PS1.05b The relationship between muscle fiber characteristics and meat quality of Korean native (Hanwoo) cattle muscles 172.00

Young-Hwa Hwang (1) stjoo@gnu.ac.kr, Gap-Don Kim (1), J-Y Jeong (1), I-K Kong (1), S-T Joo (1), G-B Park(1) (1)Division of Applied Life Science (BK21 program), Graduate School, Gyeongsang National University, Jinju 660-701, Korea

Abstract—The relationship between muscle fiber characteristics and meat quality traits was investigated with Longissmus dorsi (LD), Psoas major (PM) and Semimembranosus (SM) muscles of Korean native cattle, Hanwoo. Total fiber number was higher in PM muscle whereas cross-sectional area was higher in LD muscle. Fiber number, area percentages and density of type IIA and IIB were lower in SM muscle, but higher in PM muscle. LD muscle had higher pHu, L* value and fat content whereas SM muscle had lower L* value and fat content. The lowest Warner-Bratzler shear force (WBSF) with longer sarcomere length was observed in PM muscle, while SM muscle showed the highest WBSF with shorter sarcomere length. Consequently, percentage of type I and IIB showed higher correlation with meat quality traits, and inverse correlations between type I and IIB for fat content, L* value and WBSF were observed. Fiber number and area percentage of type I had a positive correlation with fat content and L* value, and a negative correlation with WBSF. Results suggested that Hanwoo beef had high marbling, more lightness and tenderness with increasing of type I percentage and decreasing of type IIB percentage in muscle.

Authors are with the Division of Applied Science (BK21 program), Graduate School, Gyeongsang National University, Jinju, Gyeongnam, Korea (corresponding author: S.T. Joo: +82-55-751-5511; fax: +82-55-756-5511; e-mail: stjoo@ gnu.ac.kr).

Index Terms—Muscle fiber characteristic, fiber type, meat quality, Korean native cattle

I. INTRODUCTION

Muscle fiber characteristics influence meat quality characteristics such as color, water-holding capacity, marbling and the texture of meat [1, 2]. However, the effects of muscle fiber characteristics on meat quality characteristics have not been studied extensively in ruminants, although a few reports exist in cattle [3] and pig [4, 5]. There are no reports concerning muscle fiber characteristics of Korean native cattle, Hanwoo. Therefore, this study was carried out to investigate the influence of muscle fiber characteristics on meat quality in three major muscles of Hanwoo cattle.

II. MATERIALS AND METHODS

Three major muscles (Longissmus dorsi, Psoas major and Semimembranosus) of eighteen Hanwoo cattle were obtained from a commercial slaughterhouse in Korea. Muscle samples of about 5g were taken for histochemical analysis within 1h postmortem. After 24h chilling of carcasses, the three muscles ware taken to evaluate meat quality traits, such as meat color (CIE L*a*b*), drip loss %, Warner-Bratzler shear force (WBSF), ultimate pH (pHu), myoglobin (Mb) content, total moisture and fat content. Myosin ATPase activity [6] was detected after acid (pH 4.63) and alkaline (pH 10.70) preincubation for classification of muscle fiber types (type I, IIA and IIB) and analysis of histochemical characteristics such as fiber number percentage, fiber area percentage, fiber diameter, density, total number of fibers counted and cross-sectional area of each fiber type.

III. RESULTS AND DISCUSSION

The muscle fibers in three muscles of Hanwoo cattle were divided into type I, IIA, and IIB. A clear difference in fiber type composition was observed among the muscles (Table 1 & Fig 1).

