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Effects of feeding system on growth performance, plasma biochemical components and hormones, and carcass characteristics in Hanwoo steers

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Objective: This study was conducted to compare growth performance, blood components and carcass traits by two feeding systems (concentrate with roughage separately [CON] vs total mixed ration [TMR]) in Hanwoo steers, and to learn the relationship between blood components during fattening or finishing phases and carcass traits in Hanwoo steers.
Methods: Sixty steers aged 8 months were allotted to two feeding systems and fed similar amounts of average dry matter and total digestible nutrient throughout whole experimental period according to each feeding program. Steers were weighed monthly, taken blood at the end of growing, fattening and finishing periods, and slaughtered at 30 month of age.
Results: Growing performance was higher ($p<0.05$) in the CON group compared to the TMR group during fattening and finishing periods. The CON group was lower ($p<0.05$) in blood aspartic acid transaminase, blood urea nitrogen and retinol levels during growing period, but higher in triglyceride and cholesterol levels during fattening and finishing periods compared to the TMR group. The CON group was greater ($p<0.05$) in rib-eye area, and lighter ($p<0.05$) red in meat color compared to the TMR group. In the correlation coefficients between blood components of steers and carcass traits, retinol had a negative ($p<0.05$) correlation with marbling score and rib-eye area. Leptin had a positive ($p<0.05$) correlation with back fat thickness. Blood cholesterol and triglyceride were positively ($p<0.05$) correlated with carcass weight and rib-eye area.
Conclusion: Growth performance, carcass ribeye area and meat color showed a more desirable result in the CON compared to the TMR in Hanwoo steers. Assessing the accumulated data of carcass traits with blood components including hormones—particularly retinol, cholesterol, triglyceride, and leptin—during the fattening or finishing phases, it may be possible to find a biomarker for determining beef quality in living animals.

Keywords: Feeding System; Performance; Blood Component; Carcass Traits; Hanwoo Steer

INTRODUCTION

To maximize productivity and carcass traits of beef cattle, it is common practice to provide a high amount of formulated concentrate diet in the feeding systems of many countries. However, over the last decade, feed costs of beef cattle have increased by 70% to 80% mostly due to increasing grain prices. Accordingly, there is increasing demand for low-cost alternative feedstuffs in livestock operations. This has focused attention on a total mixed ration (TMR) for beef production, which contains agricultural by-products, several grains and functional herbs as sources of feed ingredients [1,2]. As a consequence of the attempt to lower production costs, beef producing farmers have increased using a TMR in recent years, although this method has been criticized for its quality of diet such as inconsistent feed ingredients, a lower nutrient value and contamination by harmful microbes and residues, etc.

Nevertheless, using a TMR feeding system in beef production provides advantages with precision, efficiency and convenience that may improve overall on-farm level of productivity [3]. Several studies with steers have been conducted to assess the effects of a TMR on ruminal fermentation, animal performance, carcass quality, economic analyses, etc. [4,5]. Martin et al [6] reported that there was a significant difference in carcass fat score and intramuscular fatty acid compositions in cattle fed a high concentrate diet plus straw and a TMR contained cereal, soybean meal, corn silage and straw, although weight at slaughter was not different between two dietary feeding systems. However, Cortes et al [7] reported that carcass quality and composition of beef heifers fed a TMR were not significantly different from these fed a commercial concentrate (93%) and straw (7%). There is still a lack of published information on the effects of feeding system on beef performance and carcass traits because of the inherent complexity of feed ingredients and energy density, feeding duration, management practices, the effect of environmental conditions, etc. [8,9].

Thus, we applied two different feeding systems (CON vs TMR) in beef production to evaluate the effects of feeding system on growth performance, serum biochemical profiles, and carcass traits in Hanwoo steers.

