Effects of Feeding Patterns and Sexes on Growth Rate, Carcass Trait and Grade in Korean Native Cattle

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ABSTRACT : The objectives of this study were to examine growth performance and meat quality by three different feeding patterns in Korean native cattle (KNC). In each of 3 years, fifteen KNC were randomly assigned in a (3 feeding management)×(3 sex) factorial design experiment; thus, in total, there were 5 animals in each of the 9 treatments. The three feeding management treatments were long-term (24 month) restriction feeding (LTFR), long-term restriction feeding-hormone implant (LTFR-tH), and short-term (18 month) non-restriction feeding (STFNR). Three sexes were bull, steer, and heifer. Concentrate diet was fed restriction-feeding method based on body weight in LTFR and LTFR-tH. However, the diet was fed *ad libitum* in STFNR. Hormonal implantation was made three times with M-PO^{TM} for bulls and with F-TO^{TM} for heifers at 18, 20, 22 month of age in LTFR-tH. Animal were purchased from the local cattle market and managed in two local farms and at the university research unit. Animals were slaughtered at 24 months for long-term trial and at 18 month for short-term trial. The growth rate was the highest in bulls and the lowest in heifers. However, the differences were diminished in F-TO^{TM} implanted heifers. The average daily gain was high in STFNR due to *ad libitum* feeding. The carcass grade was similar among the treatments on percentage bases. Hormonal implants improved significantly the meat quality grade in all sexes. Castration increased body fat content and improved meat quality grade by intramuscular fat deposition. In conclusion, long-term feeding and hormone treatment increased meat quality grade more than short-term feeding. However, ADG was higher in the short-term trial although feedefficiency was lower. ***(Asian-Aust. J. Anim. Sci. 2002. Vol 15, No. 6 : 838-843)***

Key Words : Growth Rate, Carcass Grade, Feeding Pattern, Korean Native Cattle

INTRODUCTION

Marbling score increases and reaches a plateau at about 24 months of age in Korean native cattle (KNC). Feed efficiency of feedlot cattle may be improved by control of feed intake. Most studies have controlled intake by limiting the amount of feed supplied to certain pens of cattle to a specific percentage of the amount consumed by pens of cattle with *ad libitum* access to feed (Plegge et al., 1985; 1986; Wagner, 1987; Glimp et al., 1989). Restriction feeding improved feed efficiency of cattle fed high-energy diets (Old and Garrett, 1987; Hicks et al., 1990). Zinn (1986) reported that steers restricted to 94% of *ad libitum* intake had daily weight gains similar to those of steers allowed *ad libitum* access to feed. However, the restricted treatment group was 4.6% more efficient in feed conversion than steers with *ad libitum* access to feed.

Among the carcass grade traits, marbling was related most closely to tenderness (May et al., 1992). Other researchers have shown differences in carcass composition between sex classes (Knapp et al., 1989; Griffin et al., 1992). Paek et al. (1993) reported that as the marketing weight increased in KNC, average daily gain and retailed cuts percentage was decreased, but carcass percentage, longissimus muscle area, and marbling score gradually increased.

Bulls gain more rapidly and are more efficient in producing leaner carcasses than steers (Hedrick, 1968; Field, 1971; Seideman et al., 1982). It is generally recognized that bulls gain weight faster and require less feed per unit of gain than steers (Arthaud et al., 1969, 1977; Field, 1971). Castration reduced the growth rates of KNC. Retailed cuts were decreased by castration while body fat was increased (Hong et al., 1996). However, the mechanism for these advantages has not been determined by the effect of castration. Anabolic implants have been used to improve growth rate and feed efficiency of cattle during finishing. Even though the resulting economic benefits associated with the use of implants are well documented and widely recognized (Trenkle, 1987), concerns have been expressed regarding possible deleterious effects of implants on beef quality. The National Beef Quality Audit identified that reduced quality of beef, specifically lower marbling score and reduced beef tenderness, is due to implants (Smith et al., 1992). The objectives of this study were to understand the effect of feeding pattern and sexes on growth rate and carcass trait in KNC.

MATERIALS AND METHODS

Experiment Design

In each of 3 years, fifteen KNC were randomly assigned in a (3 feeding management)×(3 Sex) factorial design experiment; thus, in total, there were 5 animals in each of

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the 9 treatments. The three feeding management treatments were long-term (24 month, '96.5-'97.4) restriction feeding (LTFR), long-term restriction feeding-hormone treatment (LTFR-tH, 24 month, '97.4-'99.3), and short-term (18 month, '98.5-'99.11) non-restriction feeding (STFNR). Three sexes were bull, steer, and heifer.