Table 1. Histochemical characteristics for *longissimus dorsi*, *Psoas major* and *Semimembranosus* muscles of Hanwoo cattle

Characteristics	Muscles		
	Longissimus dorsi	*Psoas major*	*Semimembranosus*
Total fiber number	114.89±3.62^{C}	188.56±10.31^{A}	178.67±8.40^{B}
Cross-sectional area (μm²)	113.69±7.47^{A}	46.47±4.11^{B}	44.26±5.83^{B}
Fiber number (%)			
Type Ⅰ	33.10±3.52^{Bb}	42.80±3.80^{Aa}	12.02±0.75^{Cc}
Type ⅡA	14.86±1.31^{Cc}	20.90±1.65^{Bc}	27.31±2.50^{Ab}
Type ⅡB	52.62±1.48^{Ba}	34.96±6.23^{Cb}	61.77±2.81^{Aa}
Fiber area (%)			
Type Ⅰ	24.34±1.53^{Bb}	31.92±4.49^{Ab}	7.96±0.47^{Cc}
Type ⅡA	12.39±1.94^{Cc}	16.17±2.27^{Bc}	22.62±0.55^{Ab}
Type ⅡB	63.68±1.37^{Ba}	52.93±3.62^{Ca}	69.40±0.96^{Aa}
Fiber diameter (μm)			
Type Ⅰ	62.08±1.45^{Ac}	49.43±3.06^{Bb}	47.14±2.36^{Bc}
Type ⅡA	65.67±4.18^{Ab}	49.73±2.38^{Cb}	54.10±4.13^{Bb}
Type ⅡB	80.26±2.89^{Aa}	68.78±0.58^{Ba}	61.00±1.94^{Ca}
Fiber density (fiber number/㎟)			
Type Ⅰ	29.07±3.29^{Bb}	91.43±11.35^{Aa}	28.39±3.93^{Cc}
Type ⅡA	13.12±0.88^{Cc}	46.54±5.81^{Bc}	64.21±11.93^{Ab}
Type ⅡB	46.10±2.98^{Ca}	78.77±8.79^{Bb}	136.65±14.83^{Aa}

^{A,B,C} Means ± SD with different superscripts in the same column are significantly different (p<0.05).
^{a,b,c} Means ± SD with different superscripts in the same row are significantly different (p<0.05).

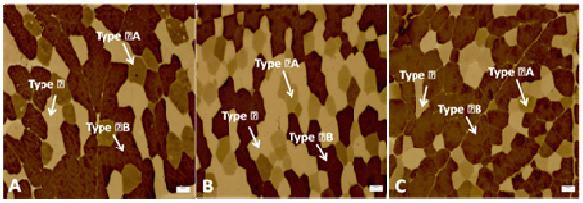

Fig. 1. Serial sections of 3 major muscles (A: *Longissimus dorsi*; B: *Psoas major*; C: *Semimembranosus*), stained for myosin ATPase reactivity after preincubation at pH 10.70. Magnification of 100 X was used (Bar = 50㎛).

Total fiber number was higher in Psoas major (PM) muscle whereas cross-sectional area was higher in Longissimus dorsi (LD) muscle ($p<0.05$). Fiber number, area percentages and density of type IIA and IIB were lower in Semimembranosus (SM) muscle compared to other muscles ($p<0.05$). The fiber number, area percentages and density of type I were significantly higher in PM muscle ($p<0.05$). These results suggested that color, water-holding capacity or marbling of beef could be affected by these differences in fiber type composition of cattle muscles. As expected, many differences in meat quality characteristics were observed among three muscles (Table 2).

Table 2. Meat quality traits for 3 major muscles of Hanwoo cattle

Traits		Muscles		
		Longissimus dorsi	*Psoas major*	*Semimembranosus*
Ultimate pH		5.42±0.02^{A}	5.37±0.04^{B}	5.37±0.02^{B}
Moisture content (%)		65.50±1.49^{C}	67.15±1.70^{B}	69.49±2.00^{A}
Fat content (%)		14.03±0.42^{A}	10.64±0.30^{B}	7.62±0.46^{C}
Myoglobin (mg/g)		7.32±0.26^{B}	8.82±0.35^{A}	7.85±0.23^{B}
Color	L* value	42.16±1.29^{A}	40.15±1.61^{B}	37.51±1.06^{C}
	a* value	19.40±1.04	19.22±1.58	19.56±2.04
	b* value	8.44±0.77	7.91±1.32	7.65±1.38
Drip loss (%)		3.51±0.15	3.28±0.28	3.25±0.54
WBSF[1] (kg/㎠)		7.53±0.42^{B}	4.97±0.71^{C}	9.32±0.99^{A}
Sarcomere length (㎛)		2.13±0.03^{B}	2.41±0.08^{A}	1.98±0.06^{C}

