EFFECT OF AGING DAYS ON WARNER BRATZLER SHEAR FORCE VALUES AND TENDERNESS OF DIFFERENT CUT FROM HANWOO STEER BEEF

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***Abstract*— This study was conducted to investigate the effect of aging on Warner-Bratzler shear force (WBS) values and the relaitonship between sensory tenderness scores and WBS values of Hanwoo beef. A total of 72 Korean Hanwoo steers (26 to 30 months old; 324 to 481 kg carcass weight) were obtained from a long-term feeding program at the Rural Development Administration Institute (RDA), Suwon, Korea. On the next day of slaughter, the carcasses were divided into four quality grade (1^{++}, 1^{+}, 1, 2) groups. The carcasses were deboned, and 11 primal cuts (loin, strip loin, chuck roll, chuck tender, eye of round, bottom round, top round, top sirloin, brisket, knuckle, and flank) were separated out and aged for 14 days at 2℃. WBS values were significantly lower in 1^{++} grade than those of 2 grade for chuck tender, chuck roll, bottom round and top sirloin on 0 days, and they were not significantly different among the quality grades on 14 days. WBS values were not significantly different in the quality grades for top round, knuckle and brisket on 0 days, and they were significantly lower in 1^{++} grade than those of 2 grade for the same muscles on 14 days. Eye of round and flank were not significantly different in the WBS values for the quality grades and the aging days ($p>0.05$) whereas loin and striploin muscles were significantly different for the quality grades and the aging days ($p<0.05$). The tenderness threshold in this study showed that four categories : 'tough' with WBS values > 5.01kg and ′tender' with WBS values < 4.68kg, ′very tender' with WBS values < 4.33kg, ′very tender' with WBS values < 4.09kg. The correlaiton of WBS values with tenderness ratings evlauated by consumer was -0.25 ($p<0.001$).**

Index Terms—tenderness, cut, aging, Hanwoo beef, sensory evaluation

I. INTRODUCTION

Meat tenderness is the most important quality trait for the consumer. However, it is a highly variable attribute, and difficult to evaluate befoe the purchase. According to the Cho et al. (2009), Korean consumers focused on tenderness than juiciness and flavor to assign their overall liking score. Meat tenderness depends on the properties of the muscle fibres and the amount and type of connective tissue. The aging process involves storing meat at refrigerated temperatures for sufficient time to maximize palatability characteristics such as tenderness, juiciness, and flavor (Parrish, Boles, Rust, & Olson, 1991; Warren & Kastner, 1992; Sitz, Calkins, Feuz, Umberger, & Eskridge, 2006). Ageing rates for individual muscles are higher for the low connective cuts relative to high connective cuts. Effects of cooking on meat tenderness have received considerable attention because consumer acceptance of cooked meat greatly depends on tenderness (Thompson, 2002). Heat solubilizes connective tissue, which causes tenderization, but hardens myofibrillar proteins, which causes toughening. Meat tenderness is closely related to meat texture, which is affected by myofibrillar proteins, muscle cytoskeleton, intramuscular connective tissue (Silva, Orcutt, Forrest, Bracker, & Judge, 1993). The most widely used method is the single blade shear test of the Warner–Bratzler type. Correlations of Warner–Bratzler shear with sensory assessment of beef tenderness are variable, with r values ranging from _0.32 to _0.94 (Caine, Aalhus, Best, Dugan, & Jeremiah, 2003). This variability depends on many factors, such as muscle type, sample preparation, cooking method, shear apparatus, measurement procedure and panel type. The objective of this study was to investigate the effect of aging days on WBS values and the relationship between instrumental measurements and sensory tenderness scores evaluated by Korean consumers for Hanwoo steer beef obtained from different quality grades.

II. MATERIALS AND METHODS

Animals, treatment, and sample preparation : A total of 72 Korean Hanwoo steers (26 to 30 months old; 324 to 481 kg carcass weight) were obtained from a long-term feeding program at the Rural Development Administration Institute (RDA), Suwon, Korea. The animals were transported to and fasted off feed for approximately 12 hours, with access to water prior to slaughter. After they were were slaughtered at the NIAS abattoir and the carcasses were immediately moved to a chilling room. On the following day, the left side of the carcass was ribbed between the 12^{th} rib and the 13^{th}

rib after splitting. Carcasses were assigned the Korean quality grades by the experienced official graders and divided into four Korean quality grade groups (Table 1). After grading, the carcasses were transferred to a cutting room. They were deboned, and 11 primal cuts (loin, strip loin, chuck roll, eye of round, bottom round, top round, top sirloin, brisket, knuckle, and flank) were separated out. For convenience of storage and analyses, cuts removed from the left side of the carcass were vacuum packaged and aged for 14 days at a 2^{o}C chiller prior to cutting into smaller blocks for sensory evaluation and chemical analysis. The samples from the right side of a carcass were used without aging. The chemical compositions of protein, fat and moisture contents were analyzed by using methods of the Association of Official Analytical Chemists (AOAC, 1996). WBS values were measured according to the method of Wheeler et al. (2000).