Animals and management

Korean native calves (about 4 months of age) were purchased from local farms, 15 calves per year during three years (1996-1998). The castration was carried out by a surgical operation at 4 months of age. Concentrate diets were restriction fed in LTFR and LTFR-tH, and *ad libitum* fed in STFNR. Restriction feeding pattern was 1.5% of weight during 6-12 months of age (Grower; concentrate for the growing stage), 1.8% of weight for 13-18 months of age (Finisher I; concentrate for the early fattening stage), and 2.0% per weight for 19-24 months of age (Finisher II; concentrate for the late fattening stage). STFNR animals were fed by 18 month of age. Roughage (rice straw:alfalfa=9:1) was fed throughout the experimental period. Animals were slaughtered at 24 months and 18 months old. In LTFR-tH, anabolic agent was implanted into the ear subcutaneously at 18, 20, and 22 months of age. Bulls and steers were implanted with M-PO^{TM} implants (Progesterone 200 mg/dose, Oestradiol benzoate 20 mg/dose). Heifers were implanted with F-TO^{TM} implants (Testosterone 200 mg/dose, Oestradiol benzoate 20 mg/dose) (Upjohn, USA).

Experimental diet

Table 1 shows the proximate analysis (AOAC, 1990) of diet fed to each experimental animal. Moisture content in formulated feed, alfalfa, and rice straw was 12.0%, 14.4%, and 9.0%, respectively. Crude protein in formulated feed (13.9%) was higher than alfalfa (15.2%) or straw (4.5%), but crude fiber content was 4.8%, 22.2%, and 28.1%, respectively.

Slaughter, grading, and carcass procurement

At the end of the 18 months or 24 months finishing trials an off-test weight was recorded and the animals were slaughtered at the National Livestock Cooperatives Federation (NLCF) in Naju. Carcass yield and quality grade data were collected by trained personnel at the slaughterhouse after 24 h chill. After 24 h chilling period (2°C±2°C), the NLCF personnel evaluated quality grade factors (marbling score, skeletal muscle maturity, fat color, meat color) and yield grade factors (adjusted external fat thickness, longissimus muscle area, hot carcass weight, and index of meat) for each carcass. Following carcass grade data collection, beef cuts from the other side of each carcass (loin, tender loin, short loin, rump, round, fore shank, chuck, brisket, shank, and rib) were obtained and weighed. Meat quantity index was determined by following calculation (MAF, 1996).

$$MQI=65.834-[0.393\times BFT]+[0.088\times LA]-[0.008\times CW]$$

* MQI : Meat quantity index
* BFT : back fat thickness (mm)
* LA : longissimus area (cm^2)
* CW : carcass weight (kg)

The grade A of meat quantity is above 69.0 of meat quantity index, and B, C grades are 66.0-69.0 and below 66.0 of meat quantity index, respectively. Meat quality grade was generally determined by intramuscular fat content and marbling score. No. 1 of marbling score was 3 grade, No. 2 and No. 3, No. 4 and No. 5, No. 6 and No. 7 were determined to 2 grade, 1 grade, and 1+ grade, respectively.

Statistical analysis

SAS/STAT 6.03 package was used to analyze the association between sex and feeding pattern in KNC. Statistical procedure was accomplished using General Liner Model (GLM) by least square procedure (Harvey, 1975). The analysis of significance test for variable was analyzed by Turkey's Studentized Range Test (TSRT). The statistical model is as follows;

$$X_{ij}=u+S_i+T_j+e_{ij}$$

Table 1. Chemical composition and nutrient contents of fed diet (as-fed bases, %)

Composition	Contentrate				Roughage	
	Early calf	Middle calf	Early fattening	Late fattening	Rice straw	Alfalfa cube
Water	11.70	11.84	11.95	12.36	9.01	14.35
C. Protein	18.05	14.05	12.34	10.99	4.50	15.19
C. Fat	2.95	2.69	2.65	3.14	2.18	2.79
C. Fiber	5.91	5.32	4.58	3.37	28.10	22.22
C. Ash	6.12	8.64	6.78	6.73	15.10	8.17
Ca	0.79	1.07	1.02	0.81	0.24	2.64
P	0.56	0.57	0.53	0.41	0.13	0.32
Ne_m	1.67	1.60	1.62	1.69	0.51	1.09
Ne_g	1.10	1.04	10.51	11.09	0.17	0.54

Xij is the record of individual
u is overall mean
Si is the effect of sex (i=bull, steer, heifer)
Tj is the effect of feeding treatment (j=LTFR, LTFR-tH, STFNR)

RESULTS AND DISCUSSION

Growth rate

Artificial rearing with *ad libitum* access to roughage and with restricted feeding access to high concentrate diet of KNC resulted in the growth rates shown in figure 1. In general, the growth rate was the higher in bulls than in heifers, and steers were in the middle. The final body weights were 590, 560, 445 kg in LTFR, 621, 578, 523 kg in LTFR-tH, and 489, 476, 447 kg in STFNR, respectively. Animals grew linearly throughout the experiment period in restriction feeding group. However, a plateau pattern appeared after 16 months of age in STFNR.

