Relationship between muscle type and myoglobin oxidation of Hanwoo muscle during cold storage

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INTRODUCTION

The myoglobin oxidation in muscle depends on the muscle type and species. Trout and Gutzk (1995) reported that there are differences in myoglobin oxidate rate of different bovine muscles indicate that different muscle types are also important factors to affect the oxidation rate of myoglobin. Differences on Mb oxidation rate can be due to differences in concentration of endogenous antioxidaiton and pre-oxidation. Renerre (1990) reported that at 192 h postmortem, *M. longissimus dorsi* are the most stable, *M. semimembranosus* being of intermediate stability whilst *M. psoas major* are of least stability. There are other possible reasons for the different myoglobin oxidizes rate of enzyme activity (NADH) in postmortem muscles. Consequently, the characteristic by differnent muscle type was different in color stability.

The variation in muscle oxidative, glycolytic and contractile properties can be assessed using biochemical techniques, since the concentration, activities and ratios of different enzymes used for contraction and energy metabolism differ in the various types of muscle (Pette and Staron, 1990). Isolation of different heavy and light chain myosin isoforms by electrophoretic techniques is another way of muscle typing. Four different single myosin heavy chain (MHC) isoforms have been identified in ATPase based on fiber types : MHC I in type I, MHC IIa in type IIA, MHC IIB and MHC IId(x) in type IID(x). Picard et al. (1998) reported that the classification of bovine muscle fibers is of particular interest for the food industry because meat quality depends in part on the proportion of the different type of fibers. Muscle comprises a heterogeneous population of fibers differing in their speed of contraction and their metabolism. Therefore, the objective of the study was to investigate muscle fiber type of Hanwoo (Korean native cattle) major muscles and their meat color characteristics.

MATERIALS AND METHODS

Commercial 13 carcasses of Hanwoo were selected randomly at 24h postmortem, and the muscles were used to make steaks (3 cm thickness). Carcasses were dissected into the following individual muscles*: M. Longissimus dorsi* (LD), *M. Psoas major* (PM), *M. Semimemebranosus* (SM). Steaks from each muscle were placed in polyvinylchloride film. Samples were stored at 4℃ for 7 days to measure the percentage of MetMb, thiobarbituric acid reactive substance (TBARS) value, Metmyoglobin reducing acitivity, Mb concentration, fat concentration, mitochondria concentration at 1, 3, 5 and 7 days of storage and muscle fiber.

RESULTS AND DISCUSSION

No significant differences were found in muscle pH among LD, PM and SM, although pH was significantly increased in LD muscle at 7 days cold storage (Table 1). Significant differences in muscle TBARS and MRA were found during cold storage (Table 2). The myoglobin concentration was not significantly different among the muscle samples (7.33- 8.87mg/g), although higer value was found in PM ($p>0.05$). The crude fat content was significantly ($p<0.05$) higher in LD, while the mitochondria content was significantly higher in PM than other muscles. MetMb (%) of SM samples were significantly ($p<0.05$) higher at 1 day, while PM samples were significantly higher at 7 days. No significant differences were found in MetMb (%) between samples of LD and SM, PM and SM at 7 days storage. Results suggested that rapid color deterioration of PM muscle during cold storage compared to other muscles might be due to higher Mb concentration of PM muscle at 7 days storage.

Muscle fiber types were seperated with SDS-PAGE electrophorasis procedure (Table 1). LD muscle found significantly higher in type IIa and lower in type I compare to PM and SM muscles. No significant differences were found in type IIx and type IIb among 3 muscles. These differences can be attributed to different metabolic functions like oxidative and glycolytic activity. There were significant correlations between muscle fiber types and TBARS at 1 day and MetMB at 7 days of storage (Table 3). Muscle differences can be attributed to differing muscle fiber type and metabolic functions. Hanwoo beef muscles differ greatly in their color, color stability, and endogenous metmyoglobin reducing activity. It could be possible to conclude that the influence of biological factors on meat color can be largely explained by biochemical (MRA, Mb concentration, mitochondria content, Mb chemistry state) and physical (TBARS, curde fat) differences in Hanwoo major muscles due to differences in metabolic fiber types.

