# MUSCLE PROFILING IN RELATION TO MEAT QUAILITY AND PALATABILITY OF THE 18 MUSCLES FROM HANWOO STEER

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**Abstract – To investigate meat quality traits and palatability attributes of 18 major muscles from Hanwoo steer, 25 Hanwoo carcasses were selected from 5 carcasses × 5 quality grades. The 18 muscles including *Psoas major* (PM), *Longissimus thoracis* (LT), *Longissimus lumborum* (LL), *Semisponals* (SS), *Supraspinatus* (SU), *Infraspinatus* (IS), *Triceps brachii* (TB), *Semimembranosus* (SM), *Semitendinosus* (ST), *Gluteus medius* (GM), *Biceps femoris* (BF), *Rectus abdominis* (RA), *Internal abdominal oblique* (IO), *External abdominal oblique* (EO), *Triceps surae* (TS), *Superficialis flexor* (SF), *Internal intercostal* (II), *Diaphragm* (DA) were separated from right side of each carcass. Means of meat quality measurements and chemical components including myoglobin, collagen, intramuscular fat and oleic acid were significantly different among 18 muscles (P<0.05). PM and SS showed the highest value of CIE a* while the lowest value was observed in SU and TS (P<0.05). TB showed the highest cooking loss (41.0 %) while RA had the lowest value (27.3 %) (P<0.05). As expected, the lowest value of shear force was observed in PM and the higher values were founded in muscles from round cut such as SM, ST and BF (P<0.05). Also, PM had the longest sarcomere length (2.89 µm) while muscles from the round, shoulder and neck cuts such as IS, SU, ST, GM, and BF had short sarcomere length (1.54~1.68 µm). IS had the highest collagen content while PM and DA showed the lowest collagen content (P<0.05). The highest intramuscular fat (IMF) content was observed in RA and II while SM and TS showed the lowest IMF (P<0.05). Also, significant differences in oleic acid percentage were found among 18 Hanwoo muscles (P<0.05). Consequently, significant correlations between sensory panel scores and meat quality traits were observed. The strongest correlations were observed between IMF and overall palatability (P<0.001).**

**Key Words – Beef quality, Muscle characteristics, Hanwoo cuts.**

## I. INTRODUCTION

The Korean beef industry is showing changes in trends toward marketing individual muscle cuts recently (Hwang et al., 2010). However, the characteristics of individual muscles in relation to chemical components, meat quality traits and palatability are not well known, although the cooking and chemical attributes of the major beef muscles from Canada beef carcasses were evaluated (Jeremiah et al., 2003).

Muscles in a beef carcass are composed of different muscle fiber types which are affected by various factors including gender, age, diet, muscle location, exercise etc. (Joo et al., 2013). Because muscle fiber characteristics influence meat quality characteristics, overall palatability also could be affected by individual muscles. In this regard, it is important to understand the relationship between chemical components, meat quality traits and palatability attributes, and there is a need to profile muscle characteristics by individual muscles. Therefore, the relationship between meat quality traits and sensory palatability attributes of the 18 Hanwoo muscles were investigated in this study.

## II. MATERIALS AND METHODS

Twenty five Hanwoo carcasses (5 carcasses × 5 grades) were selected randomly from a commercial slaughterhouse at 24 h postmortem, and eighteen muscles were separated from right side of each carcass. Muscles were vacuum packed and transported to laboratory for measuring chemical components, meat quality traits and palatability attributes. The 18 muscles sampled and Korean name of retail cuts are shown in Table 1.

Table 1. Muscles sampled and retail cuts in Korean

| Muscles | Nomen-clature | Retail cuts name in Korean |
|---|---|---|
| *Psoas major* | PM | Ansimsal |
| *Longissimus thoracis* | LT | Kotdungsimsal |
| *Longissimus lumborum* | LL | Chaekeutsal |
| *Semisponals* | SS | Moksimsal |
| *Supraspinatus* | SU | Kurisal |
| *Infraspinatus* | IS | Buchaesal |
| *Triceps brachii* | TB | Abdarisal |
| *Semimembranosus* | SM | Udunsal |
| *Semitendinosus* | ST | Hongdukaesal |
| *Gluteus medius* | GM | Boseopsal |
| *Biceps femoris* | BF | Seolgitsal |
| *Rectus abdominis* | RA | Upjinsal |
| *Internal abdominal oblique* | IO | Chimasal |
| *External abdominal oblique* | EO | Abchimasal |
| *Triceps surae* | TS | Mungchisatae |
| *Superficialis flexor* | SF | Arongsatae |
| *Internal intercostal* | II | Kalbisal |
| *Diaphragm* | DA | Anchangsal |

