RELATIONSHIP BETWEEN CARCASS WEIGHT AND MEAT QUALITY AND ANTIOXIDATIVE DIPEPTIDES OF HANWOO (KOREAN NATIVE CATTLE) BEEF

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Abstract – Effects of carcass weight of Hanwoo (Korean native cattle) beef on meat quality, antioxidative dipeptides, and sensory attributes were investigated. The carcasses of 250 Hanwoo steers were categorized into light (<375 kg), medium (375–425 kg), and heavy (>425 kg) groups and were evaluated for back fat thickness, rib eye area, and beef marbling score 24 h postmortem by using the Korean carcass grading system. The proximate composition, physicochemical meat quality parameters, and micronutrient components of the *longissimus dorsi* muscles were analyzed. Rib eye area, back fat thickness, and marbling score significantly increased with increasing carcass weight. Inosine-5′-monophosphate content was significantly higher in medium and heavy carcasses. Carnosine content was significantly higher in medium carcasses. Total saturated fatty acid content and *n*-6/*n*-3 ratio decreased as carcass weight increased. Medium and heavy carcasses had significantly higher scores for sensory quality parameters. Overall, medium carcasses of Hanwoo displayed optimal sensory and economic quality and health benefits.

Key Words – Beef Quality, Carnosine, Marbling

- INTRODUCTION

The commercialized production of Hanwoo (Korean native cattle) as meat cattle began in the 1960s, accompanying rapid economic growth in the country [1]. Hanwoo beef is characterized by its highly marbled fat, relatively thin muscle fibers, and minimal connective tissue content [2]. A rapid increase in per capita meat consumption was observed in Korea—from 14 kg in 1985 to 40 kg in 2010—with a parallel rise in beef consumption from 3 to 12 kg [1]. Beef producers have begun paying increased attention to the accumulation of intramuscular fat (IMF) in beef muscles because Korean consumers prefer to purchase highly marbled meats. This preference has led to an extension of the marketing age of Hanwoo to an average of 31 months (marketing weight, 694 kg), primarily aiming for a higher beef marbling standard compared to that at the previous age of approximately 24 months (marketing weight, 425 kg; [1]). Therefore, most Korean cattle farmers are highly interested in extended feeding using specific feeding regimes—in particular, excess levels of concentrate diet—to reach a better quality grade with high marbling scores, because beef price is currently determined by quality grade.

In the Korean beef grading system, robust marbling and less back fat result in good quality and yield grades [3]. It has been reported that the quality grade of Hanwoo can be improved by extending the feeding period [4]. Heavier carcasses produced by extended feeding result in higher quality grades but lower yield grades, primarily owing to the significant effect of back fat thickness on yield grade [5]. A study conducted by Moon et al. [3] have shown that every steer and heifer in their study lost $219.25 owing to excessive fat production, of which $111.99 and $62.94 were due to excess subcutaneous fat and excess intermuscular fat, respectively. This finding confirms that extended feeding eventually burdens stakeholders of the beef industry.

Therefore, the feeding practices of Hanwoo should be carefully monitored and strategies tailored with an economic point of view because retail carcass price is a sum of quality and yield grades [3].

No research has been conducted to elucidate the relationship between carcass weight and the quality and functional properties of Hanwoo beef. Hence, this study was conducted to determine (1) the effects of carcass weight of Hanwoo beef on meat quality, and antioxidative dipeptides, and (2) the carcass weight group of Hanwoo beef with superior sensory and economic quality and health benefits.

- MATERIALS AND METHODS

Animals and sample preparation

The carcasses of 250 Hanwoo steers (27–30 months old) were categorized into light (<375 kg; n=74), medium (375–425 kg; n=76), and heavy (>425 kg; n=100) groups after cooling at 0°C for 24 h. The left sides of the carcasses were then ribbed between the 13th rib and the 1st lumbar vertebrae 24 h postmortem and evaluated for back fat thickness, rib eye area, and beef marbling score by an official meat grader according to the Korean carcass grading procedure [6]. The *longissimus dorsi* (LD) muscles were removed from all carcasses. After aging at 4°C for 7 days, the muscles were trimmed of all subcutaneous and intermuscular fat and visible connective tissue.

