Effect of temperature conditioning and electrical stimulation on postmortem metabolism and tenderness of Hanwoo (Korean native cattle)

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Introduction

The texture of meat is of utmost importance to consumer acceptance and therefore much research effort has been put into this issue in order to be able to control and understand it (Tornberg, 1996). It is well known the tenderness varies according to species, breed, muscle type and age etc.. Since the conversion of muscle to meat is a complex process, many studies have been conducted to control the postmortem metabolism. Among those, electrical stimulation (ES) showed to accelerate glycolysis, prevent cold shortening by reducing the concentration of the ATP, and improve tenderness (George et al., 1980). In addition, temperature conditioning also influenced the rate of postmortem glycolysis (Moeller et al.). However, the most effective types of treatment and their optimal conditions remain to be elucidated. Marsh et al. (1987) reported that tenderness is the highest when glycolysis proceeds at an intermediate rate (pH of 3 hrs postmortem about 6.1) and decreased when pH of 3hrs postmortem is lower or higher than pH 6.1. Koh et al. (1987) observed that low voltage ES with 20 ℃ temperature treatment resulted in the lowest Instron shear value (ISV) and superior panel traits. On the contrary, some researchers reported that the ES showed adverse effects on the tenderness (Pommier et al., 1987) and meat quality (Unruh et al., 1986).

Objectives

The objections of the study are :

1) to investigate the effect of low voltage electrical stimulation in combination with temperature conditioning on postmortem metabolism.
2) to obtain a suitable indicator for predicting glycolytic rate and meat tenderness.

Materials and Methods

A total of 12 Hanwoo bulls were randomly assigned into two groups. One group was treated with low voltage electrical stimulation (50 V, 60 Hz, 20 sec, impulse duration 200 μsec) and the other with no electrical stimulation (NES). Within 30 min of slaughter, *longissimus* muscles were removed and each muscle was cut into three parts for temperature conditioning (2, 16, and 30 ℃) for 3 hrs followed by storage at 2 ℃ for 24 hrs. Each muscle was cut into 2.5 cm slices for vacuum packaging and was stored at 2 ℃ for 14 days postmortem. pH was measured using a Orion pH meter with a spear type electrode inserted 2.5 cm and digital thermometer was used to measure the temperature in the center of the muscle. R-values (R248, R250, R258) were measured following the procedure of Calkins et al. (1983) within 2 weeks of storaging in liquid nitrogen. R248, R250, and R258 were defined as the ratios of A248/A260, A250/A260 and A258/A250, respectively. Glycogen contents were measured using iodine assay by the method of Dreiling et al. (1987). Sarcomere lengths were determined with a Olympus microscope at a magnification of 1000X by using of an eyepiece micrometer. ISV were taken parallel to the fibers on 1.8cm diameter cores (internal temperature 71 ℃) using a Universal testing machine. Muscle fragmentation index (MFI) was measured by the procedure of Culler et al. (1978).

Results and discussion

The sample treated with ES revealed faster metabolic rate including faster pH fall, glycogen depletion and R-value decline at 1, 3hrs postmortem than NES ($p<.05$). Among temperature treatments 30 ℃ had the fastest glycolysis at 3 and 9hrs postmortem (Table 1). ES had a lower ISV at 1, 2, 3, and 7 day postmortem (approximately 1kg, $p<.05$). But there were no significant differences in sarcomere length in all treatments. Between ES and temperature, there was slight interaction only in MFI at 7 ($p=.0555$) and 14 ($p=.0526$) day postmortem. These data showed that ES with 30 ℃ treatment or low voltage ES improved tenderness.

All treatments had significant correlations ($p<.01$) among pH, R-values, glycogen content and MFI as well as between ISV and MFI (Table 2). In ES treatment, there were significant correlations between R258 and pH ($r=.9049$, $p<.01$), and between ISV and MFI ($r=-.7006$, $p<.01$). Correlations also showed between ISV and R258 ($r=.5817$, $p<.05$) in ES treatment. Since R258 showed the highest correlation with pH and glycogen content, R258 may be used as an indicator to predict ISV and MFI in ES treatment.

Conclusions

◎ ES-30 ℃ may be a good treatment for tenderness but hot-boned temperature conditioning was undesirable.
◎ R258 was preferred for predicting glycolytic rate and tenderness..

Table 1. Least-squares means pH, R-values, glycogen content(mg/g tissue) of 3, 9, and 24hrs postmortem (n=6 muscles per treatment).

Parameter	3hr postmortem					9hrs postmortem					24hrs postmortem				
	ES	NES	2 ℃	16 ℃	30 ℃	ES	NES	2 ℃	16 ℃	30 ℃	ES	NES	2 ℃	16 ℃	30 ℃
pH	6.26a	6.41b	6.50a	6.39b	6.11c	5.89	5.95	6.05a	6.00a	5.72b	5.60	5.60	5.64a	5.65a	5.57b
R248	0.757	0.785	0.760	0.762	0.791	0.959	0.906	0.880a	0.894a	1.025b	1.287a	1.217b	1.230	1.261	1.264
R250	0.846	0.846	0.831	0.842	0.865	1.033	0.968	0.963a	0.964a	1.076b	1.320a	1.262b	1.270	1.302	1.302
R258	1.180a	1.251b	1.248a	1.217ab	1.183b	1.007a	1.100b	1.089a	1.083a	0.988b	0.811a	0.875b	0.856	0.843	0.831
Glycogen	3.43a	4.20b	4.23a	3.75ab	3.43b	2.48	2.93	3.18a	2.78ab	2.15b	1.05	0.90	1.20	0.95	0.75

a.b Means in the same row apart from stimulation and conditioning with different superscripts differ ($p<.05$)

Table 2. Correlation coefficients between parameters in all combined treatments and electrical stimulation treatment.

Parameter/Treatment	ES + NES						ES					
	R248	R250	R258	Glycogen	ISV	MFI	R248	R250	R258	Glycogen	ISV	MFI
pH	-0.7749**	-0.7770**	0.8466**	0.8469**	0.0063	-0.5126**	-0.8960**	-0.8931**	0.9049**	0.8267**	0.0794	-0.4850**
R248		0.9907**	-0.9355**	-0.7325**	-0.3228	0.4106**		0.9925**	-0.9715**	-0.7984**	-0.1101	0.5561**
R250			0.9511**	-0.7392**	-0.2766	0.4187**			-0.9848**	-0.7854**	-0.2680	0.5555**
R258				0.7838**	0.2407	-0.4631**				0.7825**	0.5817*	-0.5317**
Glycogen					-0.0526	-0.4863**					-0.0096	-0.4703**
ISV						-0.6436**						-0.7006**

*Significant ($p<.05$)

**Significant ($p<.01$)

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