CHARACTERIZATION OF MARBLING FLECK DISTRIBUTION AND ITS RELATIONSHIP WITH OBJECTIVE TENDERNESS PARAMETERS IN HIGH-MARBLED HANWOO STEERS

B. Lee[1], Y. Lee[1], E. Oh[1], S. Yun[2], H. Kwon[2], B. D. Kim[2], K. Kuchida[3], and Y. M. Choi[1*]

[1]Department of Animal Sciences, Kyungpook National University, Sangju 37224, South Korea

[2]Korea Institute for Animal Products Quality Evaluation, Sejong 30100, South Korea

[3]Obihiro University of Agriculture and Veterinary Medicine, Obihiro 080-8555, Japan

*Corresponding author email: ymchoi1@knu.ac.kr

I. INTRODUCTION

Intramuscular fat (IMF) content is one of the main factors that influence the palatability of beef, especially tenderness, and distribution and extent of marbling flecks can make a variation in sensory quality traits [1]. Previous studies have been provided the indicators for marbling fleck distribution including the fineness and coarseness indexes by image analysis, and they also reported the strong correlation between marbling traits and IMF content [2, 3]. However, the relationships between marbling traits and tenderness have not been fully investigated in Hanwoo steers. Therefore, the aim of this study was to compare marbling traits and tenderness parameters in the groups classified by marbling distribution in high-marbled Hanwoo steers.

II. MATERIALS AND METHODS

A total of 30 high-marbled Hanwoo steers were used. After carcass grading, the Korean Institute of Animal Products Quality Evaluation [4] provided marbling score (1 to 9, devoid to very abundant) and loin-eye area for each carcass at the 13th thoracic vertebrae of *longissimus thoracis* muscle. The characteristics of marbling flecks were evaluated using the mirror type digital camera and BeefAnalyzer-G software [2]. Fineness (F, number of smaller marbling flecks per loin-eye area) and coarseness (C, total area of bigger marbling flecks per total marbling area measured) of marbling flecks were calculated [2]. Marbling distribution was classified into the fine ($F \geq 3.0$, $C < 0.18$) and coarse ($F < 3.0$, $C \geq 0.18$) groups [2]. Cooking loss was measured according to the procedures of Honikel [5]. Warner-Bratzler shear force (WBS) and texture profile analysis (TPA) were determined by an Instron Universal Testing Machine (Model 1011, Instron Corp., USA) and texture analyzer (TMS-Touch, Food Technology Corp., USA), respectively.

III. RESULTS AND DISCUSSION

The coarse group exhibited greater marbling surface area and percentage of marbling area compared to the fine group ($P < 0.05$), whereas there were no significant differences in marbling score and loin-eye area between the groups (Table 1, $P > 0.05$). There was marked difference in number of marbling flecks between the fine and coarse groups ($P < 0.001$). As expected, the coarse group had lower fineness and higher coarseness compared to the fine group ($P < 0.05$).

Table 1. Comparison of marbling characteristics in the groups categorized by marbling distribution at the 13th thoracic vertebrae of *longissimus thoracis* muscle

	Marbling distribution group		Level of significance
	Coarse (N = 10)	Fine (N = 20)	
Marbling score	8.00 (0.06)[1]	8.01 (0.04)	NS
Loin-eye area (cm^2)	107 (4.00)	106 (2.98)	NS
Total marbling surface area (cm^2)	39.7[a] (1.73)	32.6[b] (1.22)	**
Marbling area percentage (%)	37.2[a] (0.90)	31.8[b] (0.64)	***
Number of marbling flecks	1270[b] (332)	3120[a] (248)	***
Fineness (F)	2.49[b] (0.10)	3.64[a] (0.07)	***
Coarseness (C)	0.29[a] (0.01)	0.10[b] (0.01)	***
F/C ratio	8.78[b] (4.85)	40.8[a] (3.61)	***

[1] Standard error of least square means. Level of significance: NS = not significant; ** $P < 0.01$; *** $P < 0.001$.
[a-b] Different superscripts in the same row represent significant differences ($P < 0.05$).

Cooking loss and tenderness parameters in the marbling distribution groups are shown in Table 2. There was significant difference in cooking loss between the coarse and fine groups (18.8 vs. 22.9%, $P < 0.05$). On the other hand, there are some reasons to explain the beneficial role of marbling to tenderness [6]. For example, marbling is less dense compared to the lean tissue, and marbling flecks replace protein with lipid thereby reducing the hardness of beef [6]. The results from the present study corroborate with this observation; bovine muscles harboring coarser marbling flecks exhibited a lower WBS value compared to muscles harboring finer marbling flecks (39.4 vs. 51.8 N, $P < 0.01$) in heavily-marbled beef. However, the coarse and fine groups displayed similar TPA values ($P > 0.05$) with the exception of gumminess ($P < 0.05$).

Table 2. Comparison of cooking loss, Warner-Bratzler shear force, and texture profile analysis in the groups categorized by marbling distribution at the 13th thoracic vertebrae of *longissimus thoracis* muscle

	Marbling distribution group		Level of significance
	Coarse	Fine	
Cooking loss (%)	18.8^{b} (1.33)[1]	22.9^{a} (0.99)	*
Warner-Bratzler shear force (N)	39.4^{b} (3.32)	51.8^{a} (2.48)	**
Texture profile analysis			
Hardness (N)	21.7 (1.18)	24.0 (0.88)	NS
Adhesiveness (N·mm)	1.51 (0.27)	1.58 (0.20)	NS
Cohesiveness	0.32 (0.02)	0.35 (0.02)	NS
Springiness (mm)	6.08 (0.24)	6.29 (0.17)	NS
Gumminess (N)	6.57^{b} (0.55)	8.02^{a} (0.41)	*
Chewiness (N·mm)	41.1 (4.38)	52.2 (3.27)	NS

[1] Standard error of least square means. Level of significance: NS = not significant; * $P < 0.05$; ** $P < 0.01$.
[a-b] Different superscripts in the same row represent significant differences ($P < 0.05$).

IV. CONCLUSION

Taken together, variation was observed in WBS value, even though no significant difference was detected in marbling score between the marbling distribution groups. These variation was associated with the marbling fleck characteristics of exposed muscle surface at the 13th thoracic vertebrae of *longissimus thoracis* muscle. Thus, image analysis for the marbling fleck traits is useful tool in order to improve prediction accuracy of palatability for the beef quality grading system.

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