Carcass Traits Determining Quality and Yield Grades of Hanwoo Steers

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ABSTRACT : A group of Hanwoo (Korean cattle) steers (n=14,386) was sampled from a commercial abattoir located in Seoul over one year period (spring, summer, autumn and winter) and their carcass traits were collected. Carcass traits assessed by an official meat grader comprised degree of marbling, meat color, fat color, texture and maturity for quality grade, and back fat thickness, ribeye area and carcass weight for yield grade. A heavier carcass with a higher marbling score, more red meat color and white fat color received better quality grade ($p<0.05$). Regression analysis showed that the marbling score was the strongest attribute (partial $R^2=0.88$) for quality grade. Lighter carcasses with a thinner back fat and larger ribeye area received higher yield grade score. The back fat thickness was the most negative determinant of yield grade (Partial $R^2=-0.66$). The slaughter season had a little effect on quality and yield grades. As slaughter weight increased, back fat thickness and ribeye area increased linearly, whereas marbling score reached its asymptotic level at approximately 570 kg. As a consequence, quality grade showed a considerable improvement up to 570 kg, but increases in slaughter weight afterward showed a little benefit on quality grade. There was a clear curvilinear relationship between slaughter weight and yield grade in that the yield grade reached its highest point at approximately 490 kg and decreased afterward. These results suggested that 570 kg at the age of 24 months might be the economic slaughter weight for quality grade but 490 kg for yield grade. ***(Asian-Aust. J. Anim. Sci. 2003. Vol 16, No. 7 : 1049-1054)***

Key Words : Quality Grade, Yield Grade, Slaughter Weight, Hanwoo

INTRODUCTION

Marbling is a prime theme in Korean beef industry, as consumers judge meat quality on the basis of the degree of marbling, and they are willing to pay premium for highly marbled product (APGS report, 2001). In 2001, the prime Hanwoo (Korean cattle) striploin received a more than three US dollar premium per kilogram compared to that for an average quality. Under the Korean meat market circumstance, carcass quality is largely determined by marbling score (Park et al., 2002), and consequently breeders and producers have forced on the improvement of marbling.

Fully matured Hanwoo steer was lighter than average US commercial breeds, and average Hanwoo carcass in slaughter age was lighter than these breeds by approximately 80 kg (Lorenzen et al., 1993; Hilton et al., 1998; Apple et al., 1999; Park et al., 2002). It has been shown that carcass weight was an important factor affecting meat quality through its effect on fattiness (Vergara et al., 1999). Rossi et al. (2000) noted that premium product (e.g., highly marbled meat) could offset the feed cost. We previously reported that quality grade of Hanwoo was improved when feeding period was extended (Park et al., 2002). Retail carcass price is a sum of quality and yield grades, and back fat thickness negatively affects yield grade. In this regard, it is important to determine optimum growth performance and feeding period for better marbling with less back fat. Furthermore, it is also necessary to understand the relative importance of carcass traits and their interactions determining quality and yield grades. Therefore, the current study was conducted to determine 1) the relationship between carcass traits and quality and yield grades, and 2) the effect of slaughter weight on carcass traits, quality grade and yield grade.

MATERIALS AND METHODS

A group of Hanwoo steers (n=14,386) was sampled from a commercial abattoir located in Seoul over one year period (spring, summer, autumn and winter) and their carcass traits were collected. Majority of the steers was approximately 24 months of age. The following day after slaughter, left side of carcass was ribbed between the last rib and the first lumbar vertebrae to evaluate carcass traits by an official meat grader at Korean Animal Products Grading Service (APGS).