Analytical procedures

The proximate composition of each LD muscle was determined as outlined by AOAC [7]. The pH of each meat sample was determined with a pH meter. In addition, the water holding capacity (WHC) was determined using the centrifugation method of Kang et al. [8]. Drip loss was measured as the percentage weight loss of a standardized (3×3×3cm) meat sample placed in a Petri dish at 4C and stored for 2 days. Cooking loss was determined as the percentage weight loss of a standardized (3×3×3cm) meat sample after cooking on an electric grill with double pans for 90 s until the internal temperature reached 72C. Color (CIE L*, a*, and b*) values on the surface of meat samples and maximum shear force value (kg) were measured using a colorimeter and a Warner-Bratzler shear attachment on a texture analyzer, respectively. After extracting lipids from meat samples [9], fatty acid and cholesterol contents were determined by the methods of Jung et al. [10]. Free amino acid composition was analyzed using the method described by Hughes et al. [11] with modification. Dipeptide and nucleotide contents of the meat samples were determined according to the methods of Mora et al. [12] and Jung et al. [13], respectively.
During the sensory evaluation, 10 panelists recorded their preferences for cooked Hanwoo beef using a 9-point hedonic scale. The tested sensory parameters were color, odor, tenderness, juiciness, and overall acceptance.

Statistical analyses

Analysis of variance was performed on all variables by applying the general linear model with SAS statistical package [14]. The Duncan's multiple-range test was used to determine differences among the treatment means at $P<0.05$.

- RESULTS AND DISCUSSION

Light carcasses had higher ($P<0.05$) moisture content than medium and heavy carcasses, which had significantly higher fat content (Data not shown). This agrees with the general rule that IMF

content is inversely related to moisture content in meat [15]. Protein, ash and cholesterol contents did not differ (P>0.05) among the groups in this study (Data not shown) and were comparable to the findings of Kim et al. [15]. In general, rib eye area, back fat thickness, and marbling score significantly increased with increasing carcass weight (Table 1), which agrees with the findings of Moon et al. [3] and Park et al. [4]. The data of Kim et al. [15] suggest that marbling score and loin eye area increase as carcass weight increases, with a significant effect only on marbling score.
In addition, carcass weight had highly positive correlations with rib eye area (0.62), back fat thickness (0.53), and marbling score (0.29) in this study.

Carcass weight had no significant effect on meat color, pH, WHC, drip loss, or cooking loss (P>0.05). However, compared with the other groups, light carcasses had significantly higher shear force values (Data not shown). It was reported that increased Hanwoo steer carcass weight was associated with significantly decreased shear force and cooking loss values and increased CIE L* values [16]. Significantly higher shear force values in light carcasses can be attributed to their lower fat content and marbling score because shear force values are negatively related to IMF content [15].

Table 1 Major meat grading parameters and chemical composition of Hanwoo beef from different carcass weight groups

	Carcass weight group			
	Light	Medium	Heavy	SEM[d]
Grading parameters				
Rib eye area (cm^2)	81.24[c]	89.59[b]	94.23[a]	0.87
Back fat thickness (mm)	9.66[c]	13.95[b]	15.87[a]	0.54
Marbling score	4.26[b]	5.33[a]	5.31[a]	0.20
Nucleotides (mg/100 g)				
IMP	228.37[b]	272.88[a]	286.12[a]	11.78
Hypoxanthine	1098.12[a]	961.59[b]	850.50[b]	46.70
Dipeptide (mg/100 g)				
Carnosine	692.3[b]	745.73[a]	693.78[b]	16.71
Creatinine	16.43[b]	17.80[b]	21.22[a]	0.86

[a-c] Means with different superscript within the same row differ significantly (P<0.05)
[d] Standard error of means (n = 250)

IMP content in the studied carcasses was significantly higher in medium and heavy carcasses (Table 1). Conversely, light carcasses had the highest (P<0.05) hypoxanthine content. AMP and inosine contents did not differ among carcass weight groups (P>0.05; Data not shown). In a study comparing various cuts of Hanwoo bull beef, much higher IMP, inosine, and hypoxanthine and lower AMP levels were reported [17] than those in our study.