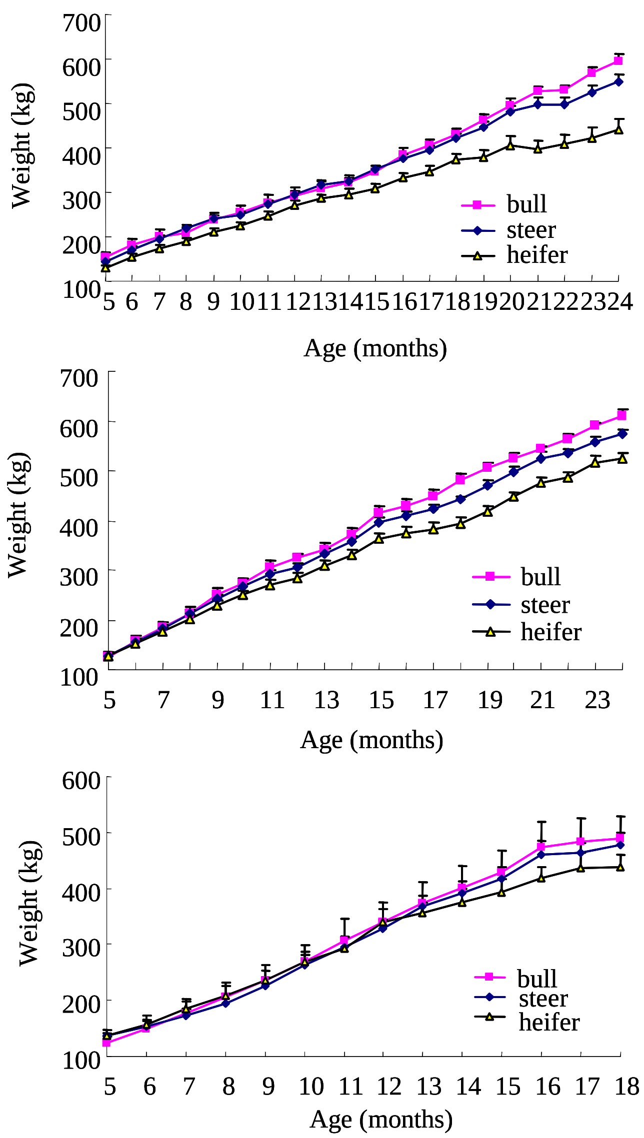

Figure 1. Body weight changes during experimental period of Korean cattle. Top: long-term restricted feeding (LTFR) for 24 month, Middle: long-term restricted feeding with hormone treatment (LTFR-tH) for 24 month, Bottom: short-term non-restriction feeding (STFNR) for 18 month.

In LTFR, the growth rates of bulls, steers and heifers were similar through 300 kg of body weight (about 14 month of age) even though there was a sex difference. However, the growth rate of heifers was diminished from 14 months of age. Castration reduced growth rate but it may be compensated by meat quality. The growth rate was retarded in 21 month due to hot summer and raining season. However, this seasonal effect was not monitored in other treatments. In LTFR-tH, as age increased, bulls had a heavier growth rate than steers. Though the growth rate of heifers non-treated was diminished from 20 months of age, F-TO™ implanted heifers had a continuous weight gain. The growth effect was much higher in heifers than in bulls because female steroid hormones suppress the estrus cycle. Generally, heifers have a low growth rate due to estrus. In STFNR, growth rate increased through 16 months of age, thereafter, growth rate was retarded. The slaughter weight was only 50 kg difference between bulls and heifer. Also weight variation was very high within sexes. Daily gain in STFNR was higher than LTFR and LTFR-tH (table 2). It may relate with *ad libitum* feeding of diet. Also hormonal implantation improved ADG. Bull had a higher daily gain than steer and heifer in all treatment.