Live and cold carcass weights represented the weights measured immediately before slaughter and at 24 h after slaughter, respectively. After a 30 min blooming period, evaluation was performed for marbling score, meat color, fat color, texture firmness and maturity on the basis of APGS manual (1995). Briefly, back fat thickness was

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Table 1. Least square means (±SD) of carcass traits, quality grade and yield grade for each quality and yield grade

Carcass traits	Quality grade				Yield grade		
	1+ (n=2,429)	1 (n=4,774)	2 (n=5,697)	3 (n=1,486)	A (n=5,685)	B (n=7,053)	C (n=1,648)
Live weight, kg	$591±58^a$	$584±59^b$	$575±60^c$	$551±69^d$	$572±55^c$	$575±64^b$	$612±63^a$
Carcass weight, kg	$348±37^a$	$341±38^b$	$333±39^c$	$316±43^d$	$330±34^c$	$335±41^b$	$364±41^a$
Back fat thickness, mm	$11.2±4.73^a$	$10.3±4.62^b$	$9.9±4.61^c$	$8.1±4.17^d$	$6.4±1.82^c$	$10.9±2.78^b$	$19.1±3.81^a$
Rib eye area, cm^2	$84.1±8.9^a$	$81.1±8.5^b$	$79.4±8.4^c$	$77.5±9.5^d$	$83.6±8.4^a$	$78.5±8.4^b$	$78.6±9.2^b$
Meat color score[1]	$4.46±0.50^d$	$4.45±0.52^c$	$4.50±0.54^b$	$4.65±0.59^a$	$4.52±0.55^a$	$4.45±0.53^b$	$4.41±0.53^c$
Fat color score[2]	$2.77±0.46^c$	$2.79±0.44^c$	$2.82±0.42^b$	$2.88±0.40^a$	$2.78±0.44^c$	$2.81±0.42^b$	$2.86±0.42^a$
Marbling score[3]	$17.3±1.2^a$	$12.3±1.8^b$	$6.3±1.8^c$	$2.4±0.7^d$	$9.5±5.1^c$	$9.8±4.9^b$	$10.4±4.2^a$
Texture score[4]	$2.6±0.7^d$	$3.2±0.7^c$	$4.0±0.5^b$	$4.2±0.6^a$	$3.6±0.9^a$	$3.5±0.8^b$	$3.4±0.8^c$
Overall maturity[5]	$2.03±0.18^a$	$2.02±0.17^a$	$2.02±0.17^a$	$2.00±0.26^b$	$2.02±0.15^b$	$2.01±0.18^b$	$2.04±0.25^a$
APGS yield and quality grade[6]	$221±67.9^c$	$226±65.9^b$	$229±65.2^b$	$245±60.0^a$	$25.0±9.1^c$	$25.9±8.8^b$	$27.3±8.6^a$

[1] 1=very light cherry red. 7=very dark red. [2] 1=white. 7=yellow. [3] 1=trace, 19=very abundant. [4] 1=very fine. 9=very coarse. [5] 1=very young 9=very old.
[6] 300=A. 200=B. 100=C, 1+ =40. 1=30. 2=20, 3=10.
[a,b,c,d] Means with a same superscript in the same row for each quality and yield grade are not differ ($p>0.05$).

determined by measuring. perpendicular to the outside surface. at a point two-thirds of the length of the ribeye ribbed between the last rib and the first lumbar vertebrae. The area of the ribeye was determined at the surface of the cut using a standard grid.

Carcasses were classified into one of four quality grades (1+, 1. 2 or 3) and one of three yield grades (A. B or C). Quality grade was primarily determined by marbling score and additionally adjusted by other carcass traits such as meat color. fat color. texture and maturity when there was a particular defect in these traits. Yield grade was determined on the basis of estimated retail cut percentage, which was a function of back fat thickness. ribeye area and cold carcass weight. The equation for retail cut percent was that : retail cut %=65.8834-(0.393×back fat thickness. mm)+(0.088×area of rib eye, cm^2)–(0.008×cold carcass weight, kg). Yield grade A. B and C counted for the retail cut percentage higher than 69%. 69-66% and less than 66%. respectively.

