Research Article

Effects of Feeding Total Mixed Ration in the Growing and Fattening Periods on the Growth and Carcass Characteristics of Hanwoo Steers

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Abstract | Sixty Hanwoo steers of average weight and average age 6.5 months were raised until the age of 18 months (growing period, G) and from the age of 19 months to 30.85–31.52 months (fattening period, F). They were separately fed concentrate and forage (C) or total mixed ration (TMR, T) in the growing and fattening periods. The treatments were GCFC (Concentrate feeding in the growing and fattening periods), GCFT (Concentrate feeding in the growing period and TMR feeding in the fattening period), GTFC (TMR feeding in the growing period and concentrate feeding in the fattening period) and GTFT (TMR feeding in the growing and fattening periods) in a completely randomized design. Dry matter intake ($p < 0.001$) in the growing period was higher in the GCFC and GCFT groups than in the other groups, whereas DMI of TMR feeding (GCFT and GTFT) during fattening period increased by 3.3% ($p < 0.001$). The *longissimus dorsi* muscle area (LMA, 94.20 vs. 96.73 cm^2) and back fat thickness (BFT 17.33 vs. 16.93 mm) were not significantly affected during fattening period among different treatments. Marbling score, which substantially affects meat quality, the GCFT and GTFT groups in the fattening period presented higher than the GTFC and GCFC groups. The incidence of C grade of meat yield was 33.3% with GCFC and GTFC) and 40.0% with GCFT and GTFT). The incidence of grade 1+ or higher meat quality was higher with (GCFT, 86.6%; GTFT, 73.3%) than (GCFC, 46.7%; GTFC, 66.6%) in the fattening period. In conclusion, feeding TMR to beef cattle has been shown to have a positive effect on productivity. Therefore, it is expected that TMR can help to improve the competitiveness of beef cattle farms.

Received | February 23, 2021; **Accepted** | July 12, 2021; **Published** | October, 13, 2021
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Citation | Ahn, J.H, J.H Choi. and I.S. Nam. 2021. Effects of feeding total mixed ration in the growing and fattening periods on the growth and carcass characteristics of Hanwoo steers. *Sarhad Journal of Agriculture,* 37(4): 1476-1484.
DOI | https://dx.doi.org/10.17582/journal.sja/2021/37.4.1476.1484
Keywords | Hanwoo steer, Total mixed ration, Carcass performance, Meat quality, Productivity

Introduction

During recent years, the Korean beef cattle industry has been decreasing in terms of number of heads and farms, and the farm scale has been shifting to full-time farmers and large-scale farming. Thus, there is a need to develop specific technologies to improve productivity. Recently, total mixed ration (TMR), a method of feeding, has been widely used in dairy cattle farms. This is because, through TMR, all feed ingredients can be provided to cattle, including concentrate and forage feeds, without distinction (Drackley and Cardoso, 2014). In addition, TMR feeding promotes the secretion of saliva as the number

of mastication increases, and therefore, the rumen pH can be maintained close to 5.5–6.5 (Kim *et al*., 2003). This increases feed intake and reduces metabolic diseases to improve milk production (Sutton *et al*., 2003).

In Korea, the scale of Hanwoo farming has been increasing in recent years owing to the convenience of feed supply and easy management of each cattle group. However, the supply of TMR is less in Hanwoo farming than in dairy farming. Feeding TMR to Hanwoo bull increased the growth rate and improved their economic efficiency by increasing the meat quality (Kim *et al*., 2008). However, when fattening cows at final stage were fed TMR containing 19% alfalfa, the feed intake and daily gain increased, but it did not affect carcass fat mass and meat quality (Madruga *et al*., 2019). Furthermore, Moya *et al*. (2011) reported that feeding beef cattle with TMR in the end stage of fattening had no effect on feed intake and rumen fermentation. A comparative study of TMR and concentrate and straw feed in Angus beef cattle showed no difference in hyperacidity in the rumen, whereas dry matter and protein digestibility increased in the separate feeding group (Genis *et al*., 2019).