Table 1. Ingredient composition of experimental diets (%)

Item	CON[1)]			TMR[1)]		
	GP[2)]	EP[2)]	LP[2)]	GP	EP	LP
Corn flake	22.5	30	30	12.5	22	20.5
Wheat bran	30	36.5	33.5	3.85	3.85	3.85
Corn gluten feed	4	4.4	4.8	5	5	5
Molasses	6.5	6.5	6.5	4.5	4.5	4.5
Palm mix	7	12	10	7.2	7.8	10
Soybean meal	-	4	12	-	-	-
Soybean hull	13.2	2.1	-	-	-	-
Brewer's grain	-	-	-	24	22	23
Wheat hull	12	-	-	-	-	-
Rye grass	-	-	-	6		8.1
Lupin	-	-	-	1.5	1.5	1.5
Alfafa+timothy hay[3)]	-	-	-	20	18	-
Rice straw+Mugwort[4)]	-	-	-	9.25	9.25	9.25
Base feed[5)]	-	-	-	-	-	8.5
Salt+limestone	2.5	2.5	1.7	1.2	1.1	1.15
Premix[6)]	2.3	2	1.5	5	5	4.65

TMR, total mixed ration; GP, growing period; EP, fattening period; LP, finishing period.
[1)] CON, steers fed concentrate and rice straw separately; TMR, steers fed a TMR.
[2)] GP, 8-12 month of age; EP, 13-23 month of age; LP, 24-30 month of age.
[3)] Alfalfa, 50%; Timothy, 50%.
[4)] Rice straw, 80%; Mugwort, 20%.
[5)] Corn flake, 38%; corn gluten feed, 6%; wheat bran 41%; soybean meal, 15%.
[6)] Contained per kg diet: Vitamin A, 180,000 IU; Vitamin D_3, 53,000 IU; Vitamin E, 1,500 IU; Mn, 4,400 mg; Zn, 4,400 mg; Fe, 13,200 mg; Cu, 2,200 mg; I, 440 mg; Co, 440 mg.

MATERIALS AND METHODS

Experimental animals and design

Sixty Hanwoo steers aged 8 month (initial mean body weight [BW] 224±3.88 kg, housed in 5 calves per pen) were weighed individually and randomly assigned to two different feeding system (CON vs TMR). Twenty steers were assigned to the formulated concentrate with rice straw separately (CON, n = 4, 5 head per pen), and forty steers were assigned to the TMR group (n = 8, 5 head per pen). Ingredient composition of experimental diets is presented in Table 1. Steers of the CON group fed a concentrate during each period (4 to 7 kg/d in growing period, 7 to 9 kg/d in fattening period, *ad libitum* in finishing period) with rice straw (*ad libitum* in growing period, 2 kg/d in fattening period, 1 kg/d in finishing period). Steers of TMR group were freely fed a TMR during each period for whole experimental period. The entire feeding period (8 to 30 month of age) was divided into growing (8 to 12 month), fattening (13 to 23 month), and finishing periods (24 to 30 month). All steers were allowed free access to feed, water and mineral blocks. Steers were daily given the corresponding experimental diet throughout the experiment period according to dietary feeding program, and fed same amounts of dry matter intake through the whole experimental period.

The pen (5 m×10 m) was installed with feeder, which allowed the animals free access to any part of the pen. Steers were weighed every 4 weeks with feed intake and average daily intake (ADG) for the entire feeding periods. The animal handling procedures in the present study followed the guidelines of the institutional animal care and use committee.

Analysis of chemical composition

The chemical composition of feeds including crude protein, ether extract, crude fiber, and crude ash was measured according to the guidelines of [10] (Table 2). Neutral detergent fiber and acid detergent fiber were analyzed by the method of [11]. All samples were performed in duplicate. Total digestible nutrient (TDN) in concentrate was obtained from the feed company based on their calculation.

Blood sampling and analysis of biochemical components and hormones

At the end of growing, fattening and finishing periods, blood samples (20 mL) were taken from the jugular veins of steers using syringe and then transferring the blood into heparin coated sterile vacutainer (Becton Dickinson, NJ, USA) wrapped with foil. Next, plasma was harvested by centrifugation (3,000 rpm, 20 min). All harvested plasma was rapidly frozen and stored at –70°C until further assay.