Quality and yield grades as a function of each carcass traits (live weight, carcass weight, back fat thickness. ribeye area. marbling. meat color. fat color, texture and maturity) were tested by GLM procedure (SAS, 1999). Seasonal effect on these carcass traits was also examined using the same model. Significance levels of least square means for each trait were separated by a probability of difference ($p<0.05$). Regression coefficients for quality grade as a function of marbling, meat color, fat color, texture and maturity were determined by a multi-regression procedure (SAS, 1999) and partial coefficients of determination were estimated by applying a stepwise selection. The regression coefficients for yield grade as a function of back fat thickness. ribeye area and carcass weight were also estimated by using the same model.

RESULTS AND DISCUSSION

Carcass traits, quality grade, yield grade and season effect of Hanwoo steers

A higher (better) quality grade score was resulted from heavier carcasses with thicker back fat. larger ribeye area. more red meat color. more white fat color and with higher degree of marbling ($p<0.05$) as in Table 1. The result was generally expected as the quality grade in Korea beef grading system is a function of degree of marbling. firmness of muscle texture, fat and meat color and degree of maturity. despite quality grade is practically determined largely on the basis of degree of marbling. Overall maturity, on the other hand. did not significantly differ between the quality grade groups with an exception of the lowest quality group. This may reflect the fact that the majority of the Hanwoo steer was approximately 24 months of age. The current data was consistent with our early report (Park et al., 2002). where better quality grade of Hanwoo was positively linked to carcass weight. In addition. this result was in a similar tendency with early reports in other breeds which demonstrated that a better USDA quality grade was related with higher carcass weight (Lorenzen et al., 1993) or fatter carcass in dairy cattle and *Bos indicus* breeds (Kauffman et al., 1975; Abraham et al., 1980: Griffin. 1992: Jeremiah, 1996; Dikeman et al., 1998).

There were some studies reporting that carcasses with a larger ribeye area resulted in a lower USDA quality grade (e.g., Lorenzen et al., 1993; Miller et al., 1997; Boleman et al, 1998). However, in the Hanwoo steers. ribeye area had highly positive correlations with slaughter weight and degree of marbling (Figures 1 and 3). Despite large variations existed in the carcass traits within each quality grade. the current result indicated that a higher quality grade mirrored higher marbling score. red meat color and white

Table 2. Regression coefficient, partial R-square and significance level for quality and yield grade as a function of carcass traits

Items	Motel terms	Regression coefficient	p-value	Partial R-square
Quality grade	Intercept	13.98		
	Marbling score	1.60	0.0001	0.88
	Meat color score	-0.34	0.0001	0.0004
	Fat color score	-0.004	0.95	-
	Texture score	-0.66	0.0001	0.003
	Maturity score	-0.03	0.81	-
Yield grade	Intercept	163.4		
	Back fat thickness	-11.7	0.0001	0.66
	Ribeye area	2.28	0.0001	0.09
	Carcass weight	-0.004	0.70	-

fat color, and that was linked with higher carcass weight. Nevertheless, regression analysis showed that the degree of marbling took a large portion of variation in quality grade (Table 2). This again demonstrated the fact the marbling score was the most significant determinant of quality grade in Korean beef grading practice. Miller et al. (1997) reported that meat color was not distinguishable between quality grades. However, our data showed that a lower quality group exhibited a greatly ($p<0.05$) lighter meat color. The finer texture for the higher quality group was supposed to be linked to the higher marbling score.