These findings indicate that the effects of TMR feeding on beef cattle are still not clear. Therefore, it is necessary to evaluate the beneficial effects of TMR in the growing and fattening periods, in order to establish a more structured TMR specification program. In this study, we compared and analyzed two feeding programs, that is, feeding TMR and separate feeding (concentrated feed and forage feed), in the growing and fattening periods of Hanwoo steer. This study was conducted to identify an optimal feeding method for Hanwoo steer in the growing and fattening periods.

Materials and Methods

Animals and feed

Sixty Hanwoo male calves purchased through the pedigree auction market were fed for 24 months in a beef cattle farm. The mean age of Hanwoo male calves was 6.5 (±0.13) months and average body weight was 195.9 (±3.31) kg. Sixty calves were divided into fifteen calves per each treatment group and completely randomized into three pen (5 m × 10 m), with five calves per each pen. Commercially available concentrated feed and TMR were used in this study; chopped timothy and rice straw were used as forage feed (Table 2). The feeding period was divided into: (i) the growing period, from stocking (approximately 6 months of age) to 18 months of age, and (ii) the fattening period, from 19 months of age to shipping (30.85–31.52 months of age). The cattle were fed concentrated and forage feed separately or the TMR. This study involved the following four treatments: GCFC (feeding the concentrated and forage feed separately in the growing and fattening periods), GCFT (feeding the concentrated and forage feed separately in the growing period and TMR in the fattening period), GTFC (feeding the TMR in the growing period and concentrated and forage feed separately in the fattening period), and GTFT (feeding the TMR in the growing and fattening periods). As for the concentrated feed, the cattle were fed growing feed from stocking to 13 months of age, early fattening feed from 14–22 months of age, and end fattening feed from 23 month of age to shipment. The TMR was provided as follows: for early growing, from stocking to 13 months of age; for end growing, from 14–18 months of age; for early fattening, from 19–24 months of age; and for end fattening, from 25 month of age to shipment. The TMR was provided twice a day (07:00 and 18:00), and the concentrate and forage feed was fed three times a day (07:00, 12:00 and 18:00). For concentrate feed, an automatic feeding device was used, and TMR and forage feed were quantitatively fed using a scale. The residual feed was measured and discarded before feeding of every next morning. Water and mineral blocks were provided *ad libitum*.

Analysis

Chemical analysis of the experimental feed: The dry matter, crude protein (method 955.04), crude fat (method 920.39), crude fiber (method 978.10), and crude ash in the feed were analyzed according to the AOAC (2002). The content of neutral detergent fiber (NDF) and acid detergent fiber (ADF) was analyzed according to Van Soest (1991), and total digestible nutrients (TDN) were determined using relevant data from feed companies (Table 1).

Feed intake and weigh gain: The feed was provided according to the instruction provided with the product. Dry matter intake (DMI) was calculated as the difference in weight between feed from the previous day and the remaining feed in the next morning. Average daily gain (ADG) was calculated based on body weight by measuring body weight at the start and end of the experiment.

Table 1: *Chemical composition of commercial concentrates and forages and total mixed ration (TMR), used as experimental diets.*

	Commercial mixed feed[1)]			Rice Straw	Timothy Hay
Parameter[2)]	**Growing**	**Early Fattening**	**Late Fattening**		
	DM, %				
Moisture	11.20	12.16	12.77	12.29	8.02
CP	16.91	14.82	13.83	5.07	12.84
EE	3.77	3.65	4.30	1.98	3.96
CF	13.61	11.40	10.31	32.04	24.68
CA	9.38	7.88	6.39	16.74	7.81
NDF	25.12	23.37	21.28	76.05	52.21
ADF	14.64	13.09	11.46	51.45	30.40
TDN	78.83	81.97	84.83	43.66	54.49
	Total Mixed Ration[3)]				
	Early Growing	**Late Growing**	**Early Fattening**		**Late Fattening**
	DM, %				
Moisture	39.58	39.80	38.90		40.12
CP	16.05	14.78	13.58		12.02
EE	5.63	5.81	5.89		6.21
CF	21.52	19.93	18.00		18.37
CA	8.28	8.14	7.69		8.52
NDF	44.69	43.19	40.92		38.41
ADF	23.17	23.42	22.42		21.71
TDN	69.51	70.60	72.01		76.82

[1)] Growing period (6–13 months); early fattening period (14–22 months); late fattening period (23–30 months).
[2)] DM: dry matter; CP: crude protein, EE: ether extract, CF: crude fiber, CA: crude ash, NDF: neutral detergent fiber, ADF: acid detergent fiber, TDN: total digestible nutrient (calculated value).
[3)] Early growing period (6–11 months); late growing period (12–17 months); early fattening period (18–23 months); late fattening period (24–30 months).