Blood biochemical components including aspartic acid transaminase (AST), alanine transaminase, blood urea nitrogen (BUN), glucose, total protein, albumin, cholesterol, and triglyceride were analyzed with the Automatic Biochemical Analyzer (HI System, Technicon, Tarrytown, NY, USA).

Plasma insulin and leptin were assayed by enzyme-immuno-

Table 2. Chemical composition of experimental diets

Item	CON[1)]				TMR[1)]		
	GP[2)]	EP[2)]	LP[2)]	Rice straw	GP	EP	LP
Dry matter (%)	89.23	90.14	89.53	88.00	68.07	65.58	65.41
Crude protein (% DM)	15.68	13.31	13.40	5.11	14.55	13.60	13.36
Ether extract (% DM)	2.80	2.77	2.79	2.39	2.98	2.22	1.35
Crude fiber (% DM)	9.98	8.85	7.23	32.16	16.70	15.20	15.20
Crude ash (% DM)	7.88	7.22	6.50	17.16	7.24	7.10	6.20
N-free extract (% DM)	52.89	57.99	59.61	43.18	26.60	27.46	29.30
NDF (% DM)	49.15	51.25	40.95	75.41	67.71	66.55	59.88
ADF (% DM)	14.27	13.61	12.26	51.02	25.55	25.35	25.45
TDN (% DM)	68.50	70.00	73.00	43.23	70.30	72.10	77.20

TMR, total mixed ration; GP, growing period; EP, fattening period; LP, finishing period; DM, dry matter; NDF, neutral detergent fiber and; ADF, acid detergent fiber; TDN, total digestible nutrient.
1) CON, steers fed concentrate and rice straw separately; TMR, steers fed a TMR.
2) GP, 8-12 month of age; EP, 13-23 month of age; LP, 24-30 month of age.

assay using Multi-species Insulin RIA kit and Multi-species Leptin RIA kit (Linco Research, Inc, St. Charles, MO, USA), respectively. I125 radioactivity was monitored using γ-counter (COBRATM II, Packard Bioscience, Downers Grove, IL, USA).

Analysis of plasma retinol by high-performance liquid chromatography

High-performance liquid chromatography (HPLC, PerkinElmer, Series 200, Waltham, MA, USA) was used for the analysis of retinol in the plasma of Hanwoo steers according to the methods of The Vitamin Society of Japan [12]. In brief, the plasma (50 μL) were placed into brown centrifuge tubes containing 50 μL of ethanol and tubes were vortexed for 10 seconds. Next, 300 μL of n-hexane were added into tubes and vortexed for 60 seconds. These tubes were then centrifuged at 3,000 rpm for 5 min to isolate the supernatant of the n-hexane layer extract (250 μL). After that, 300 μL of n-hexane was added to the remaining n-hexane layer and re-centrifuged at 3,000 rpm for 5 min to isolate the supernatant of the n-hexane layer (250 μL). The harvested supernatant of the extract was evaporated under N_2 injection and the residue was dissolved into 50 μL iso-propanol for HPLC analysis. For the quantification of retinol, an aliquot was injected into the HPLC system with Brownlee Validated C-18 column (5 μm, 4.6 mm×150 mm). A calibration curve was prepared using retinol standard (Sigma-Aldrich, St. Louise, MO, USA).

Carcass trait assessment

After feeding trial, all steers were fasted for 24 h and slaughtered at a commercial meat abattoir to assess carcass yield and quality. Carcasses were chilled for 24 h at 4°C, after which the left sides were opened between the 13th rib and the 1st lumbar and the *longissimus dorsi* was then used for grading yield and quality of carcass according to the standard criteria guided by [13]. Cold carcass weight, back-fat thickness, and size of loin-eye were evaluated for the determination of yield grade index, and yield grade ranged from 1 to 3. Marbling score (1 to 9), fat color (1 to 9), meat color (1 to 9), texture (1 to 3), and maturity (1 to 9) were evaluated for the assessment of carcass quality, and quality grade was ranged from 1 to 5.

Statistical analysis

The effects of two different feeding system on BW, ADG, feed intake, blood biochemical components and hormones, and carcass traits were analyzed by PROC t-test [14]. The correlation coefficients between blood parameters in fattening and finishing phases and carcass traits were analyzed by Pearson's methods. The level of probability for statistical difference was established at $p<0.05$. Data are presented as means±standard error.

