PE1.33 Length of Feeding of Barley-based Diet: Effects on Hanwoo Carcass Characteristics and Objective Meat Quality of Longissimus Muscle 237.00

Maria Cynthia Oliveros (1) salmonstory@chonbuk.ac.kr, Kyoung Mi Park(1), Eung Gi Kwon (2), Nag-Jin Choi (3), Jongsoo Chang (4), Byoung-Chul Choi (5), Inho Hwang (1)
(1)Department of Animal Resources and Biotechnology at Chonbuk National University
(2)National Institute of Animal Science
(3)Cheonan Yonam Universit
(4)Korea National Open University, Department of Statistical Informatics at Chonbuk National University

***Abstract*—The effect of the time on barley-based diets on the carcass characteristics and meat quality of Hanwoo (Korean native cattle) beef was evaluated. Hanwoo steers, 8 months of age, were assigned to either one of the two feeding groups: short- term (fed until 26 months of age) or long-term feeding (fed until 32 months of age) with whole-crop barley silage and barley-based concentrates. Strip loin samples taken after 24 hr chill were vacuum packed and assigned to two aging groups, 1-day aging (D1) or 10-day aging (D10). Long-term feeding increased carcass weight, rib-eye area, yield grade, marbling score and quality grade of the meat. Maturity, fat and meat color scores were not influenced by the length of the feeding period. Objective tenderness did not differ between the two feeding groups but the shear force value was numerically lower in beef from the long term-fed group. Strip loin aged for 10 days had higher Hunter L* a* b* values. TBARS value was lower in beef from the long term-fed group but it was below the maximum acceptable limit of 0.5 mg MAL/kg meat. Long-term feeding of barley-based diets to Hanwoo steers improved carcass yield and carcass quality. Results indicated that feeding for 26 months with barley based diet had a similar objective meat quality with the long term feeding, but longer feeding improved carcass yield and quality grade based on the Korean beef grading standards.**

.C. Oliveros, K.M. Park and I.H. Hwang are with the Department of Animal Resources and Biotechnology at Chonbuk National University, #664-14 Duckjin-dong, Jeonju, Jeonbuk 561-756 Korea (tel: +82 63 270 2605; fax: +82 63 270 2612, e-mail: inho.hwang@chonbuk.ac.kr)
E.G. Kwon is a senior scientist at the National Institute of Animal Science, RDA. Kwangwondo, 232-950, Republic of Korea
N.J. Choi is a professor at the Dept. of Animal Science, Cheonan Yonam University. Cheonan, Chungnam, 330-709, Republic of Korea
J.S. Chang is a professor at the Dept of Agricultural Science, Korea National Open University, Seoul, 10-791, Republic of Korea
B.C. Choi is a professor at the Department of Statistical Informatics at Chonbuk National University, #664-1 Duckjin-dong, Jeonju, Jeonbuk 561-756 Korea

***Key Words:* barley-based diets, carcass characteristics, length of feeding, objective meat quality**

I.INTRODUCTION

The beef industry have always aimed to maximize the growth potential of cattle to get the highest lean yield and meat quality. Numerous studies have shown that feeding period and diet influence carcass characteristics and quality of beef. Carcass weight, dressing yield, fat thickness, yield grades and overall maturity increased with increasing days on high concentrate diets [6, 7, 8, 12]. Similarly, a significant increase in *Longissimus* muscle area of Angus steers with prolonged feeding periods on high corn silage diet had been observed. It was noted in several studies that marbling scores increased in a nonlinear manner with days on feed [8, 12]. In terms of diets, it was observed that increasing the proportion of barley grain in the diet of Angus-crossbred steers increased carcass yield and quality grade [2]. It has been reported that carcass characteristics of barley silage-fed steers are comparable with corn and wheat silages.

With the increased competition in the beef market, it is necessary to identify feeding strategies that will ensure the production of high quality Hanwoo beef at the least production cost. On this regard, length of feeding of Hanwoo steers was increased from 24 months in 1999 to 30-32 months in 2008. Average slaughter weight increased from 550 kg to 700 kg. Hanwoo cattle are traditionally raised in feedlots and are fed high concentrate corn-based diets and rice straw. Local cattle raisers have recently explored the use of whole-crop barley silage and barley grain-based concentrates. Most of the studies on the effect of feeding period on meat quality have utilized American and British Continental breeds. No studies of the same nature have been done on Hanwoo cattle. In addition, high concentrate corn-based diets, corn silage and grass silage were the common feeds used. Very few studies have evaluated the use of whole-crop barley silage as a feed for cattle. For these reasons, the authors deemed it necessary to study the effect of the length of feeding on beef from Hanwoo steers raised under the whole-crop barley feeding system. The study aimed to determine the effect of short term and long term feeding of barley-based diets on the carcass characteristics and objective meat quality traits.

