1A, 1.55ms, 27s, n = 6; B: 0.55A, 1ms, 34s, n = 6; C: 0.55A, 2ms, 20s, n = 6; Control: no stimulation, n = 6), before chiller entry. The pH and temperature of carcasses were measured at 1, 3, 6, 12 and 24h after death. The M*. longissimus lumborum* (LL) were removed at 24h post-mortem, packaged and transferred to the lab (0-4°C), and loins were portioned into 2.54cm thick steaks, vacuum packaged and stored at 2 ± 2°C. Shear force, color, sarcomere length, cooking loss and purge were determined at day 0, 7 and 14 d of aging. The retail color stability was also measured on the following three days after each aging time. Temperature and pH values over the 24h post-mortem period of each carcass were fitted using an exponential model, and the temp@pH6.0 (the temperature when the pH drops to 6.0) was calculated. A mixed model was used to analyze each quality trait using Genstat (19th Edition, VSN International Ltd.), with treatments, aging time and their interaction fitted as fixed effects, and carcass as a random effect. For the color stability traits, the display time and its interaction with aging and/or treatments were also included as fixed factors. Least significant differences (LSD) at the 5% level were used to test the difference between predicted means.

III. RESULTS AND DISCUSSION

There was no significant treatment*aging effect on the meat quality traits except for retail color stability, while either treatment or aging showed a significant (P < 0.05) effect on most of the traits. As shown in Table 1, the temp@pH6.0 of electrically stimulated carcasses was much higher (P < 0.05) than those not-stimulated, ranging from 28.6 to 31.2°C. As expected, there is no significant difference in the ultimate pH among the treatments. Much lower values of shear force were found in stimulated beef steaks, compared with non-stimulated ones. This is consistent with a previous study, where it was shown that the best tenderness was achieved after 14 days of aging from carcasses with a temp@pH6.0 between 29 to 30°C post slaughter [5]. The sarcomere length was not significantly different among treatments, so we conclude that it was not a contributor to the difference in tenderness. The cooking loss of treatment C was higher than the control, and no significant treatment effect was found for purge. ES treatment A (1A, 1.55ms, 27s) resulted in the highest lightness (*L**) (Table 1), which indicates a paler appearance. Aging resulted in a decreased shear force as expected, increased cooking loss and purge as aging time extended, with no effect of aging on sarcomere length, which was independent of the treatment (data not shown). The retail color stability was significantly affected by the interaction between ES treatment and aging (Table 2). Treatments B and C both resulted in an improved redness (a*), yellowness (*b**) and color intensity (Chroma) at 0 and 7 d of aging. Treatment A improved the *b** and Chroma values only at 0 d, and its hue vales were higher than the control and other treatments at day 0 and 7. Treatment C resulted in a higher wavelength ratio 630/580 nm, indicating lower metmyoglobin formation during the early aging time.

However, the benefits of the color improvement caused by all the ES treatments were not obvious as aging time extended to day 14. The ES accelerated the metabolism process during early aging time, which might provide a relatively better reduced environment, facilitating the metmyoglobin reducing activity leading to the color improvement.

Table 1 Effect of stimulation with different electrical parameter combinations on meat quality traits

Quality traits	Control	A	B	C	SE
Temp.@pH=6.0	21.5^{c}	31.2^{a}	28.6^{b}	30.6^{b}	0.88
Shear Force (N)	72.5^{a}	54.3^{b}	58.1^{b}	58.0^{b}	2.03
pHu	5.51^{a}	5.53^{a}	5.52^{a}	5.49^{a}	0.015
Sarcomere length (μm)	1.75^{a}	1.80^{a}	1.80^{a}	1.77^{a}	0.02
Cooking loss (%)	29.5^{b}	30.9^{b}	30.3^{b}	31.6^{a}	0.53
*L**	44.0^{c}	47.8^{a}	44.2^{c}	44.8^{b}	0.37

Means with different superscript letters within the same row differ at $P < 0.05$ (the same as table 2)

Table 2 Effect of stimulation with different electrical parameter combinations*aging on colour traits (under display)

Color traits	0d				7d				14d				SE
	Control	A	B	C	Control	A	B	C	Control	A	B	C	
*a**	21.3^{d}	22.1^{cd}	23.6^{ab}	24.0^{a}	22.8^{bc}	22.7^{bc}	23.9^{a}	24.3^{a}	22.0^{cd}	22.3^{cd}	21.9^{cd}	22.1^{cd}	0.40
*b**	15.6^{d}	16.9^{ab}	17.0^{ab}	17.4^{a}	16.4^{bc}	17.0^{ab}	17.2^{a}	17.4^{a}	16.0^{c}	17.0^{ab}	16.4^{bc}	16.4^{bc}	0.27
Chroma	26.4^{d}	27.8^{c}	29.1^{ab}	29.7^{a}	28.1^{bc}	28.4^{bc}	29.4^{a}	29.9^{a}	27.2^{cd}	28.0^{bc}	27.4^{cd}	27.6^{cd}	0.47
hue	36.2^{c}	37.4^{a}	35.7^{cd}	36.1^{cd}	35.6^{d}	36.8^{b}	35.7^{d}	35.7^{d}	35.9^{cd}	37.3^{ab}	37.0^{ab}	36.8^{b}	0.22
R 630/580	3.74^{cd}	3.63^{de}	3.87^{bc}	4.35^{a}	3.69^{d}	3.47^{ef}	3.77^{cd}	3.96^{b}	3.41^{f}	3.32^{fg}	3.22^{g}	3.35^{fg}	0.07

IV. CONCLUSION

All the electrical stimulation treatments applied in this experiment provided a beef tenderness improvement which was not dependent on the aging time. B and C treatments also resulted in a retail color improvement during the early aging time, while the C resulted in a relatively higher cooking loss. Therefore, treatment B (0.55A, 1ms, 34s) is recommended for use in the current abattoir. Further study by applying ES treatment B on more carcasses (n > 100) to verify the promised tenderness and color improvement is guaranteed would be required to promote its industrial application.

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