RESULTS

Dry matter and total digestible nutrient intakes, and growth performance

The dry matter (DM) and TDN intakes, and growth performance of Hanwoo steers in the two different feeding systems are presented in Table 3. Average DM and TDN intakes during whole experimental period were not significant different between the treatments. But there were significant ($p<0.05$) differences in DM intake during the finishing period, and in TDN intake during growing and fattening periods between the treatments. The BW of the CON group was significantly ($p<0.05$) heavier during finishing period compared to the TMR group, while there was no difference in BW during growing and fattening periods. Daily body gain was also significantly ($p<0.05$) higher in the CON group than the TMR group during fattening and finishing periods. Overall daily body gain during the entire period was also significantly higher ($p<0.05$) in the CON group. But feed conversion ratio did not appear to be statistically different between the two feeding system.

Table 3. Effect of feeding system on DM and TDN intakes, body weight gain, and feed conversion of Hanwoo steers

Item	Treatments[1),2)]		p value
	CON	TMR	
DM intake (kg/d)			
Growing period[3)]	6.55±0.37	6.65±0.21	0.793
Fattening period[3)]	8.81±0.15	8.96±0.06	0.334
Finishing period[3)]	9.00±0.11	8.29±0.19	0.002
Average	8.46±0.14	8.33±0.10	0.444
TDN intake (kg/d)			
Growing period	4.25±0.13	4.68±0.15	0.038
Fattening period	6.03±0.07	6.42±0.04	0.000
Finishing period	6.57±0.08	6.38±0.14	0.219
Average	5.88±0.09	6.09±0.08	0.105
Body wt. (kg)			
Initial body wt.	220.9±4.58	226.5±3.18	0.312
Growing period	266.9±3.68	273.4±2.81	0.173
Fattening period	468.7±6.06	465.7±3.81	0.677
Finishing period	672.7±5.97	640.3±3.70	0.000
Final body wt.	730.2±14.11	695.7±10.34	0.056
Total body gain	509.3±18.99	469.2±22.25	0.279
Daily body gain (kg)			
Growing period	0.79±0.04	0.86±0.03	0.160
Fattening period	0.90±0.03	0.77±0.02	0.002
Finishing period	0.63±0.02	0.57±0.02	0.038
Average	0.79±0.02	0.73±0.01	0.010
Feed conversion			
Growing period	9.01±0.78	8.30±0.72	0.592
Fattening period	10.30±0.52	11.64±0.76	0.215
Finishing period	14.16±0.90	14.68±0.92	0.484
Average	11.01±0.54	11.23±0.74	0.226

DM, dry matter; TDN, total digestible nutrient; TMR, total mixed ration; SE, standard error.
1) Mean±SE.
2) CON, steers fed concentrate and rice straw separately; TMR, steers fed a TMR.
3) Growing period, 8-12 month of age; fattening period,13-23 month of age; finishing period, 24-30 month of age.

Table 4. Effects of feeding system on plasma biochemical components in Hanwoo steers