II.MATERIALS AND METHODS

a. Animals, sample collection and experimental design

Hanwoo were raised by chosen private feedlot beef cattle raisers. Steers were weaned at 8 months of age and were assigned to either one of two feeding strategies: short-term or long-term feeding. The short-term group was fed until 26 months of age while the long-term group was fed until 32 months of age. Both treatment groups were fed with barley-based concentrates and whole-crop barley silage at 80:20 concentrate to roughage ratio. At the end of the feeding period, 8 animals from each treatment group were slaughtered and chilled for 24 hours. Strip loin samples were taken from the right side of the carcass. Each loin was divided into two portions, vacuum-packed and was assigned to two aging groups, 1-day or 10-day aging. Aging was done at 4^{o}C.

b. Carcass characteristics

Carcasses were graded after a 24-hour chill. Chilled carcass weight, fat thickness and rib-eye area were measured. Marbling, meat color, fat color, fat thickness, texture and overall maturity scores were recorded. Carcass yield and quality were determined based on the Korean grading system.

c. Objective meat quality traits

The Warner Bratzler shear force values were measured in an Instron Universal Testing Machine (Model 3342, Instron Corporation, USA) on six pieces core samples with 0.5 inch diameter using a crosshead speed of 400 mm/min and a 40 kgf load cell.

Meat color evaluation was done with Konica Minolta Spectrophotometer CM-2500d with an 8 mm measuring port, D 65 illuminant and 10^{o} observer. Three measurements were taken on the bloomed surface of the meat and the Hunter L* a* b* values were determined. The data presented are means of three measurements.

Determination of pH was done in duplicates following the procedure of Bendall (1973). The pH was measured with an Orion 3 Star (Thermo Electron Corp., USA) pH meter.

The moisture content was measured in duplicates in an HR73 halogen moisture analyzer (Mettler-Toledo GmbH, Switzerland) set at 105^{o}C. A 2.5 g minced meat sample was used for each measurement.

Oxidative stability was determined by measuring the thiobarbituric acid reactive substance (TBARS) following the procedure of Buege and Aust (1978). A 2.5 g meat sample was used. TBARS was expressed as mg malonaldehyde/kg meat sample.

d. Statistical analysis

The data on carcass characteristics were analyzed using the one way analysis of variance. For the objective meat traits, the main effects of the length of feeding and aging period and length of feeding x aging period interaction were analyzed using SAS PROC GLM (SAS Institute, Cary, NC). The length of feeding x aging period interaction was not significant for the traits that were measured hence, only the least square means of the two main effects were presented.

II. RESULTS AND DISCUSSION

a. Carcass characteristics

The slaughter age of cattle subjected to short-term and long-term feeding of whole-crop barley diets were 26 and 32 months, respectively. Average live weight at slaughter was 633 kg for the short term-fed group and 700 kg for the long term-fed group.

The carcass traits of Hanwoo cattle from different feeding systems are shown in Table 1. Carcass weight was significantly higher ($P = 0.023$) in cattle fed with barley diets until 32 months of age. This is as expected since slaughter weight was higher in the long-term fed animals. Carcasses from the long-term fed group had significantly higher rib-eye area ($P = 0.052$) than those from the short-term fed group (88.63 vs. 79.38 cm2). Accordingly, carcasses from the long term fed group had higher yield grade ($P = 0.0421$) than the short term fed group. These results are in agreement with the findings that yield grade of Hanwoo cattle improved with increased animal weight and that yield grade and rib-eye area are positively correlated ($R = 0.51$) [18]. In their study, steers were slaughtered at 24 months of age and it was observed that there was no further increase in yield for cattle weighing more than 551 kg. The steers in the current study were slaughtered at a more advance age and at a higher slaughter weight but increases in yield grades and rib-eye area were observed. This could have been due to the difference in the type of feed used. High-concentrate diet and rice straw were used in the previous experiment while barley-based concentrate and whole-crop barley silage was used in the current study. It has been shown that most carcass traits of British Continental crossbreds [6], Angus x Hereford [8, 12], and Hereford [7] steers fed with high concentrate finishing diets increased with days on feed. Slaughter age in the cited studies ranged from 12 to 23 months. The result of the current experiment seems to indicate that the energy density of the barely-based diet was high enough to support lean deposition up to 32 months of age. As age increase, the rate of protein production decrease, however, the decrease was less in management systems which utilized feedstuffs with a greater concentration of energy [3].