Carcass characteristics: After the completion of the experiment, the animals were fasted for 24 h, and then shipped. After slaughter, the carcasses were stored in cold room for 24 h. Thereafter, the meat was graded based on the back fat thickness, *longissimus dorsi* muscle area, and carcass weight using the meat yield index, to determine meat yield. The meat quality was also graded by assessing intramuscular marbling score, meat color, fat color, texture, and maturity. The meat index was determined using the following formula (KIAPQE, 2011).

Meat yield index = 68.184 – [0.625 × back fat thickness (mm)] + [0.130 × longissimus dorsi muscle area (cm²)] – [0.024 × carcass weight (kg)] + 3.23

Meat quality index = 1^{++} = 5, 1^{+} = 4, 1 = 3, 2 = 2, 3 = 1

Statistical analysis
Statistical analyses were carried out using the Statistical Analysis System (SAS, 2001). All data were expressed as means ± standard error. Data were analyzed by one way analysis of variance (ANOVA) followed by Duncan's multiple range test. Significant differences among the treatment group (GCFC, GCFT, GTFC, and GTFT) were considered statistically significant at $p < 0.05$ and $p < 0.001$.

Results and Discussion

Nutrient intake
Table 2 shows the nutrient intake in the growing period, that is, from stocking to 18 months of age. The average DMI per head during the growing period was significantly higher in the GCFC (7.34 kg/d) and GCFT (7.33 kg/d) groups than in the GTFC (6.34 kg / d) and GTFT (6.34 kg/d) groups ($p < 0.05$). The DMI in the growing period was approximately 14% higher in the GCFC and GCFT groups than that in the GTFC and GTFT groups.

Table 2: *Effects of feeding TMR in the growing or fattening period on the nutrient intake of Hanwoo steers (DM basis).*

Parameter[2)]	Growing Period[1)]				P value
	GCFC	GCFT	GTFC	GTFT	
DMI, kg/d					
Concentrates	5.18 ± 0.03	5.17 ± 0.04	-	-	
Rice straw	1.32 ± 0.01	1.33 ± 0.01	-	-	
Timothy hay	0.84 ± 0.01	0.83 ± 0.01	-	-	
TMR	-	-	6.34 ± 0.05	6.34 ± 0.09	
Total	7.34 ± 0.03[a]	7.33 ± 0.04[a]	6.34 ± 0.05[b]	6.34 ± 0.09[b]	<0.001
	Fattening Period[1)]				
DMI, kg/d					
Concentrates	8.27 ± 0.02	-	8.28 ± 0.03	-	
Rice straw	0.97 ± 0.01	-	0.97 ± 0.01	-	
TMR	-	9.49 ± 0.02	-	9.56 ± 0.03	
Total	9.24 ± 0.03[b]	9.49 ± 0.02[a]	9.24 ± 0.03[b]	9.56 ± 0.03[a]	<0.001

Values are expressed as mean ± standard error.

[a,b] Means in the same row with different superscripts are significantly different, P < 0.05.

[1)] GCFC: concentrate feeding in the growing and fattening periods; GCFT: concentrate feeding in the growing period and TMR feeding in the fattening period ; GTFC: TMR feeding in the growing period and concentrate feeding in the fattening period; GTFT: TMR feeding in the growing and fattening periods.

[2)] Concentrates: commercial mixed feed; TMR: total mixed ration; DM: dry matter; DMI: dry matter intake; CPI: crude protein intake; TDNI: total digestible nutrient intake.