Item	Treatments1),2)		p value
	CON	TMR	
Aspartate transaminase (U/L)			
Growing period3)	57.25±2.98	80.11±5.09	0.016
Fattening period3)	72.75±5.39	91.00±4.29	0.200
Finishing period3)	82.50±2.25	89.23±2.83	0.119
Alanine transaminase (U/L)			
Growing period	21.75±1.11	26.22±1.48	0.087
Fattening period	24.25±0.98	28.56±1.23	0.390
Finishing period	23.33±0.94	25.23±0.87	0.177
Blood urea-N (mg/100 mL)			
Growing period	11.43±1.93	17.27±0.91	0.009
Fattening period	13.75±1.10	13.54±0.68	0.868
Finishing period	13.33±0.43	12.58±0.59	0.396
Glucose (mg/100 mL)			
Growing period	91.00±3.19	96.78±4.58	0.447
Fattening period	88.63±3.01	93.59±4.57	0.488
Finishing period	90.42±3.21	92.86±3.08	0.615
Total protein (g/100 mL)			
Growing period	6.95±0.10	6.91±0.29	0.933
Fattening period	6.84±0.30	6.87±0.21	0.928
Finishing period	7.68±0.08	7.46±0.07	0.079
Albumin (g/100 mL)			
Growing period	3.43±0.03	3.40±0.15	0.917
Fattening period	3.49±0.14	3.36±0.10	0.490
Finishing period	3.53±0.07	3.42±0.03	0.138
Cholesterol (mg/mL)			
Growing period	183.50±26.57	161.89±8.51	0.486
Fattening period	246.88±28.25	166.00±7.17	0.024
Finishing period	208.75±16.47	155.23±4.53	0.008
Triglyceride (mg/100 mL)			
Growing period	15.75±3.57	10.44±1.40	0.115
Fattening period	14.63±0.68	10.76±0.79	0.005
Finishing period	13.75±1.36	10.59±0.92	0.007

TMR, total mixed ration; SE, standard error.
1) Mean±SE.
2) CON, steers fed concentrate and rice straw separately; TMR, steers fed a TMR.
3) Growing period, 8-12 month of age; fattening period, 13-23 month of age; finishing period, 24-30 month of age.

Blood biochemical components, retinol, leptin, and insulin

Data on blood biochemical profiles and the levels of retinol, leptin and insulin of Hanwoo steers by different feeding system are shown in Table 4, 5, respectively. The CON group had significantly ($p<0.05$) lower AST and BUN level during growing period, and higher cholesterol and triglyceride levels during fattening and finishing periods compared to the TMR group (Table 4). Blood retinol concentration in the TMR group was significantly ($p<0.05$) higher for growing period, and inclined to sustain a higher level for fattening and finishing periods compared to the CON group. Blood insulin and leptin levels were not affected by feeding system (Table 5).

Carcass traits and the correlations between blood components and carcass traits

Carcass yield and quality traits of Hanwoo steers by different feeding system are shown in Table 6. Cold carcass weight, back fat thickness and meat yield index and grade were also not affected by feeding system. However, rib-eye area of *longissimus dorsi* in the CON group was greater ($p<0.05$) than that of the TMR group. In carcass quality traits, marbling score index, one important meat quality, tended to be higher ($p = 0.098$) in the CON group compared to the TMR group, but there was no significant difference in meat quality grade between two groups except for meat color. Meat color was darker ($p<0.05$) red in the TMR group compared to the CON group.

The correlation coefficients between blood biochemical components and carcass traits in Hanwoo steers are presented in Table 7. Retinol had a significantly ($p<0.05$) negative correlation with marbling score and rib-eye area. Leptin showed a significantly ($p<0.05$) positive correlation with back fat thickness, whereas it had a negative correlation with carcass yield index. Glucose

Table 5. Concentration of retinol, insulin and leptin of plasma in Hanwoo steers

Item	Treatments[1),2)]		p value
	CON	TMR	
Retinol (IU/mL)			
Growing period[3)]	252.98 ± 37.56	385.88 ± 34.53	0.021
Fattening period[3)]	280.13 ± 49.01	365.05 ± 36.62	0.192
Finishing pWeriod[3)]	294.58 ± 35.61	367.57 ± 34.61	0.185
Insulin (ng/mL)			
Growing period	0.72 ± 0.25	0.69 ± 0.34	0.963
Fattening period	2.18 ± 0.38	1.94 ± 0.30	0.652
Finishing period	2.56 ± 0.44	2.55 ± 0.29	0.992
Leptin (ng/mL)			
Growing period	0.87 ± 0.10	1.52 ± 0.38	0.291
Fattening period	2.42 ± 0.38	3.47 ± 0.34	0.770
Finishing period	4.93 ± 0.42	4.52 ± 0.23	0.356

TMR, total mixed ration; SE, standard error.
1) Mean ± SE.
2) CON, steers fed concentrate and rice straw separately; TMR, steers fed a TMR.
3) Growing period, 8-12 month of age; fattening period,13-23 month of age; finishing period, 24-30 month of age.

