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ARTICLE

Chemical Components and Meat Quality Traits Related to Palatability of Ten Primal Cuts from Hanwoo Carcasses

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Abstract

To determine chemical components and meat quality traits related to palatability of 10 primal cuts, 25 Hanwoo carcasses were selected from 5 carcasses × 5 quality grades and used to obtain proximate data and meat quality characteristics. Significant differences (p<0.05) in chemical component and meat quality were found among the 10 primal cuts. The highest fat content was found in the kalbi, followed by dungsim, yangjee, chaekeut, ansim, abdari, suldo, moksim, udun, and satae. Protein and moisture contents in the 10 primal cuts were in reverse order of fat content. Moksim had the highest drip loss % and cooking loss % than all other primal cuts while kalbi showed the lowest (p<0.05) percentage of drip and cooking loss. Ansim had the longest sarcomere length but the lowest shear force values than all other cuts (p<0.05). The highest (p<0.05) score for overall acceptability was observed in ansim. Moksim, udun, abdari, and satae were rated the lowest (p<0.05) in overall acceptability among the 10 primal cuts from Hanwoo carcasses. In conclusion, ansim, dungsim, chaekeut, and kalbi had the highest overall acceptability due to their higher fat contents and lower shear force values.

Keywords: Hanwoo, primal cuts, chemical component, meat quality

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Introduction

Meat is a valuable component in people's diets. Healthy nutrition and high quality of meat at reasonable prices are always important to consumers. The demand for nutritive and quality beef continues to grow due to income increases in Korea with a shift in choice preferences. Consequently, the Korea beef industry is showing trends toward marketing individual muscles cuts. However, the proximate composition and meat quality characteristics of individual beef cuts are not well known.

While conflicting research data have reported the relationship between consumption of red meat and cancer, heart disease, diabetes, or obesity (Bernstein *et al*., 2010; Roussell *et al*., 2014; Sinha *et al*., 2009), per capita Korea beef consumption is continually increased by 49% from 6.9 kg in 2000 to 10.3 kg in 2013 (Korea Meat Trade Association, 2014). Korean consumers and producers have increased awareness of the composition and nutritive value of beef. Fat and cholesterol content of beef have been reported to be linked to cancer, heart disease, and obesity (Micha *et al*., 2010; Pan *et al*., 2012). For this reason, the Korean beef industry is more scrutinized today than it has been in the past due to concerns about health claims and safety issues.

Although many reports have insisted that there is an relationship between red meat consumption and cardiovascular disease (CVD), other studies have showed the benefits of lean beef included in a healthy diet (Campbell and Tang, 2010; Layman *et al*., 2008; Roussell *et al*., 2012). Therefore, it is essential of obtain nutrients information of all beef cuts to make conclusive and comprehensive statements regarding the role of beef in health. Recently, Roseland *et al.* (2015) have demonstrated the importance of maintaining data for a variety of retail beef cuts due to their unique properties and different cooking methods. Needless to say, nutrient data for all wholesale or retail cuts are needed to enable researchers to accura-

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tely evaluate healthy cuts so that consumers can make healthy selections. Furthermore, understanding meat quality characteristics of individual beef muscle can improve the utilization of many retail cuts from beef carcasses.

The physical and sensory properties of major muscles of beef carcass have been characterized more than sixty years ago (Ramsbottom and Strandine, 1948; Ramsbottom *et al*., 1945; Strandine *et al*., 1949). However, the composition and physical properties of beef muscles have changed considerably over the past 60 years. The chemical components and meat quality properties of Hanwoo cattle have also changed significantly. It is necessary to assess the nutritive and palatability attributes of the primal cuts or major muscles of modern Hanwoo beef carcass. Therefore, the objective of this study was to determine the chemical components and meat quality traits 10 primal cuts of Hanwoo beef and compare data related to palatability.

