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Effects of Fattening Period on Growth Performance, Carcass Characteristics and Lipogenic Gene Expression in Hanwoo Steers

Eung Gi Kwon[a], Byung Ki Park[a], Hyeong Cheol Kim, Young Moo Cho, Tae Il Kim, Sun Sik Chang, Young Kyoon Oh, Nam Kuk Kim, Jun Ho Kim[1], Young Jun Kim[1], Eun-Jib Kim[2], Seok Ki Im and Nag-Jin Choi[2,]*

National Institute of Animal Science, Pyongchang, Gangwon, 232-952, Korea

ABSTRACT : This study was conducted to investigate the effects of different fattening periods i.e. 25, 27 and 29 months of age (25 mo, 27 mo and 29 mo), on feed consumption, body weight gain, carcass parameters, and lipogenic gene expression in 45 Korean native steers (Hanwoo). Daily DM intake was higher in steers on 29 mo compared with those on 25 mo or 27 mo. Daily body weight gain was higher in steers on 25 mo compared with those on 27 mo or 29 mo during fattening and overall experimental periods. Therefore, feed conversion ratio was lower in 25 mo compared with 27 mo or 29 mo during the fattening and whole experimental periods. As expected, slaughter and carcass weights were higher in the order of 29 mo>27 mo>25 mo. Carcass yield grade was relatively lower in 29 mo reflecting higher back fat thickness compared with other treatments, while carcass quality grade was not largely influenced by the treatments. By investigation with an ultra-sound scanning technique, the marbling score was significantly and numerically higher in 25 mo compared with 27 mo or 29 mo. The mRNA levels of stearoyl-CoA desaturase (SCD) gene were gradually increased in the late fattening stages ($p<0.01$) and mRNA of acetyl-CoA carboxylase (ACC), ATP citrate lyase (ACL) and glucose transporter 4 (GLUT4) gene were highly expressed in 29 mo compared with 25 mo and 27 mo ($p<0.05$). However, gene expressions of adipocyte fatty acid binding protein 4 (FABP4) and lipoprotein lipase (LPL) were not significantly different among the treatments. Thus the present results indicated that different fattening period has no major effect on carcass characteristics, although 25 mo had a lower carcass weight compared with 27 mo or 29 mo. (**Key Words :** Hanwoo, Steers, Fattening, Growth, Carcass Characteristics, Lipogenic Gene)

INTRODUCTION

Bovine carcass characteristics and thus beef quality are affected by various factors such as age, sex, genetics, and nutrition. In addition, meat quality is also determined by meat color, fat color, texture, and marbling (intramuscular fat) scores. Marbling plays a particularly important role in determining the juiciness and tenderness of beef, and is one of the main factors used to determine beef quality grade in Korea (Lee et al., 2001; Lee, 2004). Tatum et al. (1982) reported that marbling has been implicated as a contributing factor to beef palatability, and is used as one of the most important factor in evaluating the beef quality.

Hanwoo steers dramatically increase their marbling fat in muscle between 12 and 27 months of age (Lee et al., 2007). Generally, Hanwoo has been fattened until almost 30 months of age to improve meat quality through marbling in Korea. Chung et al. (2000) reported that lipogenesis in subcutaneous fat and intermuscular fat was higher at 30 months of age than at 24 months of age in Hanwoo bulls. Therefore, fattening period is an important factor to produce desirable beef with high proportion of marbling fat in Korea. However, it is difficult for farmers to keep their cattle until 30 months age due to increasing feed expense in recent times.

Thus, the present study was designed to investigate effects of three different fattening periods (i.e. 25, 27 and 29 months) on the growth performance, meat quality and lipogenic gene expression in relation to intramuscular fat content in Hanwoo steers.