Quality grade was negatively associated with yield grade to some extent (Tables 1 and 2). Lighter carcass with less back fat and higher ribeye area obtained a higher yield grade, as shown by Boleman et al. (1998) in the US beef grading system. This was generally expected since retail cut % has negative coefficients for cold carcass weight and fat thickness and a positive coefficient for ribeye area (APGS, 1995). Regression analysis indicated that fat thickness was the prime determinant of yield grade (partial $R^2=0.66$). This was a consistent observation with Lorenzen et al. (1993) who reported that carcasses received higher USDA yield grades were relatively lighter with lower quality grade, lower fat thickness and lower marbling score. The significant effect of back fat thickness on yield grade indicated that extended finishing feeding could result in reduction in yield grade, as suggested by other studies (Matulis et al., 1987; Van Koevering et al., 1995; Hermesmeyer et al., 2000). In practice, ribeye area was one of the most important determinants of yield grade. However, it was noticeable that ribeye area took a little variation for yield grade in stepwise regression analysis (Table 2), and there was a little difference in least square mean values among yield grades (Table 1). This was a similar tend with our previous study (Park et al., 2002). As a consequence of the higher yield grade for leaner carcass, carcasses received a higher yield grade showed darker meat color, more course texture and more yellowish fat color (Kreikemeier et al., 1998; Park et al. 2002). The current data indicated that an extended feed increased possibility for production of better carcass quality, but for reduction in yield grade. This suggests that economic consideration needs to be taken for the best feeding strategy because carcass price is a sum of quality and yield grades.

In this study, it was of a particular interest that carcass traits showed a marginal effect of slaughter season, despite seasonal effect in this study did not reflect growth performance. Korea has distinctive four seasons (spring, summer, autumn and winder) and average temperature ranges from 25°C in summer to -1°C in winter. The summer group obtained a significantly ($p<0.05$) higher quality grade than spring and winter groups. In addition, spring group resulted in a lower ($p<0.05$) yield grade compared to other seasons. However, the mean difference was practically negligible. There was a considerable range of slaughter weight, but the majority of carcass ranged approximately 24 months of age. This means that slaughter season was an approximately birth and finishing seasons. Environmental factors affect growth performance through its effect on feed intake, metabolisms, disease, and management practice (Ray et al., 1969). Compensatory growth has been known to occur after a period of heat stress in cattle. Hahn et al. (1974) studied compensatory growth under thermoneutral (20°C), high (30.9°C), and very high temperature conditions (37.7°C) in climate chambers. The authors confirmed a compensatory growth for 30.9°C treated group. The current result was somehow unexpected at the first consideration of the four idiosyncratic seasons. However, the result was supposed to be related the feeding and housing systems in this country (e.g., in-house feedlot system from birth to death). In the study of Mitlöhner et al. (2001), although slaughter weight in fall and winter was heavier than that in spring and summer, quality and yield grade was indistinguishable.

Effect of slaughter weight on marbling, back fat thickness, quality and yield grades of Hanwoo

In Korean beef industrial standpoint, it is important to make a careful decision on final Hanwoo slaughter weight because of the confounding aspects of quality grade and yield grade as well as other economic considerations. Savell et al. (1992) and Griffin (1992) estimated that every steer

Table 3. Least square means (±SD) of carcass traits, quality grade and yield grade in each season

Carcass traits	Season			
	Spring (n=4,430)	Summer (n=3,496)	Autumn (n=2,533)	Winter (n=3,927)
Live weight, kg	578 ± 63.0^{b}	588 ± 60.1^{a}	578 ± 62.8^{b}	573 ± 59.1^{c}
Carcass weight, kg	337 ± 41.2^{b}	342 ± 38.9^{a}	335 ± 39.4^{c}	332 ± 38.2^{d}
Back fat thickness, mm	10.1 ± 4.75^{a}	10.1 ± 4.70^{a}	9.9 ± 4.59^{a}	10.0 ± 4.56^{a}
Ribeye area, cm^2	80.5 ± 8.75^{b}	81.1 ± 9.01^{a}	79.9 ± 8.81^{c}	80.6 ± 8.82^{b}
Meat color score[1]	4.53 ± 0.53^{a}	4.41 ± 0.53^{c}	4.48 ± 0.56^{b}	4.46 ± 0.54^{b}
Fat color score[2]	2.82 ± 0.42^{b}	2.76 ± 0.46^{d}	2.85 ± 0.40^{a}	2.80 ± 0.43^{c}
Marbling score[3]	9.55 ± 5.01^{b}	10.02 ± 5.00^{a}	9.86 ± 4.98^{a}	9.61 ± 4.93^{b}
Texture score[4]	3.5 ± 0.80^{a}	3.4 ± 0.82^{b}	3.5 ± 0.87^{a}	3.6 ± 0.84^{a}
Maturity[5]	2.02 ± 0.18^{ab}	2.02 ± 0.19^{a}	2.01 ± 0.15^{b}	2.02 ± 0.19^{ab}
Quality grade[6]	25.4 ± 9.10^{b}	26.2 ± 8.81^{a}	$25.8\pm8.75b^{a}$	25.4 ± 8.78^{b}
Yield grade[7]	226 ± 66.0^{b}	229 ± 67.3^{ab}	$228\pm63.8b^{a}$	231 ± 64.8^{a}