Materials and Methods

Carcass selection and primal cut preparation

A total of 25 Hanwoo steer carcasses were selected at commercial plants and fabricated into 10 primal cuts. Twenty five carcasses were consisted of five carcasses by five quality grades ($QG1^{++}$, $QG1^{+}$, QG1, QG2, and QG3) primarily determined by the degree of marbling using the Korean Beef Marbling Standard (BMS). In addition, the quality grades were adjusted by other carcass traits such as meat color, fat color, texture, and maturity. The 10 primal cuts were originated from Ansim (tenderloin), Dungsim (loin), Chaekeut (sirloin), Moksim (chuck), Abdari (shoulder), Udun (outside round), Suldo (inside round), Yangjee (brisket), Satae (shank), and Kalbi (rib). As shown in Fig. 1, the major division of hindlimb was in the smaller medial udun and the larger lateral suldo. The *psoas* filet or ansim was separated from the remainder of the short loin or chaekeut. After lifting the shoulder or abdari, the dungsim was a long cut including all the thoracic vertebrae. The moksim included the neck and anterior of the chuck. The yangjee included the entire ventral region from the stenum to the abdominal muscle, while the kalbi was an equally long cut including a ladder or rib sections plus dorsal abdominal muscles (Swatland, 2000). The 10 primal (wholesale) beef cuts and sub-primal (retail) cuts including the major muscles from Hanwoo carcasses are shown in Table 1. Proximate analysis and meat quality traits were investigated by every retail cuts of each primal cuts. The 10 primal cuts were represented by mean values of all retail cuts.

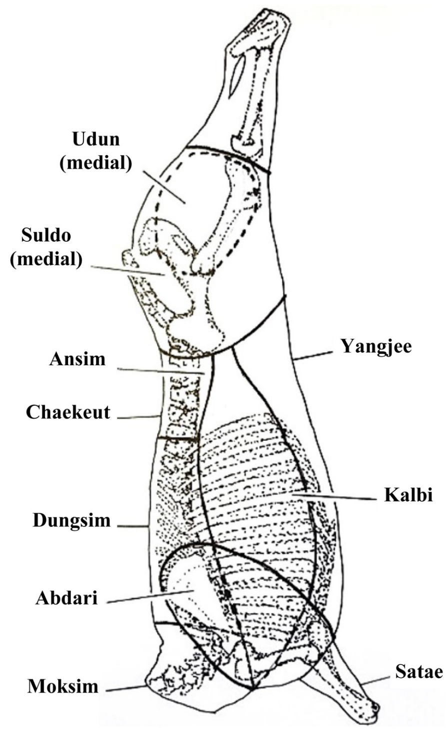

Fig. 1. Schematic illustration of fabrication 10 primal cuts from Hanwoo carcass in Korea.

Proximate Analysis

Moisture content and crude ash were determined using oven drying method (AOAC, 1995). Samples (approximately 2 g) were weighed and allowed to dry at 100°C for 24 h in an air oven. Samples were then cooled in a desiccator and weighed. Loss in weight was reported as moisture. Crude ash concentration was determined with a muffle furnace at 600°C for 8 h. Approximately 1 g of sample was weighed into crucible. Left in weight was reported as crude ash content. Crude protein content was determined using the Kjeldahl method (AOAC, 1995, Buchi Kjeldahl Digestion Unit K-424 and Distillation Unit B-324, Buchi co, Germany). Approximately 0.5 g of dried meat sample was weighed into combustion boats and the weight was recorded. Crude protein levels were determined by multiplying total nitrogen with a factor of 6.25.

Fat content was determined using modified method of Folch *et al.* (1957). Lipid was extracted from 3 g homogenized meat sample with 30 ml of Folch solution I (chloroform : methanol = 2 : 1, v/v). The homogenate was filtered with Whatman No.1 filter paper. Filtered solution was stirred with 0.88% of NaCl and allowed to separate into two layers. After washing the wall of a measuring cylinder with 10 mL of Folch solution II (chloroform : methanol : H_2O = 3 : 47 : 50), the final volume of the

Table 1. The 10 primal cuts and sub-primal cuts in Korean (major muscles) evaluated