Gonzalez *et al.* (2008) reported that in calves with an average body weight of 140 kg, the intake time of the concentrated feed was shorter than that of the forage feed. In this study, the GCFC and GCFT groupanimals in the growing period were fed 1.5 kg/d timothy after feeding concentrated feed. The DMI in the GCFC and GCFT groups increased during the growing period because chopped forages increased the rumen passing rate (Galyean and Goetsch, 1993; Kim *et al.*, 1994). According to the Korean beef feeding standard (2007), the DMI of Hanwoo steer, weighing 200–450 kg, is 5.1–9.3 kg/d (average 6.97 kg/d). In this study, the DMI of Hanwoo steer fed the TMR during the growing period was 6.34–7.34 kg/d, which was within the standard range.

Table 2 shows the nutrient intake in the fattening period from the age of 19 months to the time of shipment. The average daily DMI per head in the GCFT (9.49 kg/d) and GTFT (9.56 kg/d) groups was 3.3% higher than that in the GCFC (9.24 kg/d) and GTFC (9.24 kg/d) groups ($p < 0.001$). The ratio of forage feed to concentrated feed in the GTFC and GTFC groups increased from approximately 3:7 in the growing period to approximately 1:9 in the fattening period. In general, considering the findings of a previous study (Kim *et al.*, 1999), who reported that the rumen pH was lowered to 5.5 at a ratio of 3:7 (forage feed:concentrate), the rumen pH of the concentrate-fed groups (GTFC and GTFC) was rapidly lowered in this study. When the pH of the rumen is low, the digestion rate of cellulose reduces due to the reduction in rumen cellulolytic bacteria (Khalili and Huhtanen, 1991), and the feed intake during the fattening period is not stable due to the unstable rumen environment. According to Kim *et al.* (2003), the pH of the concentrate and forage-fed groups was below 6.0 for 2–5 h after feeding, but the TMR-fed groups maintained a relatively stable pH of 6.0–6.2 for 0–8 h. Furthermore, Moya *et al.* (2011) reported that the number of chewing and rumination times increased ($p < 0.01$) in the TMR-fed groups compared with those in the concentrate and forage-fed groups. In this study, the high intake of TMR during the fattening period was due to the ability to maintain a stable rumen environment. Several studies (Kellems *et al.*, 1991; Nocek *et al.*, 1986; Schwartzkopf-Genswein *et al.*, 2004) have showed that the TMR intake rate between the growing and fattening periods was maintained until shipment due to the stability of the rumen environment. According to the Korean beef feeding standard (2007), the DMI of Hanwoo steer, weighing 500–700 kg, is 8.6–9.5 kg/d (average 8.90 kg/d). In this study, the DMI of Hanwoo steer fed the TMR during the fattening period was 9.24–9.65 kg/d, which was within the standard range.

Table 3: *Effects of feeding TMR in growing period or fattening period on the weight gain and average daily gain of Hanwoo steers.*

Item[2)]	GCFC[1)]	GCFT[1)]	GTFC[1)]	GTFT[1)]	P value
Body weight, kg					
Initial	195.67 ± 4.14	195.33 ± 4.56	196.67 ± 7.03	196.00 ± 9.86	0.999
18 month	481.33 ± 4.56	476.00 ± 5.82	486.00 ± 2.54	487.67 ± 2.88	0.204
Final	715.87 ± 22.79	718.20 ± 18.23	729.73 ± 12.19	755.80 ± 12.59	0.335
Weight gain, kg					
Initial to 18 month	285.67 ± 4.80	280.67 ± 7.67	289.33 ± 7.88	291.67 ± 8.26	0.730
19 month to final	234.53 ± 19.97	242.20 ± 14.16	243.73 ± 11.59	268.13 ± 11.15	0.405
Initial to final	502.20 ± 21.80	522.87 ± 19.32	533.07 ± 11.85	559.80 ± 11.15	0.347
ADG, kg/d					
Initial to 18 month	0.73 ± 0.01^{b}	0.73 ± 0.01^{b}	0.77 ± 0.00^{a}	0.77 ± 0.00^{a}	<0.001
19 month to final	0.62 ± 0.05	0.64 ± 0.04	0.65 ± 0.04	0.75 ± 0.04	0.130
Initial to final	0.67 ± 0.03^{b}	0.68 ± 0.02^{b}	0.71 ± 0.02^{ab}	0.76 ± 0.02^{a}	0.039
FCR, feed/gain kg					
Initial to 18 month	10.07 ± 0.15^{a}	10.10 ± 0.24^{a}	8.26 ± 0.09^{b}	8.26 ± 0.14^{b}	<0.001
19 month to Final	16.82 ± 1.57	15.70 ± 0.97	14.79 ± 0.73	13.21 ± 0.63	0.104
Initial to final	12.61 ± 0.56^{a}	12.54 ± 0.46^{a}	11.08 ± 0.25^{b}	10.50 ± 0.24^{b}	<0.001

