5-P60

Effect of early short-term temperature conditioning on calpains, metabolic rates and tenderness of Hanwoo (Korean native cattle) and Holstein

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Background

Numerous studies have documented the postmortem tenderization, but the mechanism is not fully understood. Many researchers recognize that myofibrillar proteins degradation by endogenous enzymes plays an important role in meat tenderness (Dransfield, 1994; Ho et al., 1997). Koohmaraie (1992) demonstrated that the calpains are probably one of the major proteolytic system involved in postmortem proteolysis, and its structure, function and regulation has been studied extensively. Many researchers have studied temperature conditioning effect on tenderness using a variety of temperature and treatment time (Fernandez and Tornberg, 1994). A high temperature of postmortem muscle accelerates the rate of pH decline and activates the calpains activity (Rhee, 1998). Whipple et al. (1990), who investigated calpains activity using high-temperature conditioning (22±3℃ for 6 hr), reported that high-temperature conditioning, which changes μ-calpain and calpastatin activities may improve the tenderness of 1 day postmortem. On the contrary, Koh et al. (1987) found that high-temperature conditioning showed an adverse effect on meat tenderness.

Objectives

1) to investigate the effect of early short-term temperature conditioning on calpains activity and postmortem metabolism.
2) to compare calpains activity and tenderness between Hanwoo and Holstein.

Methods

Three Hanwoo and three Holstein bulls were evaluated. Within 30 min of slaughter, *M. longissimus*, which was hot-boned after the split process, was divided into three parts and temperature-conditioned until 3 hr postmortem at 2, 16, and 30℃, respectively. The samples were then stored at 2℃ until 24 hr postmortem. They were cut into 2.5 cm thick steaks, vacuum-packaged and stored at 2℃ until 14 days postmortem. Postmortem muscle pH was measured with a spear type electrode inserted 2.5 cm and muscle temperature was measured in the center of the muscle at 1, 3, 9 and 24 hrs postmortem. R-value (R_{258}, A_{258}/A_{250}) was measured according to the procedures of Calkins et al. (1983). Glycogen contents were measured using iodine assay by the method of Dreiling et al. (1987). Activities of μ-calpain and m-calpain were determined at 1, 3, 9 and 24 hrs postmortem according to the procedures of Koohmaraie (1990), and inhibition (%) of calpastatin was conducted according to the procedures of Homma et al. (1995). Instron shear value (ISV) was measured using a Universal testing machine and muscle fragmentation index (MFI) was measured by the procedures of Culler et al. (1978).

Results and discussion

Hanwoo revealed slower decline in muscle temperature at 1 and 24 hrs postmortem ($p<0.05$) than Holstein but there were no significant differences in metabolic rates (Table 1). As expected, the 30℃ treatment affected muscle temperature ($p<0.01$) and pH decline ($p<0.05$) at 3 hrs postmortem but the treatment did not accelerate glycolysis both breeds (Table 2). Hanwoo had a lower μ-calpain activity at 1 and 3 hrs postmortem ($p<0.05$) than Holstein. In tenderness, Hanwoo had a higher MFI at 1 day postmortem ($p<0.01$) and a trend for lower ISV at 14 days postmortem ($p=0.064$) than Holstein. But meat tenderness and calpains activity were not affected by temperature conditioning until 3 hr postmortem (Fig. 1). In conclusion, the muscle temperature and enzyme activity, which showed significant differences between Hanwoo and Holstein, did not appeared to have enough effect on meat tenderness. Furthermore, temperature conditioning until 3 hr postmortem, which resulted in higher muscle temperature and faster pH decline in both breeds, did not accelerate glycolysis and tenderization.

Conclusions

1) Early short-term temperature conditioning did not accelerate glycolysis and tenderization.

2) μ-Calpain activity was different in both breeds.

Pertinent literature

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Table 1. Comparisons of Hanwoo and Holstein on the pH, muscle temperature, R-value, glycogen content and calpains of 1, 3, 9 and 24 hrs postmortem.