Primal cuts	Sub-primal cuts	Major muscles
Ansim	Ansimsal	*Psoas major*
Dungsim	Witdungsimsal	*Rhomboideus*
	Kotdungsimsal	*Longissimus thoracis*
	Araedungsimsal	*Longissimus thoracis*
	Salchisal	*Serratus ventralis*
Chaekeut	Chaekeutsal	*Longissimus lumborum*
Moksim	Moksimsal	*Semisponals*
Abdari	Kurisal	*Supraspinatus*
	Buchaesal	*Infraspinatus*
	Abdarisal	*Triceps brachii*
	Kalbidutsal	*Latissimus dorsi*
	Buchaedupkaesal	*Subscapularis*
Udun	Udunsal	*Semimembranosus*
	Hongdukaesal	*Semitendinosus*
Suldo	Boseopsal	*Middle gluteal*
	Seolgitsal	*Biceps femoris*
	Seolgitmeorisal	*Caudal intertransverse*
	Doganisal	*Vastus medialis*
	Samgaksal	*Tensor fasciae latae*
Yangjee	Yangjeemeorisal	*Supraspinatus*
	Chadolbagi	*Ascending pectoral*
	Upjinsal	*Rectus abdominis*
	Upjinansal	*Transverse abdominus*
	Chimayangjee	*External abdominal oblique*
	Chimasal	*Internal abdominal oblique*
	Abchimasal	*Rectus abdominis*
Satae	Absatae	*Ulnaris lateralis*
	Dwitsatae	*Triceps surae*
	Mungchisatae	*Gastrocnemius*
	Arongsatae	*Superficialis digital flexor*
	Sangbacksal	*Brachialis*
Kalbi	Bonkalbi	*Internal intercostal*
	Kotkalbi	*Internal intercostal*
	Chamkalbi	*Internal intercostal*
	kalbisal	*Internal intercostal*
	Maguri	*Serratus doraslis ctanialis*
	Toshisal	*Psoas minor*
	Anchangsal	*Diaphragm*
	Jebichuri	*Longus capitis*

lower layer was recorded. The upper layer (methanol and water layer) was removed using an aspirator, while 10 mL of the lower layer (chloroform containing lipid extracts) was taken into a dish to dry at 50°C. The weight of the dish was measured before and after drying. Fat content was computed from the weight difference of dish.

Meat quality traits

The pH was measured in triplicates using a digital pH meter (MP230, Mettler-Toledo, Switzerland). Approximately 3 g sample was cut into small pieces. A total of 27 mL of distilled water was then added. A slurry was then made using a homogenizer. Its pH was then measured and recorded.

Drip loss was measured as the weight loss during suspension of a standardized (2 cm diameter × 2 cm thickness) sample in a plastic box (18 × 15 × 10 cm) at 4°C for 24 h (Joo *et al.*, 2002). Drip loss was computed from the weight of the drip and that of the sample. It was expressed as a percentage loss based on the initial sample weight. The cooking loss was determined by the weight loss during cooking. Sample (2 cm diameter × 2 cm thickness) in a plastic bag was broiled in a water bath at temperature of 90°C for 30 min. Samples were then surface dried and weighed. The cooking loss was calculated using the following equation:

Cooking loss (%) = cooked weight/uncooked weight × 100

Warner-Bratzler shear force (WBSF, kg/cm^2) was measured using Instron Universal Testing Machine Model 3343 with a V-shaped shear blade. From each of six samples, as close as practicable to a 0.5 cm × 4.0 cm (approximately 2.0 cm^2) cross section area across to the fibers was cut to measure cutting force. Samples were placed at right angles to the blade. The crosshead speed was set at 100 mm/min. The full scale load was 50 kg.

Sarcomere length was determined using the method of Cross *et al*. (1981). Briefly, samples were placed in vials containing solution A (0.1 M KCl, 0.39 M boric acid, and 5 mM ethylenediaminetetra acetic acid in 2.5% glutaraldehyde) for 2 h. Samples were then transferred to fresh vials containing solution B (0.25 M KCl, 0.29 M boric acid, and 5 mM ethylenediaminetetra acetic acid in 2.5% glutaraldehyde) for 17-19 h. On the following day, individual fibers were torn into pieces and placed onto microscope slides with a drop of solution B. The slide was then placed horizontally in the path of a vertically oriented laser beam to give an array of diffraction bands on a screen. These bands were perpendicular to the long axis of the fibers as described by Cross *et al*. (1981). Sarcomere length (μm) was calculated using the following formula:

$$(\{632.8 \times 103 \times D \times SQRT\ [(T/D)2 + 1]\} / T) \times 100$$

where D was the distance (mm) from the specimen - holding device to the screen (D = 98 mm) and T was the separation (mm) between zero and the first maximum band. An average of 10 sarcomere lengths was obtained for each meat sample.