Sensory evaluation : A total of 1,800 consumers were selected and socio-economic details were recorded for each consumer. For Korean roast thin-slice style cooking, individual beef strips were cooked by placing them on a tin plate equipped with a water jacket (ca. 245–255^{o}C). The strip was turned at the first pooling of liquid on the surface of the sample or at the start of shrinkage. The cooked strips were immediately served to each panelist for evaluation. Consumers were asked to score the samples for tenderness, juiciness, flavor, and overall liking. Scoring was done on a single sheet using four 100 mm line scale from 0 to 100, with 20-mm gradients marked. The four lines were labeled with the following words: tenderness = very tough (0) to very tender (100); juiciness = very dry (0) to very juicy (100); flavor = dislike extremely (0) to like extremely (100); overall liking = dislike extremely (0) to like extremely (100). The consumers also graded the satisfaction level of the tested sample as unsatisfactory, satisfactory, very satisfactory, and extremely satisfactory.

Statistical Analysis : Data were analyzed using PROC ANOVA and PROC DISCRIM routines in the ststical analysis system (version 9.1, SAS Institute Inc., Cary, NC, USA).

Table 1.
Means and variance for carcass traits for Korean cattle used in the experiment (n = 72 carcasses for each treatment) by the quality grades.

	Korean quality grade*			
	1^{++}	1^{+}	1	2
Sample numbers	16	22	22	12
Live weight (kg)	700.63±10.02^{a}	724.71±13.29^{ab}	642.20±15.07^{b}	603.33±15.3^{b}
Carcass weight (kg)	409.14±7.43^{a}	422.73±8.16^{a}	364.64±9.15^{b}	350.67±14.36^{b}
Intramuscular fat contents	21.48±0.89^{a}	17.61±0.36^{b}	11.02±0.63^{c}	6.60±0.74^{d}

$^{a–d}$ Means in the same row with different letters are significantly different ($P < 0.05$)

Table 2.
Warner-Bratzler shear force (WBS) values of 11 cuts obtained from Hanwoo steer beef by quality grade groups when stored at 2^{o}C for 14 days.

Primal cut	Aging days	1^{++}	1^{+}	1	2	Overall Mean
Loin	0	3.45(0.42)^{b}	3.82(0.3)^{ab}	4.00(0.21)^{ab}	4.85(0.26)^{a}	3.73(0.16)^{x}
	14	1.95(0.11)^{b}	2.51(0.11)^{a}	2.40(0.22)^{a}	2.57(0.52)^{a}	2.42(0.12)^{y}
Strip loin	0	3.95(0.36)^{c}	4.86(0.30)^{b}	5.34(0.21)^{b}	8.42(1.21)^{a}	5.14(0.14)^{x}
	14	1.38(0.21)^{b}	2.92(0.13)^{a}	3.34(0.22)^{a}	3.92(0.51)^{a}	3.07(0.19)^{y}
Chuck tender	0	4.85(0.37)	5.96(0.31)^{a}	5.79(0.29)	5.05(0.42)^{a}	5.57(0.18)^{x}
	14	3.98(0.01)	4.30(0.25)	4.6(0.25)	5.34(0.66)	4.54(0.18)^{y}
Chuck roll	0	5.08(0.40)^{b}	6.79(0.27)^{ab}	5.64(0.36)^{b}	7.82(1.45)^{a}	6.18(0.24)^{x}
	14	3.82(0.81)	4.33(0.23)	5.25(0.46)	5.34(1.56)	4.72(0.32)^{y}
Bottom round	0	4.74(0.50)^{b}	6.11(0.32)^{ab}	6.52(0.44)^{ab}	7.98(1.17)^{a}	6.15(0.27)^{x}
	14	3.64(0.37)	4.27(0.29)	4.88(0.26)	5.22(0.66)	4.58(0.20)^{y}
Top sirloin	0	4.78(0.59)^{b}	5.31(0.27)^{ab}	4.82(0.35)^{b}	6.42(0.76)^{a}	5.13(0.21)^{x}
	14	2.38(0.39)	3.08(0.15)	3.31(0.22)	3.81(0.77)	3.21(0.16)^{y}
Eye of round	0	5.16(0.19)	5.77(0.24)	6.2(0.33)	6.49(1.24)	5.86(0.18)^{x}