In 24 month feeding with restricted fed, average months when KNC reached 400 kg of body weight was 18 months of age. Also, in 24 month feeding with restricted fed and anabolic implants, and in 18 month feeding fed *ad libitum*, 400 kg was at 16 months of age and 14 months age respectively. Daily gain in 18 month feeding fed *ad libitum* resulted in higher body weight, 10.5% and 20.9%, respectively, than others. Our study suggested that the increased growth rate and efficiency of bulls compared with steers were due partially to increased protein muscle accretion resulting from reduced muscle protein degradation. However, anabolic implants (M-PO™, F-TO™) increased body weight by 8.3%, 7.7% and 23.2% for bull, steer, and heifer, respectively, in comparison with non-treatment. The increasing of intramuscular fat was accompanied with a decrease of meat quantity. In LTRF treatment, production of rump, round, foreleg, chuck, and brisket cuts in bulls was higher than in steers. It was considered that the high fat of steer decreased lean carcass mass. This result was similar to other treatments, and a significant difference in the other beef cuts was not shown.

Table 2. Comparison of ADG among treatments and sexes (kg/d, LS mean)

Composition	Treatment			Sex		
	LTFR	LTFR-tH	STFNR	Bull	Steer	Heifer
ADG	0.68[b]	0.77[b]	0.86[a]	0.85[a]	0.79[b]	0.67[b]

LTFR: Long-term feeding by restricted supply of diets.
LTFR-tH: Long-term feeding by restricted diets with hormone treatment.
STFNR: Short-term feeding *ad libitum*.
[a,b] Means in the same row with a common superscript do not differ ($p<0.05$).

Carcass trait

Carcass traits of bulls and steers can be seen in table 3. In LTFR, body weight, tenderloin, loin, sirloin, shank, whole ribs and leaned carcass were not significantly different. Dressed carcass, rump, round, foreleg, chuck, brisket bone in bulls were higher than in steers ($p<0.01$ or $p<0.05$). Fat and by-product in bulls were lower than in steers. Although fat content was high in steers it may significantly improve meat quality grade. In STFNR, body weight, dressed carcass, tenderloin, loin, sirloin, rump, round, brisket, shank, whole ribs, leaned carcass, bone and by-product were not significantly different. Foreleg, chuck, and fat in bulls were higher than in steers and heifers. Interestingly, the fat content was higher in bulls than in heifers. These results may be controversial in meat quality grade. There was not a significant difference among treatments and sex in body weight and dressed carcass. Steers had a higher fat value than bulls and heifers.

Male cattle are castrated in Korea, primarily to improve ease of management and palatability traits. However, bulls have up to a 15% advantage in growth rate, feed efficiency, and carcass leanness compared with steers at the same age or time on feed (Seideman et al., 1982). Lobley et al. (1987) concluded that treating rats and lambs with testosterone increased muscle growth by suppressing muscle protein degradation. Castration improved quality grade of meat due to high fat content although the growth rate is lower in steers. The direct mechanism by which castration alters protein turnover remains unclear. However this rate gradually changed and steer weight was lower than bull weight by 8.6% in the final weight. This growth retardation in castrated animals has been reported in many studies. The testis-origin androgenic compound may significantly influence growth rate after puberty.

Carcass grade

Carcass grades and carcass traits of beef cuts in KNC were different between bull and steer (table 4). Back fat thickness in bull was lower significantly than in steer and heifer ($p<0.001$). Carcass weight, index of meat and texture in bull were higher than in steer ($p<0.01$ or 0.05). Meat quantity grade in bull was higher than in steer, whereas meat quality in bull was lower than in steer. Intramuscular fat in bull was lower ($p<0.001$) than in steer. Therefore, the meat quality grade was significantly improved by castration. Longissimus, meat color, fat color and maturity were not significantly different between bull and steer.

In LTFR-tH, heifers had much more back fat thickness

Table 3. Comparison of carcass traits among treatments and sexes (kg, LS mean)

Items	Treatment		Sex		
	LTFR	LTFR-tH	Bull	Steer	Heifer
Body weight	564.7	535.0	585.3	549.4	514.9
Dressing weight	335.7	313.6	343.1	324.7	306.1
Tenderloin	8.2[a]	5.2[b]	6.7	6.7	6.6
Loin	34.8	33.7	38.5	34.5	29.9
Sirloin	7.9[a]	7.1[b]	7.7	7.5	7.4
Rump	20.6[a]	17.2[b]	20.5[a]	18.2[b]	18.1[b]
Round	33.1	29.7	34.0[a]	31.9[ab]	28.3[b]
Foreleg	22.6[a]	19.8[b]	24.8[a]	30.0[b]	17.9[b]
Chuck	16.3	9.5[b]	18.7[a]	9.4[b]	10.6[b]
Brisket	37.7[a]	32.1[b]	39.4[a]	34.8[ab]	30.6[b]
Shank	14.5	14.1	15.8[a]	14.5[a]	12.6[b]
Whole ribs	46.6	45.5	45.5	46.9	45.9
Lean carcass	238.8[a]	212.2[b]	244.3	225.4	206.8
Fat	35.6	38.9	35.6[a]	44.9[b]	31.1[a]
Bone	47.9	58.0	48.0	49.8	70.0

[a,b] Means in the same row with a common superscript do not differ ($p<0.05$).
Beef cuts data for LTFR-tH of was not taken because of experimental conditions.