Sensory evaluation

Samples from each treatment were evaluated by an 8-member trained expert descriptive attribute sensory panel in Meat Science Laboratory at Gyeongsang National University. Panelists evaluated the samples for flavor, juiciness, tenderness, and overall acceptability using a 9-point hedonic scale as described by Meilgaard *et al*. (1999), where point of 1 indicated "extremely dislike" and point of 9 meant "extremely like".

Statistical analysis

Data from three replications were analyzed by analysis of variance (ANOVA) using statistical analysis systems (SAS, 2002). ANOVA was adopted to design the mathematical model using SAS 9.2 (SAS Institute, Inc., USA). Duncan's multiple range tests were used to determine significance among means. Statistical significance was considered when P value was less than 0.05.

Results

There were significant ($p<0.05$) differences in chemical components among the 10 primal cuts from Hanwoo carcasses (Table 2). The highest fat content was found in kalbi, followed by dungsim, yangjee, chaekeut, ansim, abdari, suldo, moksim, udun, and satae. The fat content of kalbi was 19.42%, which was about five times higher than that of satae (4.96%). All 10 primal cuts showed significant ($p<0.05$) differences in the percentage of chemical fat, although undun showed no significant differences ($p<0.05$) from moksim or satae. In addition, the fat con-

Table 2. Proximate composition (%) of the 10 primal cuts from Hanwoo carcasses

Primal cuts	Crude fat	Crude protein	Crude ash	Crude moisture
Ansim	8.95 ± 3.05^{D}	20.58 ± 0.8^{CD}	2.72 ± 0.42^{BCD}	66.99 ± 3.40^{C}
Dungsim	17.00 ± 8.36^{B}	18.57 ± 1.80^{F}	2.54 ± 0.47^{E}	61.29 ± 6.44^{E}
Chaekeut	12.72 ± 4.98^{C}	19.93 ± 0.93^{E}	2.66 ± 0.40^{CDE}	63.09 ± 5.43^{D}
Moksim	6.63 ± 2.64^{E}	20.96 ± 0.78^{B}	2.75 ± 0.64^{BC}	69.71 ± 3.79^{B}
Abdari	8.89 ± 5.02^{D}	20.46 ± 1.29^{B}	2.82 ± 0.54^{B}	68.18 ± 4.35^{C}
Udun	5.42 ± 1.89^{EF}	21.18 ± 1.02^{B}	3.12 ± 0.49^{A}	70.46 ± 2.19^{AB}
Suldo	8.51 ± 4.01^{D}	20.92 ± 1.17^{BC}	2.83 ± 0.54^{B}	67.80 ± 4.70^{C}
Yangjee	15.85 ± 7.59^{B}	18.82 ± 1.68^{F}	2.59 ± 0.99^{DE}	61.9 ± 7.10^{DE}
Satae	4.96 ± 2.44^{F}	21.79 ± 1.48^{A}	3.06 ± 0.54^{A}	71.26 ± 2.61^{A}
Kalbi	19.42 ± 8.21^{A}	18.2 ± 2.19^{G}	2.32 ± 0.43^{F}	58.55 ± 6.99^{F}

Data are means±standard deviation.

$^{A-G}$Means within a same column with unlike superscripts are different ($p<0.05$).

tent of ansim was not significantly (p>0.05) different from abdari or suldo. Dungsim showed no difference in fat content from yangjee.

The results of protein and moisture contents were in reverse order of fat content. The highest protein content was found in satae, followed by udun, moksim, suldo, ansim, abdari, chaekeut, yangjee, dungsim, and kalbi. Satae also had the highest percentage of moisture. The lowest moisture content was found in kalbi. However, there were no significant (p>0.05) differences in protein contents among moksim, abdari, udun, or suldo. In addition, the protein and moisture contents of dungsim were similar to those of yangjee.

Differences in meat color measurements (CIE L*a*b*, Chroma and hue) are summarized in Table 3. Results of muscle pH, drip loss, cooking loss, sarcomere length, and WBSF of the 10 primal cuts from Hanwoo carcasses are summarized in Table 4. There were significant (p<0.05) differences in meat color measurements among the 10 primal cuts. The redness values (CIE a*) of ansim and moksim were significantly (p<0.05) higher than those of other primal cuts. The lightness values (CIE L*) of ansim, dungsim, yangjee, and kalbi were significantly (p<0.05) higher than others. Satae showed the lowest lightness value (p<0.05) and the lowest redness value compared to other primal cuts. However, there were no significantly (p >0.05) difference in CIE a* values among satae, udun, and chaekeut.