The meat color (CIE a*) was measured on the surface of muscles using a Minolta Chromameter CR-300 that was standardized with a white plate (Y=93.5, X=0.3132, y=0.3198). Drip loss (%) was determined by suspending muscle samples standardized for surface area in an inflated plastic box for 24 h at 4℃. Cooking loss was determined by the weight loss during broiling for 30 min at 90℃. Warner-Bratzler shear force (WBSF) (kg/cm$^2$) values were determined using an Instron Universal Testing Machine. Samples were 1.3 cm diameter cores obtained from steaks cooked to 70℃ internal temperature for 30 min. Sarcomere length (μm) was determined using the method of Cross et al. (1981).

Fat was extracted for intramuscular fat (IMF) content by the method of Folch et al. (1957) and fatty acid composition was analyzed for oleic acid (%) by gas chromatography as described by Jung et al. (2016). Myoglobin (Mb) content was determined by the method of Warriss (1979), and Mb (mg/ml) was calculated with absorbance at 525 nm and 700 nm. Collagen content was estimated from hydroxyproline quantification method described by AOAC (2000). The collagen content was calculated by the multiplication of the hydroxyproline content by 7.25.

Muscle samples were evaluated by an 8 member trained expert descriptive attribute sensory panel in Meat Science Laboratory at Gyeongsang National University. Panelists evaluated meat color, texture, surface moisture, marbling and overall acceptability for the fresh meat, and flavor, tenderness, juiciness, chewiness and overall palatability for cooked meat using a 9-point hedonic scale as described by Meilgaad et al. (1999).

Data from three replications were analyzed by analysis of variance (ANOVA) using statistical analysis systems (SA, 2002). ANOVA was adopted to design the mathematical model using SAS 9.2. Duncan's multiple range tests were used to determine significance among means. Statistical siginicance was considered when P value was less than 0.05. Also, regression analysis was used to generate Pearson correlation coefficients between muscle measurements and sensory panel scores.

## III. RESULTS AND DISCUSSION

Means of meat quality measurements and chemical components including Mb, collagen, IMF and oleic acid were significantly different among 18 muscles from Hanwoo steer (Table 2). (The standard deviation and statistical significances are not shown). SS and PM showed the highest value of CIE a* while the lowest value was observed in SU and TS ($P<0.05$). However, the highest Mb content was found in DA, and II had the lowest Mb content ($P<0.05$). Cooking loss showed a bigger difference among muscles compared to drip loss. TB showed the highest cooking loss (41.0 %) while RA had the lowest value (27.3 %) ($P<0.05$). As expected, the lowest WBSF value was observed in PM and the higher WBSF values were founded in muscles from round cut such as SM, ST and BF ($P<0.05$). Also, PM had the longest sarcomere length (2.89 μm) while muscles from the round, shoulder and neck cuts such as SU, IS, ST, GM, and BF had short sarcomere length (1.54~1.68 μm). Moreover, the lowest collagen content was observed in PM and DA, and IS had the highest collagen content ($P<0.01$).

The tenderness ranking in this study is in general agreement, but differs somewhat from the rankings previously reported by others including Jeremiah et al. (2003). Present data implied that tenderloin (PM) was the most tender cuts than high marbled cuts such as rib, striploin or rib-eye due to the longer sarcomere length and lower collagen content.

The highest IMF content was observed in RA and II while SM and ST had the lowest IMF (P<0.05). Also, significant differences in oleic acid percentage were found among 18 Hanwoo muscles (P<0.05). PM had the lowest oleic acid percentage while the highest percentage of oleic acid was found in RA (P<0.01). Consequently, significant correlations between sensory panel scores and meat quality traits were observed (Table 3). However, there were no significant correlations between sensory panel score and oleic acid percentage (P>0.05).