Table 1. Characteristics of crude fat, Mb and mitochondria concentration of Hanwoo major muscles

Muscle type	Item			Fiber type			
	Crude fat (%)	Mb con. (mg/g)	Mit. con. (mg/kg)	Type Ⅱa	Type Ⅱ x	Type Ⅱ b	Type Ⅰ
LD [1)]	13.91±2.47 [A]	7.33±1.77	15.09±3.01 [B]	39.03±5.68 [A]	25.82±3.25	20.11±0.11	15.02±2.41[B]
PM	10.85±2.68 [B]	8.87±1.41	18.83±2.59 [A]	31.41±0.51 [B]	29.39±0.17	20.39±0.23	18.80±0.46 [A]
SM	7.38±2.27 [C]	7.89±1.72	17.10±1.24 [AB]	32.30±0.84 [B]	29.05±0.85	20.21±0.13	18.43±0.12 [A]

1) LD: *Longissimus dorsi*, PM: *Psoas major*, SM: *Semimemebranosus*. Mean±S.D.
[A,B,C] Means with same letter in the same column are not significantly different (p<0.05).

Table 2. Changes in Metmyoglobin, MRA, TBARS, pH of Hanwoo major muscles during storage

Muslce type	Met		MRA		TBARS		pH	
	1day	7day	1day	7day	1day	7day	1day	7day
LD[1)]	4.73 ±2.24 [Bb]	16.97 ±4.64 [Ba]	0.464 ±0.040 [a]	0.380 ±0.011 [b]	0.168 ±0.038 [Cb]	0.379 ±0.184 [a]	5.431 ±0.047	5.474 ±0.015
PM	5.07 ±4.80 [Bb]	27.78 ±6.32 [Aa]	0.455 ±0.050 [a]	0.374 ±0.015 [b]	0.345 ±0.025 [Bb]	0.542 ±0.347 [a]	5.418 ±0.019	5.446 ±0.021
SM	10.67 ±1.51 [Ab]	22.83 ±6.18 [ABa]	0.477 ±0.034 [a]	0.374 ±0.030 [b]	0.421 ±0.037 [A]	0.652 ±0.463	5.453 ±0.103	5.468 ±0.060

1) LD: *Longissimus dorsi*, PM: *Psoas major*, SM: *Semimemebranosus*. Mean±S.D.
[a, b]Means with same letter in the same row in same parameter are not significantly different (p<0.05).
[A,B] Means with same letter in the same column are not significantly different (p<0.05).

Table 3. Correlation coeffecients between muscle fiber type and meat measurements in Hanwoo major muscles

Fiber type	Item										
	Fat	Mb	Mit	MRA 1	MRA 7	TBARS 1	TBARS 7	pH 1	pH 7	Met 1	Met 7
Type Ⅱa	0.47[y]	-0.13	-0.40[x]	-0.11	0.28	-0.80[z]	-0.23	-0.06	0.2	-0.24	-0.52[y]
Type Ⅱx	-0.44[y]	0.09	0.35[x]	0.12	-0.3	0.75[z]	0.21	0.09	-0.18	0.21	0.47[y]
Type Ⅱb	-0.07	0.22	0.47[y]	-0.16	0.01	0.41[x]	0.13	-0.19	-0.26	0	0.46[y]
Type Ⅰ	-0.50[y]	0.15	0.43[y]	0.1	-0.3	0.84[z]	0.25	0.06	-0.21	0.27	0.54[y]

[x] P<0.05, [y] P<0.01, [z] p<0.001.

CONCLUSIONS

The *M. Psoas major* of Hanwoo major muscle accelerated higher color deterioration during cold storage. Differences on classification of fibers based on contractile type were found among the three muscles. The MHC bands were separated four MHC bands (type IIa, type II x (d), type IIb, type I) and found significant difference in type IIa and type I among 3 muscles. Hanwoo muscles differ greatly in their color, color stability, lipid oxidation and endogenous metmyoglobin reducing activity. Results suggest that myoglobin stability is related with differences in muscle fiber types. Results also indicate that myoglobin oxidation may be related with pigment level, oxygen penetration depth and mitochondria concentration in relation to muscle fiber type.

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