	14	3.74(0.24)	4.31(0.21)	4.97(0.33)	4.92(1.17)	4.60(0.23)^{y}
Top round	0	4.96(0.51)	5.43(0.20)	5.97(0.32)	6.04(0.69)	5.57(0.18)^{x}
	14	2.32(0.50)^{b}	3.55(0.26)^{a}	4.35(0.24)^{a}	4.13(0.39)^{a}	3.83(0.20)^{y}
Knuckle	0	4.07(1.01)	6.09(0.50)	5.57(0.29)	4.62(0.64)	5.50(0.27)
	14	2.88(0.07)^{b}	4.32(0.28)^{a}	4.33(0.45)^{a}	4.18(0.66)^{a}	4.15(0.23)
Brisket	0	5.46(0.65)	5.04(0.23)	4.79(0.21)	4.77(0.83)	5.01(0.18)^{x}
	14	2.57(0.04)^{b}	3.69(0.23)^{a}	4.22(0.28)^{a}	4.22(0.01)^{a}	3.85(0.17)^{y}
Flank	0	5.54(0.33)	6.73(0.29)	6.28(0.3)	6.5(0.98)	6.34(0.19)
	14	4.57(0.21)	4.74(0.13)	5.84(0.43)	5.51(0.61)	5.53(0.27)

$^{a–c}$Means in the same row with different letters are significantly different ($P < 0.05$).
$^{x–y}$Means in the same column with different letters are significantly different ($P < 0.05$)

Table 3.

Relationship of cut-off boundaries of Warner-Bratzler shear force (WBS) values and sensory tenderness scoreswhen evaluated by Korean consumers.

	Tough	Tender	Very tender	Extremely tender	Correlation of tenderness and WBS
Warner-Bratzler shear force (kg)	5.01 (1.43)	4.68 (1.47)	4.33 (1.48)	4.09 (1.44)	-0.25***

*$p<0.05$; **, $p<0.01$; ***, $p<0.001$*

III. RESULTS AND DISCUSSION

Live weight, carcass weight and intramuscular fat contents were significantly different among the Korean quality grades ($p<0.05$). 1^{++} grade had highest intramuscular fat contents (21.48%) and follwed by 1^{+}(17.61%), 1(11.02%) and 2 (6.60%) grade of loin ($p<0.05$). Tenderness is the most important textural characteristic of meat and has the greatest influence on consumer acceptance of meat. Postmortem aging is widely known to improve the tenderness of beef. As presented in Table 2, overall means of the WBS values were significantly decreased when compared to those of 0 days aging for most muscles after 14 days of aging treatment. This result could be expected that the myofibrilar component underwent structural disruption with increasing the aging time. WBS values were significantly lower in 1^{++} grade than those of 2 grade for chuck tender, chuck roll, bottom round and top sirloin on 0 days, and they were not significantly different among the quality grade on 14 days. WBS values were not significantly different in the quality grades for top round, knuckle and brisket on 0 days, and they were significantly lower in 1^{++} grade than those of 2 grade for the same muscles on 14 days. Eye of round and flank were not significantly different from the quality grades and the aging days ($p>0.05$) whereas loin and striploin muscles were significantly different both the quality grades and the aging days ($p<0.05$). Kim & Lee (2003) reported that the WBS values for the grade 3 samples at 1, 7 and 14 days postmortem was slightly higher than for the grade 1 and grade 2 samples. Huff & Parrish (1993) reported the age and postmortem aging time had more influence on tenderness atributes than did the sex of the animal and increased postmortem aging time improved tenderness attributse regardless of sex or age. WBS values were negatively correlated with the tenderness scores when evaluated by consumer panels (Table 3). Several studies have been carried out employing a trained panel in order to establish threshold values of WBS for tenderness acceptability (Shackelford, Wheeler, & Koohmaraie, 1997). These values ranged from 4.31 to 5.99 kg. Our results indicated that tenderness threshold of Hanwoo beef with WBS values divided into four categories : 'tough' with WBS values > 5.01kg and 'tender' with WBS values < 4.68kg, 'very tender' with WBS values < 4.33kg, 'very tender' with WBS values < 4.09kg. In this study, the correlations of WBS values with sensory assessment of beef tenderness are variable, with r values were - 0.25 ($p<0.001$).

IV. CONCLUSION

Aging was effective to increase the tenderness of Hanwoo beef. However, WBS values were different depending on the muscles type and the quality grade. Results suggested that the tenderness degrees can be determined by the WBS values.

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