The sensory meat color for fresh meat was significantly correlated with Mb content (P<0.01), but not correlated with CIE a* (P<0.05). The sensory texture scores were correlated with CIE a* (P<0.05) and IMF (P<0.01). The surface moisture scores were correlated with cooking loss (P<0.05) and IMF (P<0.01). The sensory marbling scores were correlated with cooking loss (P<0.01), WBSF (P<0.05) and IMF (P<0.001). The IMF was strongly correlated with sensory panel scores except meat color for fresh meat. The strongest correlations were observed between IMF and overall acceptability (P<0.001).

Table 2. Least squares mean for meat quality traits[a] of the 18 muscles from Hanwoo steers (n=25)

| Muscles | CIE a* | DL | CL | WBSF | SL | IMF | Mb | Collagen | Oleic |
|---|---|---|---|---|---|---|---|---|---|
| PM | 22.5 | 0.91 | 34.3 | 2.34 | 2.89 | 8.9 | 7.79 | 0.82 | 42.1 |
| LT | 20.8 | 0.90 | 32.9 | 3.29 | 1.88 | 17.3 | 7.53 | 1.54 | 44.9 |
| LL | 19.3 | 0.83 | 32.8 | 3.62 | 1.84 | 12.7 | 6.87 | 1.91 | 46.3 |
| SS | 22.6 | 0.97 | 39.3 | 4.84 | 1.98 | 6.6 | 7.19 | 5.96 | 47.9 |
| SU | 18.9 | 0.80 | 39.9 | 4.99 | 1.62 | 6.5 | 7.99 | 3.43 | 47.1 |
| IS | 19.8 | 0.78 | 30.9 | 3.88 | 1.54 | 15.7 | 7.19 | 10.41 | 47.6 |
| TB | 22.0 | 0.84 | 41.0 | 4.78 | 2.08 | 6.3 | 7.99 | 4.19 | 48.0 |
| SM | 19.8 | 0.80 | 37.8 | 5.47 | 1.80 | 4.9 | 7.55 | 2.31 | 46.4 |
| ST | 19.5 | 0.73 | 37.4 | 5.47 | 1.67 | 5.9 | 5.41 | 3.01 | 45.6 |
| GM | 22.2 | 0.93 | 38.4 | 4.52 | 1.65 | 5.5 | 7.68 | 3.12 | 46.0 |
| BF | 19.2 | 0.80 | 36.3 | 5.52 | 1.68 | 10.1 | 7.92 | 3.37 | 47.9 |
| RA | 20.7 | 0.79 | 27.3 | 3.39 | 2.81 | 26.5 | 5.85 | 1.67 | 48.8 |
| IO | 22.2 | 0.74 | 32.8 | 3.91 | 1.95 | 14.8 | 9.05 | 2.30 | 45.6 |
| EO | 21.2 | 0.73 | 33.6 | 4.29 | 1.83 | 14.5 | 8.96 | 3.15 | 45.9 |
| TS | 18.6 | 0.78 | 35.6 | 4.24 | 2.43 | 4.6 | 8.87 | 3.73 | 48.3 |
| SF | 19.4 | 0.70 | 33.0 | 4.43 | 1.85 | 6.6 | 7.76 | 7.84 | 47.6 |
| II | 21.3 | 0.82 | 32.4 | 2.82 | 2.37 | 24.1 | 5.03 | 2.67 | 48.3 |
| DA | 19.8 | 0.76 | 29.9 | 2.59 | 2.04 | 18.4 | 9.57 | 0.93 | 44.6 |

[a] DL: drip loss %, CL: cooking loss %, WBSF: Warner-Bratzler shear force (kg/cm$^2$), SL: sarcomere length (μm), IMF: intramuscular fat %, Mb: myoglobin %, Oleic: oleic acid %.