Values are expressed as mean ± standard error.

[a,b] Means in the same row with different superscripts are significantly different, P < 0.05.

[1)] GCFC: concentrate feeding in the growing and fattening periods; GCFT : concentrate feeding in the growing period and TMR feeding in the fattening period; GTFC: TMR feeding in the growing period and concentrate feeding in the fattening period; GTFT: TMR feeding in the growing and fattening periods.

[2)] FCR: feed conversion ratio. Initial: GCFC 6.19 months, GCFT 6.42 months, GTFC 6.66 months, GTFT 6.57 months. Final: GCFC 31.52 months, GCFT 31.52 months, GTFC 31.39 months, GTFT 30.85 months.

Daily gain and feed conversion rate

Table 3 shows the weight change and weight gain by each treatment group in the growing and fattening periods. From the start of the experiment to the age of 18 months, the weight gain in the growing period was not significant, but the weight gain in the TMR-fed groups (GTFT, 291.67 kg; GTFC, 289.33 kg) was 2.6% higher than that in the concentrate and forage-fed groups (GCFC, 285.67 kg; GCFT, 280.67 kg). From 19 months of age to the end of the experiment, the increase in weight in the fattening period was 6.7% higher in the TMR-fed groups (GTFT, 268.13 kg; GCFT, 242.20 kg) than in the concentrate and forage-fed groups (GTFC, 243.73 kg; GCFC, 234.53 kg). The daily weight gain during the growing period was 0.77 kg/d in the TMR-fed groups (GTFT and GTFC), which was significantly higher than 0.73 kg/d in the concentrate and forage-fed groups (GCFC and GCFT) ($p < 0.001$). In addition, the daily weight gain in the fattening period tended to be higher in the TMR-fed groups, GTFT (0.75 kg/d), than in the concentrate and forage-fed groups (GCFT, 0.64 kg/d and GCFC, 0.62 kg/d). Feeding the TMR stabilizes the rumen pH (Nocek *et al.*, 1986) and increases the time to maintain the pH above 5.8 (Harrison *et al.*, 1989). TMR feeding improved rumen stabilization and digestibility by increasing the daily rumination time compared with concentrate and forage feeding (Lee *et al.*, 2010; Kellems *et al.*, 1991). In addition, Li *et al.* (2003) reported that the number of bacteria and protozoa in the rumen increased and the activity of fibrinolytic enzymes increased when TMR was fed. Engel *et al.* (2013) compared the concentrate and forage-fed groups and the TMR groups after 120 d of feeding in end-fattening beef cattle. The DMI was 10.7% higher in the concentrate and forage-fed groups, but the daily gain was 6.3% higher in the TMR groups, which is similar to the findings of this study. In addition, Kang *et al.* (2005) reported that the TMR-fed groups showed a higher growth rate than the concentrate and forage-fed groups. Cho *et al.* (2008) reported that the average daily gain was higher in the TMR-fed groups than in the concentrate and forage-fed groups, especially in the early fattening period ($p < 0.05$). Kwon (2009) reported that feeding TMR during the growing

Table 4: *Effects of feeding TMR in the growing period or fattening period on the carcass characteristics of Hanwoo steers.*