[1] 1=very light cherry red, 7=very dark red. [2] 1=white, 7=yellow. [3] 1=trace, 19=very abundant. [4] 1=very fine, 9=very coarse. [5] 1=very young 9=very old.
[6] 40=1−, 30=1, 20=2, 10=3. [7] 300=A, 200=B, 100=C
[a, b, c, d] Means with a same superscript in the same row for each quality and yield grade are not differ ($p>0.05$).

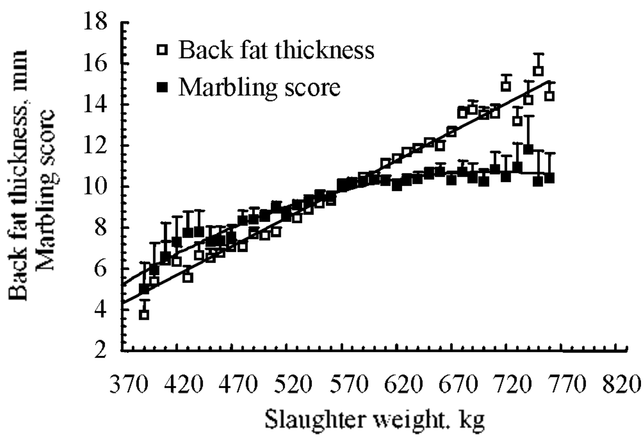

Figure 1. Marbling score and back fat thickness as a function of slaughter weight. Regression for back fat thickness: Y=-5.94+0.03 ×Slaughter weight. Regression for marbling score: Y=-13.22+ 0.00005× (Slaughter weight)^2+0.068×Slaughter weight.

and heifer lost $219.25 as a direct result of excessive fat production. Of that loss, $111.99 was due to excess subcutaneous fat and $62.94 was due to excess intermuscular fat. The previous section indicated that heavier carcasses resulted in higher quality grades, but in lower yield grade. On account of this, we were interested in the changes in marbling score, back fat thickness, quality grade and yield grade as a function of slaughter weight. The result showed that back fat thickness linearly increased as slaughter weight increased up to 760 kg (Figure 1). On the other hand, there was a weak curvilinear relationship between marbling score and live weight. Boleman et al. (1998) reported that marbling score was dramatically increased from 227 to 454 kg. The current result was also consistent with early studies (Duckett et al., 1993; Short et al., 1999). The studies showed a fast linear increase up on 18 months and a little subsequent change with time on feed. In the current study, marbling score linearly increased up to approximately 570 kg of slaughter weight and thereafter almost reached its asymptotic level. The result indicated that extended feeding over 570 kg provided a little benefit on quality grade, whereas the increased back fat had negative influence on yield grade. Our early study in Hanwoo (Park et al., 2002) also demonstrated that slaughter weight above 550 kg did not affect marbling score. Similarly, Hong et al. (1996) also reported that slaughter weight from 550 to 650 kg resulted in an identical marbling score in Hanwoo steer. Changes in texture score had a curvilinear relationship with slaughter weight where the score linearly decreased up to approximately 570 kg, and the rate was little changed beyond approximately 570 kg (Figure 2). This relationship was in a similar with that observed between marbling score and slaughter. This may be an indication that improvement in texture was associated with the improved marbling and the subjective meat texture reflected degree of marbling to some extent. As shown by Short et al. (1999), ribeye area linearly increased as slaughter increased (Figure 2).