Marbling score was almost two times higher in beef from the long-term fed group than in those from the short-term fed group (6.13 vs. 3.50) hence, quality grade of the former was significantly higher (P = 0.0007). The current findings support the report that quality grade improved with increased weight of Hanwoo carcasses. Several researches have shown that intramuscular fat deposition proceeds in a non-linear manner. The optimum marbling score was attained after 119 d and 112 d [8, 12] on high-concentrate feed. There was no further increase in marbling fat beyond the feeding days mentioned. The cattle in the cited studies were younger than the Hanwoo in the current experiment. Our results reveal that intramuscular fat deposition still proceeds between 26 and 32 months of age. The point of optimum marbling may vary with genetics and mature size. It was stated in a review that oxidative muscles have a great ability to deposit fat. It has been reported that *Longissimus dorsi* muscle of Hanwoo is composed of more oxidative muscle fibers than that of European breeds [10] and this may explain the current observations on marbling. The diet given to steers in the current experiment may have also contributed to the increased marbling score of the beef loin. Supplementation of grass silage with barley grain (70% DM basis) increased marbling score and better quality grade [2].

Maturity, fat color and meat color scores did not differ between the short-term and the long-term fed cattle. Similar maturity scores were obtained by cattle from the two feeding groups. The lack of difference in fat and meat color scores may be attributed to similar feeding and management systems used during the experimental period. It was only the feeding period that differed but diets were similar. Furthermore, postmortem handling of carcasses was similar. It was previously reported that feeding period had no effect on lean color [7].

The longissimus muscle from the long-term fed group tended to be more firm (P = 0.059) than the short-term fed group. This is due to higher marbling of beef from cattle fed up to 32 mo of age. The chilled intramuscular fat tended to increase the firmness of raw meat. Carcasses with higher degrees of marbling were significantly firmer than those with lower marbling.

b. Objective meat quality traits

Neither feeding system nor aging significantly influenced the objective tenderness of the beef samples (Table 2). Nonetheless, beef from steers belonging to the long term-fed group had numerically lower Warner Bratzler shear force value than beef from steers in the short term-fed group (28.64 vs. 31.98 N). Several researches have indicated that tenderness tended to increase with increased time on feed but only to a limited extent because age of the animal also exerts an influence [12]. Heavier, fatter carcasses produced more tender steaks than thinner and lighter carcasses [4]. Days on feed and carcass grade traits affect tenderness by delaying carcass chilling rate and enhancing early postmortem muscle temperature [12] thus, meat toughening due to cold shortening is prevented. This explains the current findings. The strip loin steaks from steers fed diets until 32 mo of age had higher intramuscular fat content thus shear force value tended to be lower than that of steaks from steers fed until 26 mo of age.

Loin steak aged for 10 d (D10) had numerically lower shear force value than those chilled for one day (D1). The mean improvement in shear value with aging over the first week differed depending on the shear value starting point (original shear value), with tougher steaks undergoing more change. In the present experiment, strip loin which is a tender meat cut was used thus only a minimal change in shear force value was obtained. Based on shear force values, the steaks from the long term-fed steers and the D10 group can be classified as tender while those from the short-term fed steers and the D1 group are of intermediate tenderness. Beef was categorized tender, intermediate and tough steaks as having less than 3 kg (29.43 N), between 3 kg (29.43 N) and 4.6 kg (45.13 N), and greater than 4.6 kg (45.13 N) of shear force, respectively.

Instrumental meat color was not influenced by the length of feeding period, however, all the Hunter color parameters were significantly higher in the D10 aged beef than the D1 beef implying a brighter red color in the D10 beef. The increase in lightness (L* value) of meat during aging is due to the modification of protein structures thus giving a higher dispersion of light [9]. A 10 day aging period at 4°C used in the present experiment was sufficient to cause some changes in muscle protein thus a higher L* value was obtained. Change in the color of meat during aging is partially influenced by the type of muscle. The M. *Longissimus lumborum* was classified under the "high" color stability muscle group [14] and it is characterized by a high resistance to induced metmyoglobin formation. This finding may explain the high a* value of the strip loin after 10 day aging. Similarly, a more vivid, redder and more yellow color of *Gluteus medius* steaks that were aged for 14 d or less was observed as compared to the steaks that were aged for longer periods [11].