^{A,B,C} Means ± SD with different superscripts in the same column are significantly different ($p<0.05$).
[1] Warner-Bratzler shear force

LD muscle had higher pHu, L* value and fat content whereas SM muscle had lower L* value and fat content compared to other muscles ($p<0.05$). The lowest WBSF with longer sarcomere length was observed in PM muscle, while SM muscle showed the highest WBSF with shorter sarcomere length ($p<0.05$). Although PM muscle had higher Mb content ($p<0.05$) [7], there were no significant differences in redness (a* value) and drip loss % among three muscles. There were significant correlations between fiber type composition and meat quality traits (Table 3).

Table 3. Correlation coefficients (r) between histochemical characteristics and meat quality traits for 3 major muscles of Hanwoo cattle

Items	Fiber number percentage			Fiber area percentage			Fiber diameter		
	Type Ⅰ	Type ⅡA	Type ⅡB	Type Ⅰ	Type ⅡA	Type ⅡB	Type Ⅰ	Type ⅡA	Type ⅡB
Ultimate pH	0.20	-0.32***	-0.11	0.24	-0.34**	-0.13	0.36***	0.32**	0.34**
Moisture content (%)	-0.42***	0.44***	0.25	-0.33***	0.41***	0.26	-0.41***	-0.37**	-0.45***
Fat content (%)	0.42***	-0.40***	-0.33**	0.39***	-0.33***	-0.31**	0.37**	0.22	0.35***
Myoglobin (㎎/g)	0.29*	0.20	-0.37***	0.29*	0.23	-0.38***	-0.31***	-0.33***	-0.33*
Color L* value	0.36***	-0.38***	-0.30*	0.30**	-0.42***	-0.25	0.32***	0.26	0.32***
a* value	0.18	-0.05	-0.16	0.20	-0.07	-0.24	0.04	0.01	0.01
b* value	0.25	-0.23	-0.19	0.25	-0.42*	-0.22	0.20	0.06	0.21
Drip loss (%)	0.13	-0.26	0.03	0.15	-0.41	0.05	0.19	0.14	0.19
WBSF[1] (kg/㎠)	-0.40***	0.21	0.45***	-0.40***	0.32*	0.43***	0.01	0.15	-0.19
Sarcomere length (㎛)	0.33***	-0.16	-0.44***	0.32***	-0.26	-0.44***	-0.20	-0.29**	0.07

*$p<0.05$, **$p<0.01$, ***$p<0.001$.
[1] Warner-Bratzler shear force.

Especially, composition of type I and IIB showed higher correlation with meat quality traits, and inverse correlations between type I and IIB for fat content, L* value and WBSF were observed. When fiber number and area percentage of type I had a positive correlation with fat content or L* value and a negative correlation with WBSF, those of type IIB showed the converse. Thses results confirmed the finding of Ozawa et al. [3] who reported negative correlation between white muscle fiber (áW) content and marbling in beef, and implied that marbling of beef could be increased with increasing of type I or decreasing of type IIB in muscles. Our results also suggested that tenderness and lightness of beef could be increased by transformation of type IIB or IIA to type I (increasing of red muscle fiber) in muscles through genetic, breeding and feeding etc. of cattle.

IV. CONCLUSION

There is a clear difference in composition of muscle fiber type between Hanwoo cattle muscles, and differences in marbling, tenderness and meat color among beef cuts are due to the different composition of muscle fiber type. As increasing of type I percentage and decreasing of type IIB percentage in muscle, beef has more marbling, tenderness and lightness.

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