Although the pH of all primal cuts was within acceptable ranges (pH 5.54-5.84), kalbi had significantly (p< 0.05) greater pH values than all other cuts (Table 4). The pH value of udun was significantly (p<0.05) lower than other primal cuts. There were significant (p<0.05) differences in the percentages of drip loss and cooking loss among the 10 primal cuts. However, the variation in drip loss % was not bigger compared to cooking loss % among samples. Moksim had the highest drip loss % and cooking loss % than all other primal cuts while kalbi showed the lowest percentage of drip and cooking losses (p<0.05). The cooking loss % of dungsim, chaekeut, and yangjee were significantly (p<0.05) lower than all other cuts except moksim. Ansim had the longest sarcomere length and the lowest WBSF values than all other cuts (p<0.05). The highest WBSF value was observed in udun (p<0.05), follo-

Table 3. Meat color measurements (CIE L*a*b*, Chroma, hue) of the 10 primal cuts from Hanwoo carcasses

Primal cuts	L*	a*	b*	Chroma	hue
Ansim	$37.12±3.24^{A}$	$22.52±3.32^{A}$	$8.15±1.51^{A}$	$23.99±3.46^{A}$	$19.87±2.30^{AB}$
Dungsim	$37.10±3.93^{A}$	$20.84±2.73^{B}$	$7.57±1.51^{B}$	$22.20±2.87^{B}$	$20.00±3.17^{A}$
Chaekeut	$36.03±3.01^{B}$	$19.26±2.42^{E}$	$6.63±1.47^{E}$	$20.39±2.50^{C}$	$18.94±3.15^{C}$
Moksim	$36.15±2.37^{B}$	$22.63±2.49^{A}$	$8.36±1.77^{A}$	$23.81±2.62^{A}$	$20.10±3.08^{A}$
Abdari	$35.39±3.31^{B}$	$20.13±6.91^{CD}$	$6.52±1.56^{E}$	$20.92±2.73^{C}$	$18.03±3.46^{D}$
Udun	$35.66±2.89^{B}$	$19.65±3.10^{DE}$	$6.97±1.36^{D}$	$21.69±1.31^{B}$	$19.67±3.18^{AB}$
Suldo	$35.54±3.14^{B}$	$20.74±2.72^{BC}$	$7.28±1.56^{BC}$	$22.02±2.89^{B}$	$19.25±3.34^{CD}$
Yangjee	$37.46±4.32^{A}$	$20.99±3.02^{B}$	$7.54±1.65^{B}$	$22.31±3.09^{B}$	$19.81±3.53^{AB}$
Satae	$33.56±2.83^{C}$	$19.28±2.80^{E}$	$6.20±1.97^{F}$	$20.20±3.03^{C}$	$17.37±3.84^{E}$
Kalbi	$36.95±6.06^{A}$	$20.89±2.97^{B}$	$7.12±1.66^{CD}$	$22.02±3.10^{B}$	$18.92±4.44^{C}$

Data are means±standard deviation.
$^{A-F}$Means within a same column with unlike superscripts are different (p<0.05).