Figure 3 shows quality and yield grade as a function of slaughter weight. A quadratic relationship indicated that slaughter weight approximately higher than 570 kg had a little benefit on quality grade, whereas yield grade decreased beyond approximately 490 kg. Hong et al. (1996) commentated that longer feeding period of Hanwoo steer above 550 kg was undesirable for quality and yield grade. Paisley et al. (1999) also advised that the benefit of increasing weight might be offset by other detrimental aspects such as maturity, nutrition and management practices. Given to that Hanwoo steer sampled in this study was approximately 24 months old, the current data suggested that 570 kg and 490 kg might be desirable slaughter weight at this age for the best quality and yield

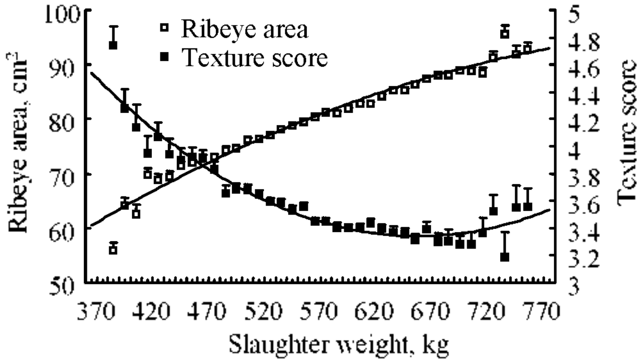

Figure 2. Ribeye area and texture score as a function of slaughter weight. Regression for ribeye area: Y=64.23+0.79×Slaughter weight. Regression for texture: Y=4.46+0.0014×(Slaughter weight)^2-0.08×(Slaughter weight).

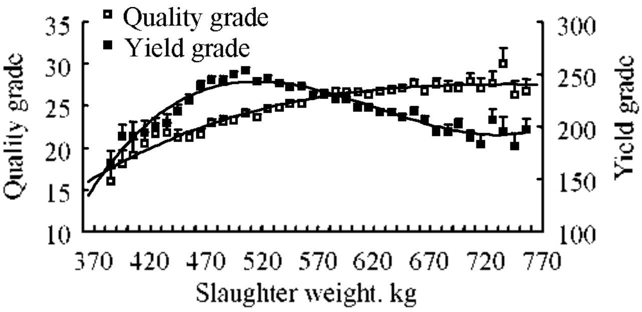

Figure 3. Quality and yield grades as a function of slaughter weight. Regression for quality grade: Y=17.18+0.01×(Slaughter weight)^2+0.65×(Slaughter weight). Regression for yield grade: Y=150.2-0.76×(Slaughter weight)^2+5.28×(Slaughter weight).

grades. respectively. In Korean grading and retailing systems. quality and yield grades determine retail carcass price to a similar extent. On the basis of the current result, approximately 570 kg at 24 months appears to be the optimum growth rate and slaughter weight for Hanwoo steer in a point of economic benefit.

IMPLICATIONS

This is the second report of carcass characteristics from South Korean Hanwoo cattle. In the first report, we reported that Hanwoo carcasses were similar to those from cattle breeds in the United States, considering the relationship between carcass characteristics (e. g., weight and sex) and quality / yield grades. Although data of steers was only used in this study, high yield grade carcasses showed a lighter weight, less back fat and marbling and larger ribeye area with a prime determinant of back fat thickness. Linear increase in marbling score was completed by approximately 570 kg of slaughter weight, whereas back fat thickness and ribeye area linearly increased until 750 kg. The results indicated that 570 kg of live weight at the age of 24 months was the optimum growth performance and slaughter age for producing better quality grade. On the other hand, 490 kg of live weight resulted in better yield grade. Noticeable observation in this study was a little effect of slaughter season on carcass traits.

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