Table 6. Effect of feeding system on carcass yield and quality traits of Hanwoo steers

Item	Treatments[1),2)]		p value
	CON	TMR	
Yield traits[3)]			
Carcass wt. (kg)	431.75 ± 10.70	408.73 ± 7.14	0.730
Back fat thickness (mm)	11.95 ± 0.87	13.95 ± 0.72	0.980
Rib-eye area (cm^2)	96.85 ± 2.33	89.88 ± 1.59	0.015
Meat yield index	66.17 ± 0.75	64.54 ± 0.52	0.800
Meat yield grade	2.15 ± 0.67	1.98 ± 0.62	0.320
Quality traits[4)]			
Marbling score	5.65 ± 0.48	5.25 ± 0.32	0.098
Fat color	4.75 ± 0.10	4.83 ± 0.09	0.599
Meat color	3.00 ± 0.00	3.13 ± 0.05	0.023
Texture	1.15 ± 0.08	1.28 ± 0.07	0.288
Maturity	2.15 ± 0.08	2.18 ± 0.06	0.810
Meat quality grade	3.65 ± 0.23	3.30 ± 0.16	0.122

TMR, total mixed ration; SE, standard error.
1) Mean ± SE.
2) CON, steers fed concentrate and rice straw separately; TMR, steers fed a TMR.
3) Rib-eye area, *longissimus dorsi* muscle area; meat yield index = 68.184–(0.625 × Back fat thickness)+(0.130 × Rib-eye area)–(0.024 × carcass weight)+3.23; meat yield grade, highest (3 point) to lowest (1 point).
4) Marbling score, highest (9 point) to lowest (1 point); meat color, very light red (1 point) to very dark red (9 point); fat color, white (1 point) to yellow (9 point); texture, soft (1 point) to rough (3 point); maturity, mature (9 point) to youthful (1 point); quality grade, highest (5 point) to lowest (1 point).

was negatively correlated with back fat thickness, while cholesterol and triglyceride appeared to have a significantly ($p<0.05$) positive correlation with carcass weight and rib-eye area.

DISCUSSION

In comparison of feeding systems (CON vs TMR) in beef cattle production, there are complicated practical difficulties including nutrient composition, feed ingredients, energy density, etc. in designing an experiment. There are several studies showing that feeding system did not affect growth performance and carcass traits [3,15], but there are also studies demonstrating that TMR feeding system improved animal performance and carcass traits [4,5,16]. In agreement with the report of [17], the present study demonstrated that the steers fed the higher proportion of concentrates in finishing periods had an increased DM intake compared with those fed a TMR. Caplis et al [8] also concluded that feeding method (concentrate and straw vs TMR) did not affect any of the growth performance parameters, suggesting that dietary energy value and dry matter intake are more important factors to increase growth performance rather than type of feeding system. It is evident that dietary energy level in finishing steers plays a crucial role in the production of high quality beef rather than feeding method [7,13]. Martin et al [6] also reported that weight at slaughter was not different in steers fed high concentrate diet compared with those fed a TMR. By contrast, Cooke et al [4] observed that TMR feeding increased feed intake, weight gain and carcass weight compared with separate feeding. From our study, it was concluded that feeding CON diet had advantages over a TMR especially during finishing period in beef production. This advantage might be attributed to increased DM intake during finishing periods in the CON group compared to the TMR group.

Table 7. The correlation coefficients between plasma biochemical compositions and carcass traits of Hanwoo steers

Item	Yield traits				Quality traits			
	Carcass wt.	Back fat thickness	Rib-eye area	Yield index	Marbling score	Fat color	Texture	Maturity
Retinol	–0.406	0.123	–0.233*	–0.060	–0.628*	–0.167	0.128	–0.343
Insulin	–0.018	0.063	–0.009	–0.047	0.081	–0.229	–0.215	0.030
Leptin	–0.030	0.286*	–0.121	–0.274*	–0.028	–0.245	–0.079	–0.082
Glucose	0.137	–0.252*	0.112	0.203	0.124	–0.229	0.182	–0.025
Total protein	0.180	0.167	0.032	–0.183	–0.121	–0.245	0.051	0.054
Albumin	0.172	0.006	0.073	–0.033	–0.180	–0.167	0.230	0.004
Cholesterol	0.312*	0.135	0.255*	–0.098	–0.243	0.204	0.081	0.201
Triglyceride	0.324*	–0.161	0.409*	0.207	–0.073	–0.199	–0.015	0.116

* $p<0.05$.