Table 3. Correlations between sensory panel scores for fresh meat and meat quality traits[a] of Hanwoo steers.

| | CIE a* | DL | CL | WBSF | SL | IMF | Mb | Collagen | Oleic |
|---|---|---|---|---|---|---|---|---|---|
| Meat color | -0.21 | -0.07 | 0.21 | 0.29 | -0.19 | -0.41 | 0.60$^{**}$ | 0.11 | 0.12 |
| Texture | -0.48$^{*}$ | -0.11 | 0.26 | 0.39 | -0.36 | -0.62$^{**}$ | 0.29 | 0.37 | 0.10 |
| Surface moisture | 0.15 | 0.06 | -0.53$^{*}$ | -0.37 | 0.11 | 0.68$^{**}$ | -0.40 | -0.16 | 0.08 |
| Marbling | 0.13 | -0.12 | -0.74$^{***}$ | -0.52$^{*}$ | 0.20 | 0.86$^{***}$ | -0.25 | -0.28 | -0.09 |
| Overall acceptability | 0.16 | 0.09 | -0.77$^{***}$ | -0.64$^{**}$ | 0.32 | 0.87$^{***}$ | -0.34 | -0.30 | -0.14 |

[a] DL: drip loss %, CL: cooking loss %, WBSF: Warner-Bratzler shear force (kg/cm$^2$), SL: sarcomere length (μm), IMF: intramuscular fat %, Mb: myoglobin %, Oleic: oleic acid %.

* P<0.05, **P<0.01, **P<0.001.

Table 4. Correlations between sensory panel scores for cooked meat and meat quality traits[a] of Hanwoo steers.

| Sensory panel score | CIE a* | DL | CL | WBSF | SL | IMF | Mb | Collagen | Oleic |
|---|---|---|---|---|---|---|---|---|---|
| Flavor | 0.19 | -0.09 | -0.67** | -0.50* | 0.14 | 0.61** | 0.08 | 0.32 | 0.06 |
| Tenderness | -0.23 | 0.19 | 0.60** | 0.54* | -0.57* | -0.68** | 0.23 | 0.54* | 0.13 |
| Juiciness | 0.20 | -0.26 | -0.59** | -0.42 | 0.33 | 0.71*** | -0.24 | -0.08 | 0.09 |
| Chewiness | 0.13 | -0.31 | -0.69** | -0.57* | 0.38 | 0.73*** | -0.17 | -0.17 | -0.08 |
| Overall palatability | 0.07 | -0.34 | -0.75*** | -0.52* | 0.21 | 0.83*** | -0.03 | 0.11 | 0.09 |

[a] DL: drip loss %, CL: cooking loss %, WBSF: Warner-Bratzler shear force (kg/cm$^2$), SL: sarcomere length (μm), IMF: intramuscular fat %, Mb: myoglobin %, Oleic: oleic acid %.
* P<0.05, **P<0.01, **P<0.001.

Table 5. Correlations between sensory panel scores for fresh and cooked meat from Hanwoo steers.

| | Meat color | Texture | Surface moisture | Marbling | Overall acceptability |
|---|---|---|---|---|---|
| Flavor | 0.07 | -0.08 | 0.31 | 0.44 | 0.43 |
| Tenderness | 0.54* | 0.75*** | -0.45* | -0.60** | -0.56* |
| Juiciness | -0.65** | -0.65** | 0.59** | 0.72*** | 0.62** |
| Chewiness | -0.62** | -0.65** | 0.56* | 0.71*** | 0.63** |
| Overall palatability | -0.40 | -0.53* | 0.52* | 0.71*** | 0.65** |

* P<0.05, **P<0.01, **P<0.001.

Cooking loss was strongly correlated with all sensory palatability attributes for cooked meat (P<0.01), but drip loss had no significant correlation (P>0.05) (Table 4). Also, all sensory panel scores were not significantly correlated with CIE a*, Mb and oleic acid content (P>0.05). Tenderness was more closely correlated with IMF and cooking loss (P<0.01) than WBSF, sarcomere length and collagen content (P<0.05). The IMF was strongly correlated with sensory juiciness and chewiness scores (P<0.001) compared to other meat quality traits. Consequently, overall palatability of cooked beef was closely correlated IMF (0.83, P<0.001), cooking loss (-0.75, P<0.001) and WBSF (-0.52, P<0.05).

Finally, all sensory panel scores for fresh meat were correlated with palatability attributes for cooked meat except flavor (Table 5). Especially, marbling was strongly correlated with juiciness, chewiness and overall palatability (P<0.001) while texture was strongly correlated with tenderness (P<0.05).

## I. CONCLUSION

Meat quality traits and chemical components vary among the 18 Hanwoo muscles and related to sensory palatability attributes. The most tender muscle is PM due to long sarcomere length and less collagen content. Overall palatability of cooked beef is strongly correlated with IMF and sensory marbling score of fresh beef.

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