Cooking loss, pH and moisture content did not differ among treatment groups. It has been demonstrated the length of time on concentrate feed had little influence on the cooking properties of meat [7].

Oxidative stability (TBARS value) was significantly influenced by the feeding system. Oxidative stability was lower in beef from the long term fed-group as indicated by the significantly higher TBARS value ($P = 0.009$) than the beef from the short term-fed group (0.34 vs. 0.24). This can be attributed to the higher intramuscular fat content of the beef from the long term-fed group. On the other hand, the TBARS values of the D1 and D10 beef did not differ significantly. It could have been that the 10 d aging period was short for lipid oxidation to cause a significant difference on the TBARS value of the strip loin from the two aging groups. Research had shown a gradual increase in the TBARS values of Hanwoo *Longissimus dorsi* muscle during the first 14 days of aging and the sharp increase in TBARS occurred after 14 days [10]. The TBARS values of the strip loin in the current experiment were below the maximum acceptable limit of 0.5 mg MAL/kg meat.

III. CONCLUSION

The current findings indicate that feeding for 26 months with barley-based diet produce similar objective meat quality in Hanwoo *longissimus* muscle with the long term-fed group (i.e, 32 months), but feeding up to 32 months of age improved carcass yield and quality grade by Korean beef grading standards.

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Table 1. Least square means of carcass traits of Hanwoo cattle (DF=1/14) subjected to different feeding systems

Traits	Feeding System		Average S.E.	F ratio
	Short-term	Long-term		
Carcass weight (kg)	361.13	399.00	10.53	6.46*
Ribeye area (cm^2)	79.38	88.63	3.09	4.49*
Yield index[a]	66.34	68.82	1.05	2.77
Yield grade[b]	2.25	2.88	0.20	5.00*
Marbling score[c]	3.50	6.13	0.36	25.94***
Quality grade[d]	2.63	3.88	0.21	18.42***
Maturity score[e]	2.00	2.00	0.00	
Fat color score[f]	2.75	3.00	0.12	2.33
Meat color score[g]	5.00	4.75	0.18	1.00
Texture score[h]	1.38	1.00	0.13	4.20*

[a]Yield index = 64.184 -[0.625 x backfat thickness (mm)] + [0.130 x ribeye area (cm^2)] + 3.23

[b]Yield grade was scored as: 1 = C grade (yield index < 62.00); 2 = B grade (62.00 ≤ yield index < 67.50); 3 = A grade (yield index ≥ 67.50)

[c]Marbling score: 1 (devoid) to 9 (abundant)

[d]Quality grade was scored as: 1 = 3 grade (marbling score no.1); 2 = 2 grade (marbling score no. 2 or 3); 3 = 1 grade (marbling score no. 4 or 5); 4 = 1^+(marbling score no. 6 or 7); 5 = 1^{++}(marbling score no. 8 or 9).

[e]Maturity score was scored from 1 (youthful) to 9 (mature).

[f]Fat color score: 1 (white) to 7 (dark yellow)

[g]Meat color score: 1 (bright cherry red) to 7 (extremely dark red)

[h]Texture score: 1 (firm) to 3 (soft)

* (P≤0.05), ** (P≤0.01), *** (P≤0.001)

Table 2. Least square means (DF=1/28) of the objective meat quality traits of *longissimus* muscle from Hanwoo subjected to different feeding systems and subjected to different aging periods

Traits	Feeding System		Aging		Average S. E.	F ratio	
	Short	Long	D1	D10		Feeding	Aging
Total energy (J)	0.31	0.28	0.32	0.28	0.02	1.67	2.80
WB shear force (Peak force, N)	31.98	28.64	32.96	27.66	0.22	1.25	3.13
Hunter L	37.06	37.07	35.75	38.39	0.86	0.00	4.71*
Hunter a	17.37	17.58	16.65	18.31	0.47	0.10	6.29*
Hunter b	14.37	13.76	13.05	15.08	0.26	2.87	30.38***
Cooking loss (%)	17.60	16.64	17.59	16.65	0.54	1.55	1.53
pH	5.57	5.53	5.54	5.55	0.02	1.41	0.07
Moisture (%)	52.54	53.50	52.05	53.99	1.23	0.31	1.24
TBARS (mg MAL/ kg meat)	0.24	0.34	0.28	0.30	0.02	7.87**	0.44

* (P≤0.05), ** (P≤0.01), *** (P≤0.001)