In the present study, carcass weight showed no significant association with soluble amino acid content except for aspartic acid, glutamic acid, cysteine, and phenylalanine (Data not shown). Light and medium carcasses had significantly higher aspartic acid content. Heavy carcasses had the highest (P<0.05) glutamic acid content. Both cysteine and phenylalanine contents were significantly greater in heavy and medium carcasses. The content of dipeptides with the exception of creatinine fluctuated as carcass weight increased (Table 1). Medium and heavy carcasses had significantly higher carnosine and creatinine content, respectively.

In general, total saturated fatty acid (SFA) content and n-6/n-3 ratio decreased, whereas total unsaturated fatty acid (USFA) content increased with increasing carcass weight (Data not shown). Total SFA content was significantly higher in light carcasses, whereas total USFA content, total monounsaturated fatty acid (MUFA) content, USFA/SFA ratio, and MUFA/SFA ratio were significantly higher in medium and heavy carcasses. Oleic acid (C18:1) was the main

fatty acid we found in Hanwoo beef, followed by palmitic (C16:0) acid. Further, polyunsaturated fatty acid (PUFA) content did not differ among carcass groups (P>0.05). n-6/n-3 ratio was higher (P<0.05) in light carcasses and lower in medium carcasses which indicated higher availability of n-3 essential fatty acids in medium carcasses. Although much lower values were reported for PUFA/SFA ratio in this study, medium and heavy carcasses of Hanwoo had better fatty acid compositions, with higher USFA content and lower SFA content and n-6/n-3 ratio.

Color and odor did not differ (P>0.05), but significant differences were found for tenderness, juiciness, and overall acceptance (P<0.05; Table 2). Similarly, sensory qualities including tenderness and juiciness increased as carcass weight increased in previous studies of Hanwoo beef [16]. Significantly higher tenderness and juiciness scores in medium and heavy carcasses might be attributed to higher IMF content in these carcasses (Hocquette et al., 2010). The higher overall acceptability scores of beef from medium and heavy carcasses might be associated with the synergistic effect of their higher (P<0.05) tenderness and juiciness scores.

Table 2 Sensory characteristics of Hanwoo beef from different carcass weight groups

	Carcass weight group			
	Light	Medium	Heavy	SEM[d]
Colour	5.19	5.07	5.32	0.10
Odour	5.18	4.93	5.15	0.26
Tenderness	4.55[b]	5.04[a]	5.27[a]	0.15
Juiciness	4.63[b]	5.16[a]	5.42[a]	0.14
Overall acceptance	4.50[b]	5.07[a]	5.18[a]	0.14

[a-b] Means with different superscript within the same row differ significantly (P<0.05)
[c] Standard error of means (n = 10)

- CONCLUSION

Carcass weight was significantly associated with the quality and functional properties of Hanwoo beef. In particular, IMP, carnosine, and USFA contents increased, whereas shear force, SFA content, and n-6/n-3 ratio decreased with increasing carcass weight. Considering all parameters examined in the present study, the medium (375–425 kg) carcass weight of Hanwoo appears optimal for superior sensory and economic quality and health benefits.

ACKNOWLEDGEMENTS

This research was supported by the Technology Development Program for Agriculture and Forestry (Project No. 311016-3), Ministry of Agriculture, Forestry, and Fisheries, Republic of Korea.

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