* Corresponding Author: Nag-Jin Choi. Tel: +82-41-580-1064, Fax: +82-41-580-1241, E-mail: nagjin@yonam.ac.kr
[1] Department of Food and Biotechnology, Korea University, Jochiwon, Chungnam, 339-700, Korea.
[2] Division of Animal Husbandry, Cheonan Yonnam College, Cheonan, Chungnam, 330-802, Korea.
[a] The first two authors equally contributed to this work.
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MATERIALS AND METHODS

Animals and diets

Forty five Hanwoo calves, 3 months of age and weighing an average of 94.2±6.4 kg, were distributed into 3 groups of 15 calves, each with an individual feeding system (Calan system, Seil Tech, Korea). The calves were assigned to 3 different fattening periods, which lasted for 25 months (25 mo), 27 months (27 mo) and 29 months (29 mo), respectively. In the treatments, 3 pens (5.3×10.6 m) which had concrete floors with sawdust bedding were arranged with 15 calves per pen. The growth trial was conducted with the animals at 4 months of age after a one-month adaptation period. The present study was categorized into the following periods: early growing (4-6 months age), late growing (7-12 months age), early fattening (13-17, 18 and 20 months age in 25 mo, 27 mo and 29 mo, respectively), and late fattening (18-25 months age, 19-27 months age and 21-29 months age in 25 mo, 27 mo and 29 mo, respectively). During the growing and early fattening periods, animals were offered a commercial concentrate at 1.6%-1.8% of body weight, and they were offered concentrate *ad libitum* during the late fattening period until slaughtered. During the early and late growing periods, animals were offered commercial concentrate at 1.5-1.6% of body weight. In the early fattening period, animals were offered commercial concentrate at 1.7-1.8% of body weight. The ingredients and chemical composition of the experimental concentrate offered at different growth stages are presented in Table 1. Klein grass hay (*Fanicium Contoratom L.*) was offered from 2 kg/animal/d (1.8% of BW) to 4 kg/animal/d (1.3% of BW) between 4 and 12 months of age. From 13 to 15 months of age, the hay was changed to rice straw, and animals were offered hay at 2.0, 1.5 and 1.0 kg/animal/d, and rice straw at 2.0, 2.1, and 2.2 kg/animal/d at 13, 14 and 15 months of age, respectively. From 16 months of age only rice straw was offered at 2.2 kg/animal/d. The amount of rice straw offered was decreased with increasing age, and it was restricted to 0.6 kg/d during the late fattening period. The contents of DM, crude protein, ether extract, NDF and ADF of hay were 91.5%, 10.9%, 1.7%, 71.6% and 39.5%, respectively. The contents of DM, crude protein, ether

Table 1. Ingredient and chemical composition of the experimental diets

Item	Early growing period	Late growing period	Early fattening period	Late fattening period
Ingredient (DM)				
Corn	22.00	25.60	36.31	-
Corn, flaked	-	-	-	45.00
Barley	13.00	11.00	10.00	10.00
Soybean meal	5.00	-	-	-
Soy-hull	-	-	-	15.00
Rape seed meal	10.00	6.00	5.70	-
Gluten feed	20.00	26.06	20.00	15.00
Wheat bran	25.00	26.00	23.00	7.99
Limestone	1.00	1.00	1.00	0.63
Lasalocid	0.02	0.02	0.02	0.02
Vit.-min. premix[1]	0.20	0.30	0.20	0.20
Salt	0.30	0.30	0.30	0.30
Molasses	3.00	3.00	3.00	3.00
Calcium phosphate	0.48	0.72	0.47	0.46
Sodium bicarbonate	-	-	-	0.40
Yeast culture	-	-	-	2.00
Total	100.00	100.00	100.00	100.00
Chemical composition (%)				
Dry matter	85.79	88.40	86.08	86.06
Crude protein	16.63	14.77	13.16	10.95
Ether extract	2.20	2.71	2.89	3.21
Crude fiber	7.36	7.09	6.13	7.06
Crude ash	5.40	6.53	4.91	3.66
Neutral detergent fiber	31.14	29.52	22.85	19.50
Acid detergent fiber	4.06	5.21	2.74	7.70
Ca	0.46	1.03	0.81	0.76
P	0.65	0.76	0.69	0.46

