EFFECTS OF ELECTRICAL STIMULATION TO LOCALIZED PART OF CARCASSES ON SHEAR FORCE OF HANWOO BEEF

Jieun Yang[1], Dawoon Jeong[1], Touseef Amna[1], Beom-Young Park[2], Soohyun Cho[2] and Inho Hwang[1,*]

[1]*Department of Animal Science, Chonbuk National University, Jeon-ju, Republic of Korea*
[2]*Quality control and utilization of animal products division, National Institute of Animal Science, Suwon 441-706, Republic of Korea*
*inho.hwang@jbnu.ac.kr

Abstract – The aim of the present study was to investigate the effects of an early post mortem low voltage electrical stimulation to localized part of carcasses on Warner-Bratzler (WB) shear force in beef *Longissimus dorsi* (LD) and *Biceps femoris* (BF). A total of twenty Hanwoo steers was slaughtered and immediately were subjected to electrical stimulation using laboratory made-electrical stimulator and electrode probe at 45 volt alternative current (AC) for 60 sec. The left side of carcass was used as control; right side of carcass was used for the treatment. After additional chiller ageing (2, 14 days), the shear values were determined by Instron. In stimulated beef BF the WB shear force during ageing periods have reduced the value about 1.5 kg, 1.2 kg compared to non-stimulated muscles respectively. While for LD electrical stimulation significantly decreased WB shear force during ageing periods about 0.6 kg, 0.2 kg, but decrease effectiveness of tenderness by chiller ageing more remarkable than that of electrical stimulation. Furthermore, the shear values of stimulated BF aged for 2 days less than that of non-stimulated BF aged for 14 days. It can be concluded from the present study that the reduction of shear values via selective electrical stimulation in the part of carcasses has the potential to have ageing periods-saving effects as well as enhance meat tenderness.

I. INTRODUCTION

Meat tenderness is the main concern with meat flavor, juiciness in terms of decision of meat taste [1]. In particular, shear force is an objective instrumental measurement of meat tenderness. Meat with high shear values is considered as an unacceptable meat and an objective measure of tenderness is the shear force using standardized piece of meat; the lower the shear values the more desirable it is [2].

Electrical stimulation accompanies passing an electric current through carcass of slaughtered animals [2]. Cross *et al.* [3] reported that application of electrical stimulation of carcasses after slaughter bring significant effect on the ageing periods saving and the following economic feasibility through improvement of meat tenderness. Numerous researchers have focused on the effect of electrical stimulation on the meat tenderness and quality under various conditions [4]. Polidori *et al.* [5] reported significant effects of an early post mortem low voltage electrical stimulation (28 V) on final tenderness using WB shear force of lamb carcasses. According to Gursansky *et al.* [6], the initial tenderness of LD was enhanced by electrical stimulation with low and high voltage on the carcass of beef and it was found that the electrical stimulated muscles have good tenderness compared to non-stimulated muscles after ageing. It is well known that post-mortem ageing increases meat tenderness [7]. However, the national beef tenderness surveys [8, 9] stated considerable variation in the length of post-mortem ageing periods of beef cuts. However, there is no report about the effects of electrical stimulation to localized part of carcasses as contributor for meat tenderness in Hanwoo beef. In the present study we investigated the effects of early post mortem low voltage electrical stimulation to localized part of Hanwoo beef carcasses LD and BF muscles for meat tenderness using instrumental measurements (WB shear force values).

II. MATERIALS AND METHODS

Animals, procedure of electrical stimulation

A total of twenty Korean native Hanwoo steers was slaughtered using the following procedure: removal of internal organs – skinning – cutting – cleaning. The electrical stimulation was applied at the entering of chilling cooler. To exactly investigate the effect of electrical stimulation, the left side of

the carcass was used as control; right side of carcass was used for the treatment purpose. Briefly, stimulation was applied by using laboratory-made two-multi point electrode probe, which one electrode was inserted at LD muscle and the other into BF muscle (probe was produced for easily earthing until inside of back fat). The condition was 45 volt alternating current for 60 sec and the whole process completion time was within 30 min of slaughter. After grading, muscle samples were stored at 4°C in chilling room for additional ageing (2, 14 days).