Parameter	1 hr PM		3 hrs PM		9 hrs PM		24 hrs PM	
	HA	HO	HA	HO	HA	HO	HA	HO
pH	6.88	6.89	6.49	6.54	6.00	6.20	5.60	5.66
Temp	37.30^{a}	35.07^{b}	18.70	17.47	11.97	9.13	7.50^{a}	5.40^{b}
R_{258}	1.20	1.30	1.20	1.26	1.13	1.19	0.93	0.86
Glyco	4.79	3.45	3.90	3.34	3.62	2.25	1.05	0.52
μ-Cal	42.92^{a}	49.55^{b}	40.08^{a}	47.17^{b}	33.63^{a}	41.95^{b}	24.57	33.34
m-Cal	43.90	50.95	43.69	49.94	41.32	46.51	38.70	43.05
Calpa	51.69	55.12	49.63	54.14	43.20	44.35	34.83	37.72

Glyco; glocogen contents (mg/g tissue), μ-Cal; μ-calpain activity (units/50g muscle), m-Cal; m-calpain activity (units/50g muscle), Calpa; calpastatin (inhibition %)

Table 2. Effects of temperature conditioning on the pH, muscle temperature and R-value of 3, 9 and 24 hrs postmortem.

		Hanwoo			Holstein		
		3 hrs	9 hrs	24 hrs	3 hrs	9 hrs	24 hrs
pH	2℃	6.49^{a}	6.00^{a}	5.60	6.54^{a}	6.21	5.66
	16℃	6.43^{a}	6.07^{a}	5.58	6.44^{ab}	6.11	5.65
	30℃	6.06^{b}	5.66^{b}	5.55	6.33^{b}	5.89	5.55
Temp	2℃	18.71^{a}	11.97	7.50	17.47^{a}	9.13	5.40
	16℃	22.80^{b}	10.30	6.27	20.83^{a}	9.03	5.53
	30℃	31.30^{c}	10.07	6.73	28.93^{b}	9.70	6.13
R_{258}	2℃	1.20	1.13	0.93	1.26	1.19	0.86
	16℃	1.20	1.08	0.89	1.27	1.25	0.84
	30℃	1.14	1.01	0.88	1.27	1.00	0.79

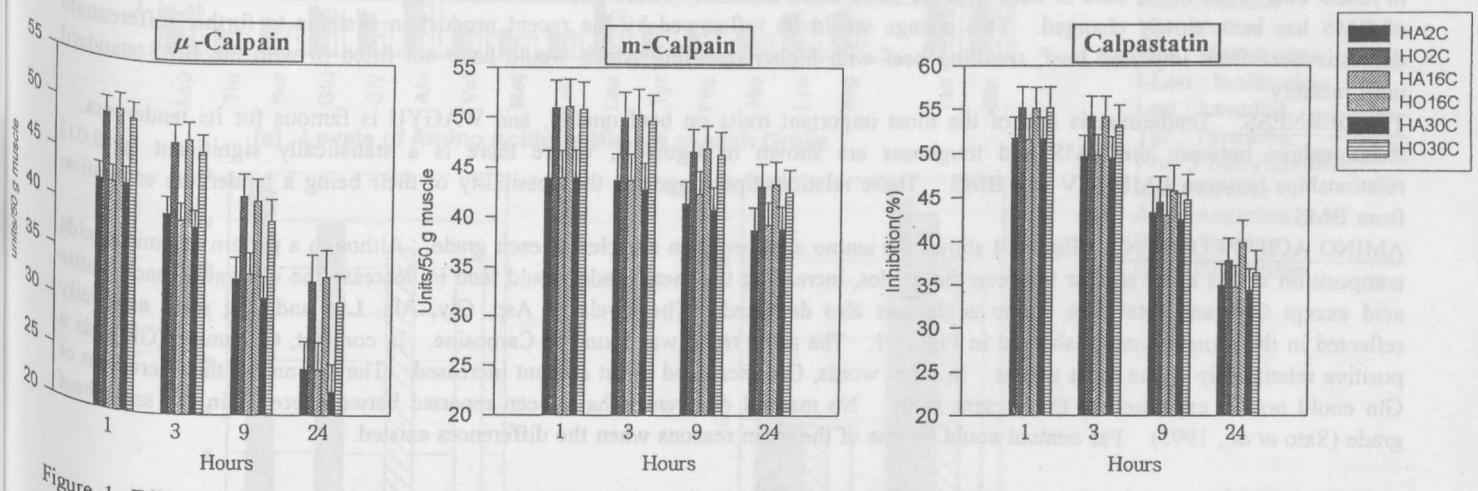

Figure 1. Effect of temperature conditioning on the activities of the calpains from Hanwoo and Holstein.
HA=Hanwoo; HO=Holstein ; 2C, 16C and 30C=2, 16, 30℃ temperature conditioning until 3 hr postmortem.