[1] Contains the following, (Vit. A, 2,650,000 IU; Vit. D_3, 530,000 IU; Vit. E, 1,050 IU; BHT (butylated hydroxy toluene), 10,000 mg; Fe, 13,200 mg; Mn, 4,400 mg; Cu, 2,200 mg; co, 440 mg; I, 440 mg)/kg.

extract, NDF and ADF of rice straw were 88.9%, 3.9%, 1.3%, 60.2% and 39.2%, respectively. Steers had free access to fresh water and mineral block during the whole period. Steers were weighed every month during the experiment period. Forage was fed at 09:00 h daily, and the concentrates in two equal portions at 08:00 and 16:00 h. Dietary refusals were collected and weighed every day. Feed conversion ratio was expressed as average feed intake per daily body weight gain.

Slaughter and carcass assessment

Marbling score was predicted between the 13th thoracic and 1st lumbar vertebrae of steers using ultra sound scanning equipment (Falco 100, 3.5 MHz, 18 cm linear probe, Pie Medical, Netherlands) at 18, 20, 22, 24, 25, 27 and 29 months of age before they were slaughtered, The steers on 25 mo, 27 mo, and 29 mo treatments were slaughtered at 25, 27 and 29 months of age, respectively, according to the procedure of APGS (2007). Their carcass characteristics such as yield grade and quality grade were assessed at 24 h *post-mortem* by a carcass grader of the Animal Products Grading Service (APGS, 2007), Korea.

Quality grades (marbling, meat color, fat color, texture, and overall mature score) and yield grades (cold carcass, fat thickness, and *Longissimus* muscle area) were recorded. Live weights were determined immediately before slaughter. After a 24-h chill, cold carcass weights were measured and then the left side of each carcass was cut between the last rib and the first lumbar vertebrae to determine quality grade. The quality grade was determined by assessing the degree of marbling and firmness in the cut surface of the rib eye, in relation to the maturity and fat color of the carcass. The rib eye area was measured from *Longissimus* muscle taken at the 13th rib and back fat thickness was also measured at the 13th rib. Yield index was calculated as follows: Yield index: 68.184-(0.625×back fat thickness (mm))+(0.130×*Longissimus* muscle area (cm^2))-(0.024×dressed weight (kg)). The degree of marbling was evaluated with the Korean Beef Marbling Standard, and the scores of meat color and fat color were made using the color standard (APGS, 2007). The scores for texture and maturity were made using the APGS reference index (APGS, 2007). The grading ranges were 1 to 9 for marbling score with higher numbers for better quality (1 = devoid, 9 = abundant); meat color (1 = brightly cherry red, 7 = extremely dark red); fat color (1 = white, 7 = dark yellow); texture (1 = soft, 3 = firm); Maturity (1 = youthful, 9 = mature). The *Longissimus* muscles were taken and immediately frozen in liquid nitrogen, and stored at -80°C until analysis of lipogenic gene expression.

Quantitative real-time RT-PCR

Total RNA was prepared from each *Longissimus* muscle (100 mg) using 1 ml of TRIzol reagent (Invitrogene Life Technologies, USA) according to the manufacturer's instructions. For real-time RT-PCR analysis, 500 ng of RNA was reverse transcribed in a 20-μl reaction volume using a RT-PCR high kit (Toyobo, Japan) as described in the RT-PCR high kit protocol. We analyzed the expression levels of lipogenic-related genes such as adipocyte fatty acid binding protein 4 (FABP4), glucose transporter 4 (GLUT4), lipoprotein lipase (LPL), acetyl-CoA carboxylase (ACC), stearoyl-CoA desaturase (SCD) and ATP citrate lyase (ACL) in Hanwoo *Longissmus* muscle. The primer sets were designed with the Primer3 out program, and the sequences of the sets are shown in Table 2. The amplification was performed in a total volume of 50 μl included 5 μl cDNA (125 ng), each 1 μl of 10 pmol/μl