Warner-Bratzler (WB) shear force

WB shear force was measured by Instron Universal Testing Machine (Model 3342, Instron Corporation, USA), adapted from the methods of Hwang *et al.* [10]. The levels of WB shear values were determined on the approximately 200 g same sample steak block (2.54 cm thickness) cooked in a pre-heated water bath for 60 min until the core temperature had reached 70°C. The cooked samples were immediately cooled in running water (18°C) for 30 min to reach a core temperature below 30°C. A total of eight cores of 1.25 cm diameter were made for each sample and peak force was determined using a V-shaped shear blade with a cross-head speed of 400 mm/min.

Statistical analysis

Effect of electrical stimulation and chiller ageing and the interaction between electrical stimulation and chiller ageing (electrical stimulation x chiller ageing) on shear values were evaluated using the Analysis of variance by SAS PROC GLM (general linear model) at significant difference ($P < 0.05$), means were separated using the p-diff option (SAS Institute, Cary, NC, 2007).

III. RESULTS AND DISCUSSION

Effects of electrical stimulation on the shear values

The aim of present study was to investigate the effects of an early post mortem low voltage electrical stimulation to localized part of carcasses with chiller ageing on the levels of shear values of Korean native Hanwoo beef (steers) related to meat tenderization.

Kim *et al.* [11] reported that in electrical stimulated (alternative current, direct current, and AC-DC dual current) Hanwoo beef the levels of shear values were low and the length of sarcomere was long compared to non-stimulated Hanwoo beef. Voges *et al.* [1] who assessed the WB shear force of beef from US retail and found that the consumer ranked shear values such as less than 3.2 kg (very tender) > 3.2 – 3.9 kg (tender) > 3.9 – 4.6 kg (normal).

In stimulated beef BF the levels of shear values of early post mortem stage (2 days) have declined about 1.5 kg (from 6.85 to 5.35 kg) and that of late post mortem stage (14 days) also have declined about 1.2 kg (from 5.58 to 4.38 kg) compared to non-stimulated BF (Table 1). These results indicated that the shear values of early post mortem stage (2 days) in stimulated BF less than that of late post mortem stage (14 days) in non-stimulated BF. While for LD the levels of shear values of early post mortem stage (2 days), late post mortem stage (14 days) have declined about 0.6 kg (from 5.16 to 4.57 kg), 0.2 kg (from 2.65 to 2.4 kg), respectively. From what we examine, reduction of tenderness by the effects of chiller ageing was more remarkable than that of electrical stimulation in stimulated LD. However, no significant effects of interaction between the electrical stimulation and chiller ageing were found. Polidori *et al.* [5] reported significant effects of early post mortem low voltage electrical stimulation (28 V) on meat tenderness in lamb m. *longissimus thoracis et lumborum* at both 2 and 7 days post mortem. Furthermore, the same authors also demonstrated the effects of electrical stimulation on meat tenderness in *m. semimembranosus* at 7 days post mortem. On the other hand, Nazil *et al.* [12] reported significant reduction of shear force values by the effects of high voltage electrical stimulation (500- 800 V) in Beef *m. longissimus dorsi* and *m. semimembranosus* when compared with non electrical stimulation.

Therefore, it is necessary that the appropriate conditions of electrical stimulation depending upon the purpose of the study must be optimized as the effects of electrical stimulation vary with various factors.

Table 1. Least square means, significance levels for WB shear values as a function of electrical stimulation to localized part of carcasses with chiller ageing

		M. biceps femoris	*M. longissimus dorsi*
2 days	NE	6.85	5.16
	ES	5.35	4.57
14 days	NE	5.58	2.65
	ES	4.38	2.4
SE		0.15	0.16
Model terms	Treat	36.3***	4.07*
	Ageing	24.96***	150.22***
	Treat* Ageing	0.46	1.25

* $P < 0.05$,
*** $P < 0.001$.
NE: Non electrical stimulation; ES: Electrical stimulation; SE: Standard error; Treat: electrical stimulation; Ageing: chiller ageing (2, 14 days).

IV. CONCLUSION

In conclusion, we assessed the effects of early post mortem low voltage electrical stimulation (45 volt AC) to localized part of carcasses in Hanwoo beef (Korean cattle) LD and BF muscles. The shear force values were significantly improved by electrical stimulation for LD, BF muscles at both 2 and at 14 days post mortem. In particular, for BF muscles the effects of electrical stimulation was more significant and outstanding than that of chiller ageing.

Moreover, it is also important that the appropriate conditions of electrical stimulation depending upon the purpose must be optimized because the effects of electrical stimulation vary by numerous factors. Additionally, early post mortem low voltage electrical stimulation to localized part of carcasses using both sensory evaluation and instrumental measurements of tenderness will be investigated in the future studies.

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