Item[2)]	GCFC[1)]	GCFT[1)]	GTFC[1)]	GTFT[1)]	P value
CW (kg)	432.07 ± 13.83	431.33 ± 11.06	437.67 ± 7.36	455.20 ± 7.82	0.336
BFT (mm)	14.33 ± 1.21	17.33 ± 1.73	14.80 ± 1.80	16.93 ± 1.75	0.477
LMA (cm^2)	88.53 ± 1.80	94.20 ± 3.09	90.93 ± 2.32	96.73 ± 2.98	0.082
Yield index	63.46 ± 0.95	62.47 ± 1.03	63.48 ± 1.25	62.48 ± 1.29	0.855
Yield grade	2.13 ± 0.19	2.27 ± 0.18	2.13 ± 0.19	2.33 ± 0.18	0.823
Marbling score	5.47 ± 0.47	6.73 ± 0.44	5.87 ± 0.49	6.73 ± 0.48	0.150
Meat color	4.93 ± 0.07	4.80 ± 0.11	4.87 ± 0.09	4.93 ± 0.07	0.637
Fat color	2.87 ± 0.09	2.67 ± 0.13	2.93 ± 0.07	2.93 ± 0.07	0.135
Texture	1.13 ± 0.09	1.13 ± 0.07	1.07 ± 0.09	1.07 ± 0.07	0.873
Maturity	2.13 ± 0.09	2.27 ± 0.12	2.53 ± 0.13	2.20 ± 0.11	0.078
Quality grade	3.53 ± 0.26	4.20 ± 0.22	3.73 ± 0.25	4.20 ± 0.22	0.122

Values are expressed as mean ± standard error.

[1)] GCFC: concentrate feeding in the growing and fattening periods; GCFT: concentrate feeding in the growing period and TMR feeding in the fattening period; GTFC: TMR feeding in the growing period and concentrate feeding in the fattening period; GTFT: TMR feeding in the growing and fattening periods.

[2)] Marbling score: 1 = the worst fat deposition, 9 = the most fat deposition; Meat color: 1 = bright red, 9 = dark red; Fat color: 1 = white fat, 9 = yellow fat; Texture: 1 = soft, 3 = rough; Maturity: 9 = mature, 1 = young; Quality grade: 1^{++} = 5, 1^{+} = 4, 1 = 3, 2 = 2, 3 = 1.

period had a positive effect on weight gain. Therefore, as observed in this study, feeding TMR improves digestibility due to stabilization of the rumen and has a positive effect on daily gain. The feed conversion rate in the growing period was lower in the TMR-fed groups (GTFT, 8.26 kg and GCFT, 8.26 kg) than in the concentrate and forage-fed groups (GCFC, 10.07kg and GTFC, 10.10kg), ($p < 0.001$). The feed conversion rate in the fattening period was also similar to that in the growing period, but there was no significant difference. Schwartzkopf-Genswein *et al.* (2004) reported that TMR feeding improved the average daily gain by approximately 26% and feed efficiency by 8.4% compared with treatment of repeated restricted feeding and *ad libitum* feeding every 3 d. Moya *et al.* (2011) reported that the feed efficiency of the concentrate and forage-fed groups was lower than that of the TMR-fed groups. The results of these studies were similar to those of this study.

Carcass characteristics and meat quality

Carcass characteristics for each treatment are shown in Table 4. According to recent studies (Roh *et al.*, 2010; Lee *et al.*, 2011; Cheong *et al.*, 2012), the slaughter age of Hanwoo steer is around 31 months of age, which is similar to the finding of this study (30.85–31.52 months of age). The average carcass weight for each treatment group was as follows: 432.07 kg in the GCFC group, 431.33 kg in GCFT, 437.67 kg in GTFC, and 455.20 kg in GTFT. The carcass weight was the highest in the GTFT group, which presented the highest daily weight gain per day and showed a difference in the carcass weight of 23.87 kg although the animals were slaughtered 0.6 months earlier than those in the GCFT group (the lowest carcass weight). The thickness of the back fat was 14.33 mm in the GCFC group, 17.33 mm in GCFT, 14.80 mm in GTFC, and 16.93 mm in GTFT. The longissimus muscle area was as follows: 88.53 cm^2 in the GCFC group, 94.20 cm^2 in GCFT, 90.93 cm^2 in GTFC, and 96.73 cm^2 in GTFT. The GCFT and GTFT groups showed better results than the GCFC and GTFC groups in terms of the longissimus muscle area, possibly due to TMR feeding in the fattening period (Kim *et al.*, 2003). The marbling score (Table 4) was the highest in the TMR groups (GCFT, 6.73 points and GTFT, 6.73 points) during the fattening period. There were no significant differences in meat color, fat color, texture, and maturity by treatment. Kim *et al.* (2003) reported that meat yield and meat quality were improved by feeding TMR in the late stage of fattening in Korean beef cattle (Kim *et al.*, 2003). Cho *et al.* (2008) reported that feeding wet TMR improved meat mass and quality compared with feeding concentrate and forage. The results of this study on meat quality are similar to those of these previous studies.