Table 2. Primer sequences of lipogenesis genes for real-time PCR analysis

Primer name		Primer sequence (5`-3`)	GenBank accession No.
FABP4[1]	Forward	CGT GGG CTT TGC TAC CAG	NM 174314
	Reverse	TGG TTG ATT TTC CAT CCC AG	
GLUT4[2]	Forward	GGT GGC ATG ATC TCA TCC TT	AY 458600
	Reverse	AGGAGG AGT GGC CAT AAG GT	
ACC[3]	Forward	ATG GTC TTT GCC AAC TGG AG	NM 174224
	Reverse	TGA TTT CGA CTG TCC CTT CC	
LPL[4]	Forward	TAC CCT GCC TGA AGT TTC CAC	XM 871618
	Reverse	CCC AGT TTC AGC CAG ACT TTC	
ACL[5]	Forward	CAG GAC ACT GCA GGA GTC AA	BC 108138
	Reverse	CAA ACA CTC CAG CCT CCT TC	
SCD[6]	Forward	CCA GAG GAG GTA CTA CAA ACC TG	NM 173959
	Reverse	AGC CAG GTG ACG TTG AGC	
GAPDH[7]	Forward	GGGTCATCATCTCTGCACCT	BC102589
	Reverse	GGTCATAAGTCCCTCCACGA	

[1] FABP4 = Adipocyte fatty acid binding protein 4. [2] GLUT4 = Glucose transporter 4. [3] ACC = Acetyl-CoA carboxylase.
[4] LPL = Lipoprotein lipase. [5] ACL = ATP citrate lyase. [6] SCD = Stearoyl-CoA desaturase. [7] GAPDH = Glyceraldehyde-3-phosphate dehydrogenase.

forward and reverse primer, 25 μl SYBR Green Master Mix (Toyobo, Japan), and 18 μl distilled water using a 7500 Real time PCR system (Applied Biosystems, USA) as follows: 50°C for 2 min, 95°C for 1 min, and 40 cycles of 95°C for 15 s, 58°C for 15 s, and 72°C for 32 s. Following amplification, a melting curve analysis was performed to verify the specificity of the reactions. The end point used in the real-time RT-PCR quantification, C_T, was defined as the PCR threshold cycle number. All samples were examined for glyceraldehyde-3-phosphate dehydrogenase (GAPDH) as an internal control, and quantities of each gene were presented as the $2^{-\Delta Ct}$ which was calculated using the ΔCt value (Ct value of sample-Ct value of GAPDH).

Statistical analysis

Statistical analysis for all dependent variables by treatments as environmental effects was performed using the GLM procedure (Version 8.1; SAS Inst. Inc., Cary, NC). Significant differences among treatments were determined by Duncan's multiple range test (Duncan, 1955) at a level of p<0.05.

RESULTS AND DISCUSSION

Growth performance

Final body weight of steers on 25 mo was lower (p<0.05) compared with 27 mo or 29 mo treatments (Table

Table 3. Effect of fattening period on intake, body weight (BW) gain and feed conversion ratio of Hanwoo steers

Item	Treatment			SEM	p value
	25 mo[1]	27 mo[2]	29 mo[3]		
Initial BW (kg)	112.5	110.8	111.7	1.1824	0.8526
Final body weight (kg)	637.7[b]	668.3[a]	695.8[a]	6.8278	0.0012
Daily BW gain (kg/d)					
Early growing period	0.76	0.65	0.67	0.0252	0.1537
Late growing period	0.83	0.90	0.86	0.0133	0.1137
Early fattening period	0.90	0.89	0.84	0.0145	0.2140
Late fattening period	0.80[a]	0.76[ab]	0.69[b]	0.0172	0.0229
Overall period	0.83[a]	0.80[ab]	0.77[b]	0.0093	0.0292
Intake (DM kg/d)					
Early growing period					
Concentrate	1.72	1.72	1.72	-	-
Hay	2.02	1.99	1.98	0.0062	0.0540
Total feed	3.73[a]	3.70[b]	3.70[b]	0.0062	0.0346
Late growing period					
Concentrate	3.45	3.46	3.46	0.0047	0.5565
Hay/rice straw	3.52	3.49	3.52	0.0162	0.7063
Total feed	6.96[b]	6.95[b]	7.41[a]	0.0602	0.0009
Early fattening period					
Concentrate	5.93[c]	6.39[b]	6.64[a]	0.0450	<0.0001
Hay	2.56[a]	2.42[b]	2.36[c]	0.0129	<0.0001
Total feed	8.71[c]	8.81[b]	9.00[a]	0.0196	<0.0001
Late fattening period					
Concentrate	8.94	8.62	9.11	0.0896	0.0796
Rice straw	0.70[c]	0.72[b]	0.82[a]	0.0079	<0.0001
Total feed	9.64[ab]	9.35[b]	9.93[a]	0.0915	0.0306
Whole period					
Concentrate	5.01[b]	5.05[b]	5.23[a]	0.0266	0.0005
Hay/rice straw	2.20[a]	2.16[b]	2.17[b]	0.0053	0.0010
Total feed	7.26[b]	7.20[b]	7.51[a]	0.0323	<0.0001
Feed conversion ratio					
Early growing period	5.32	5.82	6.67	0.3281	0.2394
Late growing period	9.08[ab]	8.37[b]	9.35[a]	0.1646	0.0393
Early fattening period	9.94[b]	10.44[b]	11.41[a]	0.1982	0.0062
Late fattening period	13.41[b]	15.63[a]	16.43[a]	0.4070	0.0048
Whole period	9.44[b]	10.06[b]	10.96[a]	0.1612	0.0001