Table 4. Meat quality traits of the 10 primal cuts from Hanwoo carcasses

Primal cuts	pH	Drip loss (%)	Cooking loss (%)	Sarcomere length (μm)	Shear force (kg/cm^2)
Ansim	$5.55±0.18^{EF}$	$0.91±0.25^{AB}$	$34.33±3.45^{C}$	$2.89±0.39^{A}$	$2.34±0.58^{I}$
Dungsim	$5.62±0.21^{D}$	$0.87±0.29^{BC}$	$32.45±5.09^{D}$	$1.81±0.32^{E}$	$3.24±0.99^{G}$
Chaekeut	$5.58±0.25^{DEF}$	$0.83±0.30^{BCD}$	$32.85±4.45^{D}$	$1.84±0.23^{E}$	$3.62±0.92^{F}$
Moksim	$5.62±0.18^{D}$	$0.97±0.33^{A}$	$39.26±4.39^{A}$	$1.98±0.28^{C}$	$4.84±1.32^{B}$
Abdari	$5.68±0.21^{C}$	$0.82±0.30^{CD}$	$36.91±5.15^{B}$	$1.83±0.43^{E}$	$4.61±1.35^{CD}$
Udun	$5.54±0.17^{F}$	$0.77±0.27^{D}$	$37.62±3.72^{B}$	$1.74±0.31^{F}$	$5.47±1.47^{A}$
Suldo	$5.59±0.20^{DE}$	$0.81±0.28^{CD}$	$36.81±4.14^{B}$	$1.95±0.50^{CD}$	$4.55±1.27^{D}$
Yangjee	$5.70±0.18^{C}$	$0.80±0.30^{CD}$	$32.35±5.05^{D}$	$2.19±0.53^{B}$	$3.99±1.12^{E}$
Satae	$5.75±0.22^{B}$	$0.77±0.31^{D}$	$34.62±4.63^{C}$	$1.90±0.50^{D}$	$4.77±1.53^{BC}$
Kalbi	$5.84±0.20^{A}$	$0.77±0.28^{D}$	$30.76±5.38^{E}$	$2.21±0.43^{B}$	$2.94±0.86^{H}$

Data are means±standard deviation.
$^{A-I}$Means within a same column with unlike superscripts are different (p<0.05).

Table 5. Sensory panel scores of the 10 primal cuts from Hanwoo carcasses

Primal cuts	Flavor	Juiciness	Tenderness	Overall acceptability
Ansim	7.14±0.36^{AB}	6.82±0.22^{D}	8.28±0.56^{A}	8.10±0.48^{A}
Dungsim	7.40±0.26^{A}	7.96±0.27^{AB}	7.36±0.21^{B}	7.62±0.24^{A}
Chaekeut	6.86±0.21^{BC}	7.62±0.24^{BC}	7.16±0.42^{BC}	7.52±0.37^{A}
Moksim	5.32±0.41^{E}	4.86±0.30^{G}	4.86±0.22^{D}	5.22±0.31^{D}
Abdari	5.48±0.51^{E}	5.84±0.47^{E}	5.00±1.58^{D}	5.50±0.50^{CD}
Udun	6.24±0.30^{D}	5.24±0.47^{FG}	4.54±0.39^{D}	5.44±0.34^{D}
Suldo	6.36±0.42^{CD}	5.38±0.30^{F}	5.08±0.31^{D}	6.16±0.34^{BC}
Yangjee	6.76±0.43^{BC}	7.34±0.36^{C}	6.48±0.31^{C}	6.50±0.39^{B}
Satae	5.98±0.35^{D}	6.42±0.40^{D}	4.90±0.33^{D}	5.60±1.14^{CD}
Kalbi	7.50±0.50^{A}	8.24±0.38^{A}	7.34±0.44^{B}	7.84±0.30^{A}

Data are means±standard deviation.
$^{A-G}$Means within a same column with unlike superscripts are different (p<0.05).
[1)]Based on a 9-point intensity scale (1=dislike extremely or extremely and 9=like extremely or extremely).

wed by moksim, satae, abdari, suldo, yangjee, chaekeut, dungsim, kalbi, and ansim.

Sensory evaluation results are shown in Table 5. Overall flavor scores ranged from 5.98 to 7.50. Kalbi and dungsim were rated the highest (p<0.05) in flavor. Sensory flavor scores of moksim and abdari were significantly (p< 0.05) lower than other cuts. Similarly, the highest scores for juiciness were observed for kalbi and dungsim, while moksim was rated the lowest (p<0.05) in juiciness. Overall juiciness scores ranged from 4.86 to 8.24. Sensory tenderness scores of ansim was significantly (p<0.05) higher than other cuts. No difference (p>0.05) was detected in seonsory tenderness among moksim, abdari, udun, or satae. The panel rated these primal cuts as tougher than beef cuts. Although the sensory tenderness scores of dungsim, chaekeut, and kalbi were lower than ansim, these cuts were rated as tenderer than other primal cuts. Consequently, the highest score for overall acceptability was observed for ansim. Dungsim, chaekeut, kalbi, and ansim had no significant (p>0.05) difference in overall acceptability. Moksim, udun, abdari, and satae were rated the lowest (p<0.05) in overall acceptability among the 10 primal cuts from Hanwoo carcasses.