Table 4. Comparison of meat grade among treatments and sexes in Korean native cattle (LS mean)

Items	Treatment			Sex		
	LTFR	LTFR-tH	STFNR	Bull	Steer	Heifer
Back fat thick (mm)	7.2[a]	11.3[ab]	9.1[b]	3.6[a]	10.5[b]	13.5
Longissimus area (cm2)	83.5	87.6	82.3	84.5[ab]	81.4[b]	87.6[a]
Carcass wt (kg)	335.5[ab]	350.5[a]	313.6[b]	355.1[a]	330.2[b]	314.3[b]
Yield index	76.0[a]	68.3[b]	69.0[b]	73.0[a]	70.5[b]	69.8[b]
Meat quantity grade	1.9	1.7	1.4	1.1[b]	1.9[a]	2.1[a]
Intramuscle	3.0[ab]	3.7[a]	2.6[b]	0.9[b]	4.2[a]	4.2[a]
Meat color	4.7[a]	4.6[a]	3.9[b]	4.7[a]	3.9[b]	4.7[a]
Fat color	2.4[b]	3.0[a]	2.7[ab]	2.4[b]	2.6[ab]	3.0[a]
Texture	1.7	1.5	1.6	2.0[a]	1.2	1.6[b]
Maturity	1.0	1.1	1.0	1.1[a]	1.0[b]	0.9[b]
Meat quality grade	2.9[a]	2.1[b]	3.0[a]	3.5[a]	2.2[b]	2.3[b]

[a,b] Means in the same row with a common superscript do not differ ($p<0.05$).
MQG (Meat quantity grade): A, B, C and D grade=each 1, 2, 3 and 4.
IMT (Intramuscle fat): 1 (devoid)→7 (very good).
Meat color: 1 (scarlet)→7 (dark red).
Fat color: 1 (white)→7 (yellow).
Texture: 1 (good), 2 (standard), 3 (bad).
Maturity: 1 (less 3 years old), 2 (3-5 years old), 3 (more 5 years old).
MQS (Meat quality score): 1+, 1, 2, 3, and D grade=each 1, 2, 3, 4, 5.

than bulls and steers. Longissimus and index of meat in bulls were higher than steers and heifers ($p<0.05$). Other yields and quality grades were not significantly different. Meat quantity grade was low in heifer due to small carcass weight and meat index. However, meat quality grade was very high in heifer due to intramuscular fat content although high in back fat thickness. In STFNR, heifers had much back fat thickness than bulls and steers. Longissimus and index of meat in bulls were higher than in steers and heifers ($p<0.05$). Other yield and quality grades were not significantly different. The back fat thickness was almost 4 fold greater in heifers compared to bulls. The results indicated that 18 month feeding is not enough for bull in order to improve marbling score; therefore meat quality grade is bad. On the other hand, meat quantity grade is still high in bulls although the variation was high. There was no significant difference among each treatment in meat quantity grade. In sex, steer and heifer had a similar meat quantity grade, and higher than bull. Intra-muscle fat in steer and heifer were similar and higher than bull. Meat quality grade of treatment LTFR-tH was better than treatment LTFR and STFNR. Steer had a better meat quality grade than bull and heifer. Anabolic hormone implants improve growth rate and intramuscular fat due to high total fat content.

Many reports link the growth advantages associated with intact males to greater amounts of androgens such as testosterone. Female rats injected with a synthetic androgen, trenbolone acetate increased muscle gain by the reduction of protein degradation (Hietzman, 1980). Additionally, several reports have concluded that feeding β-adrenergic agonists to growing animals increased muscle mass and improved whole-body composition due at least in part to reduction in muscle degradation. These results have been observed in lambs (Bohorov et al., 1987), rats (Reeds et al., 1986), veal calves (Williams et al., 1987), chickens (Morgan et al., 1989), rabbits (Forberg et al., 1989), and cattle (Wheeler and Koohmaraie, 1992). In conclusion, LTFR improved meat quality grade, and anabolic implant effectively improved feed efficiency and marbling score.

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