[a, b, c] In this and all other tables, means with different superscripts in the same row significantly differ (p<0.05).
[1, 2, 3] In this and all other tables, 25 mo = slaughtered at 25 months age, 27 mo = slaughtered at 27 months age, 29 mo = slaughtered at 29 months age.

3). During the growing and early fattening periods, daily body weight gain was not significantly different among the treatments. Daily body weight gain during the late fattening period and for the overall experimental period was in the order 25 mo>27 mo>29 mo ($p<0.05$). Total DM intake by steers was higher ($p<0.05$) on 25 mo compared with 27 mo or 29 mo during the early growing period. However, during the late growing period, total DM intake was higher ($p<0.05$) in steers on 29 mo compared with 25 mo or 27 mo. During the early fattening period, concentrate intake was higher ($p<0.05$) and hay intake was lower ($p<0.05$) in steers on 29 mo compared with 25 mo or 27 mo. Total DM intake was greater in steers on 29 mo followed by 27 mo and 25 mo during the early fattening period ($p<0.05$). Although concentrate intake was not significantly different among the treatments, rice straw and total feed intakes were higher ($p<0.05$) in 29 mo compared with other treatments during the late fattening period. During the overall period, concentrate and total DM intakes were higher in 29 mo ($p<0.05$), while rice straw/hay intake was higher in 25 mo compared with other treatments ($p<0.05$) during the overall period. Chu et al. (2003) reported similar results that concentrate and rice straw intakes during growing, early and late fattening, and the whole period were 2.60, 5.14, 8.07 and 5.02 kg/d, and 2.87, 2.91, 2.41 and 2.58 kg/d, respectively. In the present study, during the growing period average daily body weight gain and daily feed intake was 0.8 kg/d and 5.4 kg/d/animal, respectively. Similarly, Cho et al. (2001) reported that daily body weight and feed intake of Hanwoo steers during the growing period was 0.7 kg/d and 5.5 kg/d/animal, respectively. Feed conversion ratio in steers fattened for different periods was similar during the early growing period, however, it was lower for the late growing period ($p<0.05$) in the order 27 mo>25 mo>29 mo. During the whole fattening period, feed conversion was lower in 25 mo compared with 27 mo or 29 mo ($p<0.05$). In addition, feed conversion ratio was lower ($p<0.05$) in 25 mo or 27 mo compared with 29 mo during the whole period. Thus, 25 mo and 27 mo had a beneficially lower feed conversion ratio compared with 29 mo.