Meat yield grade and meat quality grade

Table 5 shows the meat quality and meat yield grade

results for each treatment. In the fattening period, the meat yield of the TMR groups was of grade C, based on low back fat thickness and meat yield index. However, due to the wider longissimus muscle cross-sectional area, TMR was found to affect the final meat yield grade. The highest grade of 1^{++} was recorded in the GCFT and GTFT groups compared with that in the GCFC and GTFC groups during the fattening period. The occurrence rate of grade 1+ or higher meat quality was higher in the GCFT (86.6%) and GTFT (73.3%) groups than in the GCFC (46.7%) and GTFC (66.6%) groups during the fattening period. Taken together, these results show that TMR feeding is effective for weight gain and feed conversion rate in the growing period by improving rumen stability and digestibility. In addition, meat quality improved during the fattening period (19–30 months of age), and feeding TMR throughout the fattening period could improve the productivity of Korean native steer.

Table 5: *Effects of feeding TMR in the growing period or fattening period on the meat yield grade (%), meat quality grade (%), and carcass weight of Hanwoo steers.*

Item		GCFC[1)]	GCFT[1)]	GTFC[1)]	GTFT[1)]
Meat yield grade (%)	A	3 (20.0)	2 (13.3)	3 (20.0)	1 (6.7)
	B	7 (46.7)	7 (46.7)	7 (46.7)	8 (53.3)
	B over	10 (66.6)	9 (60.0)	10 (66.6)	9 (60.0)
	C	5 (33.3)	6 (40.0)	5 (33.3)	6 (40.0)
Meat quality grade (%)	1^{++}	3 (20.0)	6 (40.0)	3 (20.0)	7 (46.7)
	1^{+}	4 (26.7)	7 (46.7)	7 (46.7)	4 (26.7)
	1^{+}over	7 (46.7)	13 (86.6)	10 (66.6)	11 (73.3)
	1	6 (40.0)	1 (6.7)	3 (20.0)	4 (26.7)
	1under	2 (13.3)	1 (6.7)	2 (13.3)	0 (0.0)
Carcass weight(kg)		432.07 ± 13.83	431.33 ± 11.06	437.67 ± 7.36	455.20 ± 7.82

[1)] GCFC: concentrate feeding in the growing and fattening periods; GCFT: concentrate feeding in the growing period and TMR feeding in the fattening period; GTFC: TMR feeding in the growing period and concentrate feeding in the fattening period; GTFT: TMR feeding in the growing and fattening periods.

Conclusions and Recommendations

This study investigated the effect of TMR feeding on the productivity of beef cattle. The effectiveness of TMR has been proven through the results of this study. In particular, it has been shown that the TMR has a significant effect on the carcass weight and marbling of beef cattle. In order to improve the quality and quantity of beef cattle, it is recommended to supply TMR from growing period. This TMR feeding method is expected to be advantageous for improving the competitiveness of beef cattle farms.

Novelty Statement

This study investigated the productivity and carcass characteristics of beef cattle according to TMR feeding for each growing stage. This result is expected to help improve the competitiveness of beef cattle farms.

Author's Contribution

Jong Ho Ahn: Collected the data and wrote the research paper.
Jang Hoon Choi: Performed statistical analysis of the data.
In Sik Nam: Conceived the idea, designed the experiment and wrote the research paper.

Conflict of interest
Authors have declared no conflict of interest.

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