MUSCLE PROFILE: BOVINE MUSCLE PROPERTIES OF HANWOO

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Introduction
Different bovine muscles have different functions to contribute their various quality traits. Ramsbottom *et al.* (1945) compared 25 major muscles from heifer carcasses and found significant differences in tenderness and Warner-Bratzler shear force (WBS) between muscles. Many researchers reported differences in tenderness (as measured by shear force and/or sensory property) among muscles (Prost *et al.,* 1975). Muscles vary greatly in proteolysis, rigor shortening, or cold shortening, potentially attributing to their quality variation. Thus, this variation results in the relative contribution of various factors in the meat quality traits of individual muscle. An intramuscular fat content has been thought to affect palatability (Tatum, 1981); however that theory has been difficult to prove. Jennings *et al.* (1978) and Tatum *et al.* (1980) have reported positive relationships between marbling (or percent fat) and tenderness. It appears that there are consumers willing to pay a premium for guaranteed tender beef. However, inconsistency in meat tenderness has been identified as one of the major problems in beef industry (Boleman *et al.,* 1998; Rhee *et al.,* 2003). Therefore, the objective of this study was to determine the extent of variation and relationship among meat quality properties and palatability traits in major beef muscles of Hanwoo beef.

Materials and Methods
A total of 6 Korean Hanwoo steers (approximately 550-650kg live weight) were obtained at the National Livestock Research Institute (NLRI), and slaughtered. Chemical compositions were determined by Food scan^{TM}Lab (FOSS). WB-shear force was measured on cooked steaks (25mm thick) according to the method described by Wheeler *et al.* 2000). Water-holding capacity (WHC) was determined by the centrifugation method (Kristensen and Purslow, 2001). On the following day of slaughter, a total of 60 muscles were dissected, and frozen until analysis. WHC was expressed as a percentage of weight loss of sample tissue during the centrifugation. Five trained sensory panellists evaluated sensory characteristics of tenderness, juiciness and flavour intensity on a six-point scale. The panellists were asked to score from one point for extremely dislike to six point for extremely like. Thin slice samples (*ca.* 4mm in thickness, and 50 x 70mm in size) were cooked by placing on the tin plate (*ca.* 245-255^{oC}) with turning at the first pooling of liquid on the surface of the strip, or at the start of shrinkage. The cooked strip was immediately served to each panellist for evaluation.

Results and Discussion
The weight and intramuscular fat contents (%) of individual muscle are in Table 1. *Longissimus dorsi* muscle weighed highest (6.21±1.2kg) among the muscles followed by *Biceps femoris* muscle (5.43±1.30kg). Intramuscular fat contents were high in the *Seratus ventralis* muscle (25.81±8.88%), Intercostal muscle, *Transverse thoracis* muscle and *Semispinalis* muscle while relatively low fat was accounted in Sartorius muscle(2.13±0.93%). As shown in Table 1 and Figure 1, the proportion of intramuscular fat contents in the muscle originated from the same retail cut. This difference could be attributed to animal to animal variation and location effects of the portion (Rhee *et al.*, 2003). Intramuscular fat contents were relatively high in the muscles around chuck and loin when compared to the other muscles. The WBS, WHC, intramuscular fat, protein and sensory properties of twenty one major muscles among sixty muscles were investigated the physico-chemical properties (Table 2). The Warner-Bratzler shear force (WBS) values were significantly low for *Seratus ventralis* muscle and Intercostal muscle, and followed by *Infraspinatus* muscle and *Psoas major* muscle, while *Semimembranosus* muscle and *longissimus dorsi* muscle had significantly high WBS values ($p<0.05$). Across all muscles, tenderness rating of sensory evaluation was highly correlated with WBS scores. Intercostal muscle, *Seratus ventralis* muscle, External abdominal oblique muscle and *Psoas major* muscle had the most favourable scores in flavour whereas the muscles around the hindquarter had the lowest flavour scores when compared to the other muscles. There was no significant difference in WHC among different muscles ($p>0.05$) however, juiciness scores of sensory evaluation were significantly different depending on the muscles ($p<0.05$).

Conclusion
The result indicated that meat quality traits such as intramuscular fat contents, tenderness and juiciness are highly variable within and among different beef muscles. This variation might be based on the complex interaction of various biochemical traits that changes from muscle to muscle depending on the animals. This result will provide the information to facilitate the development of cut-specific strategies by targeting specific muscle characteristics.

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Table 1: Weight and intramuscular fat contents(%) of major beef muscle of Hanwoo beef