Carcass characteristics

Slaughter and carcass weights of steers were increased as fattening period was increased ($p<0.05$) (Table 4). In carcass yield traits, rib-eye area was similar in steers on different treatments, whereas back fat thickness was significantly higher and yield index was lower in 29 mo compared with 25 mo or 27 mo ($p<0.05$). In the yield grade of 25 mo, appearances of A, B, and C grades were 60%, 40%, and 0%, respectively. The A, B and C grades in 27 mo were 53%, 47%, and 0%, respectively, whereas the A, B and C grades in 29 mo were 33%, 47%, and 20%, respectively. Similar to the present results, Kim et al. (2005) reported that quantity grade A was decreased with increasing age of Hanwoo steers. In quality traits, marbling score, fat color, texture, and maturity were similar in steers on different treatments. Meat color was beneficially lower in the order 27 mo<25 mo<29 mo ($p<0.05$). The numerically higher marbling score with increasing fattening period could be related to the higher back fat thickness as

Table 4. Effect of fattening period on carcass characteristics of Hanwoo steers

Parameters	Treatments			SEM	p value
	25 mo	27 mo	29 mo		
Slaughter weight (kg)	637.7[b]	668.3[a]	695.8[a]	6.90	0.0055
Carcass weight (kg)	382.7[b]	406.2[a]	424.5[a]	4.98	0.0014
Yield traits[1]					
Rib-eye area (cm^2)	87.40	86.53	87.00	0.87	0.9230
Back fat thickness (mm)	9.33[b]	9.60[b]	13.13[a]	0.64	0.0222
Yield index (%)	67.75[a]	66.91[a]	64.34[b]	0.50	0.0108
Yield grade[2] (A:B:C, head)	9:6:0	8:7:0	5:7:3	-	-
Quality traits[3]					
Marbling score	5.80	5.93	6.07	0.24	0.9053
Meat color	4.53[ab]	4.33[b]	4.80[a]	0.07	0.0346
Fat color	3.00	3.00	3.00	-	-
Texture	1.13	1.33	1.33	0.07	0.3765
Maturity	2.13	2.20	2.47	0.07	0.0949
Quality grade (1^{++}:1^{+}:1:2, head)	1:8:4:2	2:5:6:2	1:7:6:1	-	-

[1] Area was measured from *Longissimus* muscle taken at 13th rib and back fat thickness was also measured at 13th rib; Yield index were calculated using the following equation: Yield index: 68.184-(0.625×back fat thickness (mm))+(0.130× *Longissimus* muscle area (cm^2))-(0.024×dressed weight (kg)).

[2] Carcass yield grades from C (low yield) to A (high yield).

[3] Grading ranges are 1 to 9 for marbling score with higher numbers for better quality (1 = devoid, 9 = abundant); meat color (1 = brightly cherry red, 7 = extremely dark red); fat color (1 = white, 7 = dark yellow); texture (1 = soft, 3 = firm); Maturity (1 = youthful, 9 = mature); quality grades from 3 (low quality) to 1^{++} (very high quality).

Table 5. Marbling score measured using ultra sound scanning at different growth stages

Age (month)	Treatment			SEM	p value
	25 mo	27 mo	29 mo		
18	1.47	1.13	1.13	0.07	0.09
20	2.47[a]	1.87[b]	2.07[ab]	0.10	0.04
22	3.20	2.73	2.80	0.12	0.25
24	5.00[a]	3.87[b]	3.87[b]	0.18	0.01
25	5.73[a]	4.80[ab]	4.53[b]	0.21	0.05
27	-	5.80	5.40	0.26	0.45
29	-	-	6.07	0.38	-

[1] Grading ranges are 1 to 9 for marbling score with higher numbers for better quality.

fattening period increased. Nade et al. (2003) reported that the deposition of body fat such as back fat might be influenced by the feed intake. Yang and Ahn (2001) reported that back fat thickness and marbling score were increased as carcass weight was increased in Hanwoo steers. Thus, marbling score and back fat thickness could be activated as increasing fattening period with feed intake.

The appearance of 1^{++}, 1^{+} and 1 quality grade of beef was 87%, 87%, and 93% in 25 mo, 27 mo and 29 mo, respectively. The best 1^{++} grade appearance was 7%, 13%, and 7% in 25 mo, 27 mo and 29 mo, respectively. The present results for meat quality were supported by the marbling score by ultra sound scanning examination which was significantly and numerically higher in 25 mo compared with 27 mo or 29 mo (Table 5). Therefore, intramuscular fat may have been deposited from 25 months of age and consistently lasted until steers were 29 months of age.