Discussion

Comparison of chemical components across 10 primal cuts from Hanwoo carcasses can provide insight into attributes that can dictate variation in sensory palatability and meat quality traits. In Korea, consumers and producers of Hanwoo beef have increased awareness of the nutrition value and quality traits related to chemical components in retail beef cuts. Hanwoo beef cuts traditionally have been marketed by primal cuts that usually contain several different sub-primal cuts. In most cases, these sub-primal cuts vary considerably in physical and chemical properties, resulting different sensory and nutritive characteristics. Our results revealed considerable variations in chemical components among the 10 primal cuts from Hanwoo carcass (Table 1). These results were consistent with previous findings about their differences in moisture (Briskey *et al*., 1960; Hunt and Hedrick, 1977) and fat (Jeremiah *et al*., 2003; McKeith *et al*., 1985).

More chemical fat was extracted from kalbi and dungsim compared to that from satae or udun. On the contrary, the percentage of moisture in kalbi and dungsim was higher while that in satae and udun was lower. The percentage of protein among the 10 primal cuts showed a similar tendency as moisture content. Our results were in agreement with previous observation that high fat content meat had less protein and moisture levels (Hunt *et al*., 2014; McKeith *et al*., 1985; Von Seggern *et al*., 2005).

Variation in chemical component among the 10 primal cuts has contributed to the inability of the Korean beef industry to supply consumers with consistent nutritive and palatability of Hanwoo beef cuts. Previous research studies have suggested that beef muscles should be merchandised as individual muscles (Jeong *et al*., 2009; Jeremiah *et al.*, 2003; Johnson *et al*., 1988; Lepper-Blilie *et al*., 2014; Roseland *et al*., 2015). However, the chemical and quality attributes of the 10 primal cuts or major muscles of the modern Hanwoo carcass have not been comprehensively investigated or characterized. Our present study results provided up-to-date nutrient data of modern Hanwoo beef cuts as well as meat quality data so that consumers could make healthy selection and cooking method.

In this study, variations in meat quality traits including color measurements, pH, drip loss %, cooking loss %, sarcomere length, and WBSF were observed for 10 primal cuts from Hanwoo carcass. The difference in color measurements was probably due to difference in red muscle fiber rate and myoglobin content of the 10 primal cuts. In general, muscles from pasture-fed cattle have higher proportion of oxidative fibers and darker colors than muscle from grain-fed cattle (Vestergaard *et al*., 2000). Moreover, active muscles have been reported to be darker and less tender (Segars *et al*., 1974). Jeong *et al*. (2009) have investigated the color characteristics of 3 major muscles from grain-fed Hanwoo were cattle and found that *Psoas major* muscle has more myoglobin content than *Longissimus dorsi* and *Semimembranosus* muscles. They also have found that the rapid discoloration found in *Psoas maj*or muscle is due to its higher myoglobin and mitochondria contents. Our present results also indicated that primal cuts containing active muscles such as ansim and moksim sustained higher redness (CIE a*) and chroma.

It has been reported that highly marbled meat has less drip loss, resulting in increased water-holding capacity (Joo *et al*., 2000, 2002), in agreement with our results in this study. According to Jeremiah *et al*. (2003), fatter cuts have lower drip and cooking losses. In addition, cuts containing more moisture can sustain greater drip and cooking losses. In this study, the highly marbled primal cuts such as kalbi, dungsim, and yangjee had lower percentage of drip and cooking losses compared to lean primal cuts such as moksim, abdari, udun, and suldo. Our results also supported previous findings that steaks from carcasses with higher marbling scores had lower shear force values than steaks with lower marbling scores (Smith *et al*., 1985). In addition, active muscles have been reported to be less tender (Segars *et al*., 1974). In the present study, primal cuts containing more lipids showed lower WBSF values than primal cuts containing less lipids. Consequently, the higher fat content cuts were rated higher score in flavor, juiciness, and tenderness, resulted in higher overall acceptability. Our results were consistent with earlier reports indicating that intramuscular fat and moisture were related to palatability attributes (Jeremiah, 1978). The highest score for overall acceptability was observed in ansim, dungsim, chaekeut, and kalbi that were primal cuts containing higher fat content but lower WBSF with shorter sarcomere length.

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