With the biochemical parameters in blood, steers fed concentrate and roughage separately showed a more desirable plasma biochemical profile including lower AST and BUN during growing period. While the steers of CON group showed higher levels of cholesterol and triglyceride during finishing period, which might be associated with the increased marbling score in the CON group compared to the TMR group. In general, it is known that increased circulating blood triglyceride is derived from the mobilization of the deposited fat content [18]. In agreement with the present study, Kim et al [5] demonstrated that blood cholesterol concentration was positively correlated with BW of Hanwoo steers.

Blood retinol level in the steers of CON group was a significantly lower than that in the TMR group during growing period. This result might be due to lower β-carotene concentration in concentrates with straw than in a TMR containing forages [19]. Recent studies have demonstrated that depletion of retinol in the diet of beef cattle increased intramuscular fat and subsequently improved the quality of meat [20,21]. Leptin, a hormone secreted by adipocytes and recognized as a biomarker of body fat deposition, has been shown to increase when animal had a higher fat deposition [22,23]. Geary et al [22] reported that serum leptin level was significantly related to marbling score and back fat deposition in beef cattle, indicating that serum leptin may be a good indicator of body fat content in beef cattle. However, Yonekura et al [24] reported that serum leptin level in Japanese black cattle was not significantly associated with the marbling score of the *longissimus dorsi*. The level of blood insulin typically increases in well-fed and concentrate-fed cattle than in fasted- and forage-fed cattle [25,26]. In the present study, we did not see any statistical difference in insulin and leptin levels between two feeding systems, reflecting that blood leptin and insulin levels were not directly affected by the feeding system in Hanwoo steers.

In carcass yield traits, most indicators including carcass weight, yield grade, and back fat thickness except rib-eye area were not affected by dietary feeding system. However, rib-eye area in the *longissimus dorsi* of the CON group was greater than that of the TMR group.

In carcass quality traits, meat color score was significantly lower in the steers fed concentrates with straw than those fed a TMR without affecting the other carcass quality indicators between two groups. In general, the present study is similar to a study of [16], who reported that carcass traits were not differ between finishing steers fed a TMR and those self-fed rations consisted of corn, wheat and barley with free-choice grass hay. Several studies also reported that feeding system itself did not influence carcass traits in steers [8,21,27]. However, not all studies have reported that feeding system did not affect carcass traits in beef cattle. In particular, it is widely accepted that meat color is much lighter in concentrates-fed beef cattle than in forage-fed cattle [28]. This is also in agreement with our observation that the steers fed concentrate with rice straw showed a lower meat color compare with those fed a TMR containing higher level of forage. Consistent with the present data, Caplis et al [8] reported that steers fed silage had less bright and darker red muscle color than those fed concentrates. This difference may be attributed to higher carotene level of the forage in TMR. According to the reports of [29], carotenoid content was measured at 30 mg and 2 mg/kg DM for the TMR and high concentrate, respectively, although there are complicating factors in comparison of a TMR with concentrate diet. It seemed that the response of carcass traits to feeding method in beef steers could be differently affected, mostly depending upon the sort and percentage of feed ingredients, the level of forage, the density of energy level, etc. [4].

In summary, the feeding system of CON compared to the TMR system may give more desirable growth performance and carcass traits in Hanwoo steers under the circumstances of the present study. However, it is still required to explore the effects of feeding system on beef production under the various conditions of feeding and management. Through correlating data between the blood biochemical compositions during the fattening and finishing phase in Hanwoo steers and subsequent carcass traits, it may be possible to find a biomarker for beef quality prior to slaughter.

CONFLICT OF INTEREST

We certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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