Expression levels of lipogenic-related genes

Lipogenesis encompasses the processes of fatty acid synthesis and subsequent triglyceride synthesis and takes place in both liver and adipose tissue, and various enzymes take part in this metabolism (Kersten, 2001). According to Lee et al. (2006) lipogenic-related genes were significantly increased in 27 months-old compared to 12 months-old Hanwoo steers. These reports suggested that expression of lipogenic-related genes may be related with overall fat deposition in cattle. Among these genes, SCD is the major enzyme responsible for conversion of saturated fatty acids into monounsaturated fatty acids in mammalian tissues. Previous reports showed that SCD was a good indicator for intramuscular fat content and fatty acid composition (Taniguchi et al., 2004; Wang et al., 2008). In the present study, the expression level of the SCD gene was significantly increased during the late fattening stages ($p<0.01$, Figure 1). In addition, mRNA of ACC, ACL and GLUT4 gene were highly expressed in 29 mo compared with 25 mo and 27 mo ($p<0.05$). However, FABP4 and LPL genes were not significantly different among the treatments.

Although expression of lipogenic-related genes may differ from various body fat pads or organs, unlike the present results lipogenesis in subcutaneous fat and intramuscular fat was higher in 30 months-old Hanwoo bulls compared with those at 24 months of age (Chung et al., 2000). Smith and Crouse (1984) reported that expression level of the ACL gene increased with increasing age of Angus×Hereford crossbred steers. However, the age of these animals, which ranged between 9 and 18 months, was different from that of the present experimental animals.

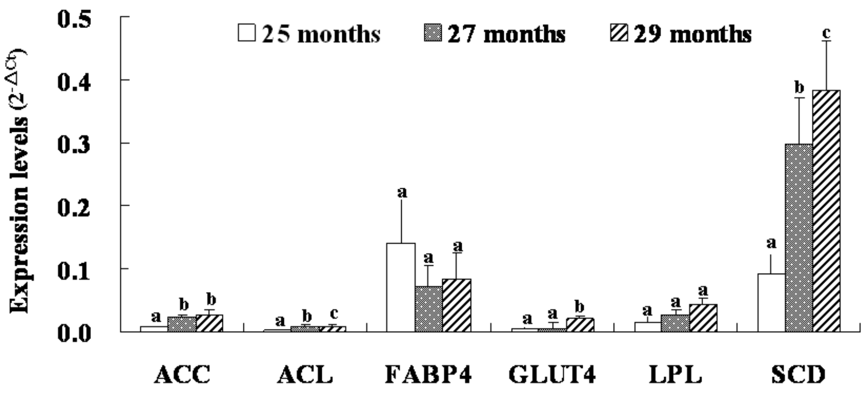

Figure 1. Expression levels ($2^{-\Delta Ct}$) of lipogenic-related genes in Hanwoo *Longissimus* muscle, determined using real-time RT-PCR. [a, b, c] As above in Table 3; Abbreviations are defined in Table 2.

Cattle undergo a dramatic increase in intramuscular fat during a late-finishing stage that occurs between 18 and 26 months of age. In Wagyu (Japanese Black) cattle, approximately 20% of the total intramuscular fat is added between 12 and 26 months (Nishimura et al., 1999) rather than after 27 months of age. In the present study, expression levels of lipogenic-related genes were little different in essence, although the patterns of gene expression were different among the muscle samples. Thus, these findings indicate that rate of lipogenesis made slow progress after the age of 27 months in Hanwoo cattle.

CONCLUSION

The present findings indicated that different fattening periods resulted in similar carcass characteristics and marbling score in Hanwoo steers. In addition, expression of several lipogenic genes in the *Longissmus* muscle varied with different fattening periods without consistent effects. Therefore, the present results indicated that different fattening period has no major effect on carcass characteristics, although 25 mo had lower carcass weight compared with 27 mo or 29 mo.

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