Muscle	Weight (kg)	Intramus-cular Fat	Muscle	Weight (kg)	Intramus-cular Fat	Muscle	Weight (kg)	Intramus-cular Fat
Cutaneous trunci m.	1.62±0.30	6.30±3.13	Triceps brachii m.	3.52±1.08	7.43±3.53	Seratus ventralis m.	**1.83±0.95**	25.81±8.88
Trapezius m.	1.51±0.39	10.82±5.88	Rhomboideus m.	1.05±0.78	9.45±8.58	intercostal m.	**3.20±0.51**	24.96±10.72
Longus capitis m.	1.15±0.47	6.72±2.77	Teres major m.	0.40±0.11	4.06±1.24	Deep gluteal m.	**0.35±0.10**	8.13±4.24
Brachiocephalicus m.	1.51±0.47	6.47±2.60	Biceps brachii m.	0.44±0.19	8.83±4.69	Diaphragm	**0.67±0.12**	19.95±7.12
Sternocephalic m.	0.58±0.13	6.03±3.64	Brachialis m.	0.37±0.06	5.99±4.96	Supraspinatus m.	**1.40±0.28**	6.52±3.05
Splenius m.	1.48±1.07	10.83±9.33	Subscapularis m.	1.25±0.34	5.52±2.20	Infraspinatus m.	**2.06±0.40**	16.28±9.24
Pectineus m.	0.34±0.06	7.75±3.87	Deltoid muscle	0.33±0.21	4.93±2.44	Semispinalis m.	**1.77±0.32**	21.95±1.58
Longus colli m.	0.93±0.30	6.26±1.77	Teres minor m.	0.32±0.15	7.39±2.23	Spinalis muscle	**2.38±0.88**	17.54±9.69
Seratus cervicis m.	3.23±1.04	13.41±8.25	Longissimus m.	6.21±1.25	10.77±5.13	deep pectoral m.	**3.45±0.57**	8.42±3.41
Semispinals m.	2.46±1.01	17.54±9.38	Psoas major m.	1.90±0.35	9.54±3.15	Rectus femoris m.	**1.69±0.31**	7.10±0.33
Omohyoid m.	0.74±0.34	4.24±0.73	Psoas minor m.	0.48±0.25	11.20±5.09	Vastus lateralis m.	**1.96±0.26**	4.45±1.64
Omotransverse m.	0.67±0.20	6.76±3.57	Iliocostalis m.	0.49±0.12	13.28±5.13	Gracialis m.	**1.08±0.30**	5.12±2.63
Rectus abdominis m.	1.69±0.25	18.38±8.52	Multifidus m.	1.20±0.30	14.53±6.43	Middle gluteal m.	**3.13±0.61**	5.85±2.39
Superficial pectoral m.	1.47±0.14	14.24±7.28	Biceps femoris m.	5.43±1.30	8.51±4.25	Sartorius m.	**0.32±0.09**	2.13±0.93
Latissimus dorsi m.	2.20±0.39	7.48±4.32	Iliacus m.	0.42±0.18	7.75±2.80	Adductor m.	**1.28±0.56**	4.67±2.27
Semimembranosus m.	5.34±1.37	4.39±1.02	Semitendinosus m.	1.99±0.39	5.67±2.59	Vastus medialis m.	**0.54±0.05**	6.85±2.10

Table 2. Meat quality properties of major 21 muscles of Hanwoo beef.

Muscle	WBS kg/0.5inch^2	Water Holding Capacity (%)	Crude Protein(%)	Sensory panel score(Point/6Point)		
				Juiciness	Tenderness	Flavour
Deep pectoral m.	4.23±0.86c	54.30±4.17	19.25±0.91	3.25±0.27c	3.62±0.75bc	3.90±0.34bc
Superficial pectoral m	3.11±0.35b	49.56±3.48	17.86±1.86	3.97±0.82abc	4.08±1.08abc	4.15±0.42ab
Seratus ventralis m.	2.07±0.39a	43.79±2.85	15.90±2.21	4.83±0.62a	5.37±0.61a	4.53±0.25ab
Semispinals m.	2.63±0.48ab	48.75±5.23	17.06±2.26	4.60±0.58a	5.02±0.58a	4.70±0.23a
Supraspinatus m	3.47±0.22b	48.78±2.66	19.26±1.00	3.32±0.34bc	3.55±0.47bc	4.00±0.30bc
Infraspinatus m.	2.66±0.29ab	48.80±4.09	16.86±2.43	4.25±0.93ab	5.08±0.49a	4.35±0.57ab
Triceps brachii m	3.16±0.11b	50.87±1.56	19.99±0.82	3.93±0.64abc	4.18±0.76bc	4.25±0.43ab
intercostal m	2.08±0.48a	49.31±5.20	17.73±2.60	4.85±0.52a	4.68±0.79ab	4.65±0.32ab
Rectus abdominis m.	3.34±0.33b	51.80±3.61	16.75±2.37	4.05±0.64ab	4.55±0.66ab	4.03±0.30b
Longissimus m.	4.45±2.18c	54.19±5.69	20.05±0.94	3.80±0.77ab	4.43±0.83ab	4.38±0.46ab
Latissimus dorsi m.	3.76±0.4bc	53.28±3.07	20.20±0.81	3.55±0.47bc	3.45±0.72bc	4.05±0.35b
Psoas major m	2.85±0.16ab	56.88±3.35	19.91±0.75	4.04±0.45ab	5.00±0.28a	4.50±0.36ab
Biceps femoris m.	3.80±0.96abc	53.55±2.43	19.48±1.09	3.53±0.61bc	3.75±0.69bc	3.62±0.53bc
Tensor faciae latae m	3.13±0.34ab	52.15±3.72	19.83±0.97	3.70±0.32bc	4.08±0.44b	4.12±0.25bc
Rectus femoris m.	3.23±0.46ab	52.41±5.46	19.68±0.88	3.34±0.42bc	3.88±0.60bc	3.96±0.44bc
Semimembranosus m.	4.51±0.87c	54.08±4.29	21.22±0.85	3.15±0.51c	3.37±0.58bc	3.65±0.48bc
Middle gluteal m.	3.64±0.49bc	50.35±3.44	20.63±0.89	3.07±0.27c	3.90±0.41bc	3.90±0.31bc
Semitendinosus m.	3.46±0.22b	54.04±2.75	20.75±0.49	3.05±0.45c	3.48±0.37c	3.97±0.34bc

[a,b,c] Means in the same vertical column with different superscripts are significantly different ($P<0.05$). WBS; Warner-Bratzler shear force.