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Growth Performance and Carcass Evaluation of Jeju Native Cattle and Its Crossbreds Fed for Long Fattening Period

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ABSTRACT : This study compared the growth performance and carcass evaluation of Jeju native cattle (JNC) and its crossbreds (CBK = 25 JNC:50 Charolais:25 Brahman and BCBK = 62.5 JNC:25 Charolais:12.5 Brahman). Eight male calves of each JNC, CBK and BCBK were weaned at 4 month of age and were fed for 24 months of age. All animals grazed a pasture between 5 to 10 months of age then they were fed growing ration at the rate of 1.5% of their BW along with *ad libitum* supply of Italian ryegrass hay between 11 to 16 months of age and thereafter switched to *ad libitum* feeding of finishing ration and hay between 17 to 24 months of age. Mean body weight (BW) and BW gain were higher in CBK compared with BCBK and JNC at 4, 10, 16 and 24 months of age. Average daily BW gain during 4 to 10 months of age was the highest for CBK followed by BCBK and JNC. However, daily BW gain was higher in BCBK than in CBK and JNC during 11 and 16 months of age. During fattening period (17 to 24 months) average daily BW gain was higher in JNC than in CBK and BCBK. Slaughter weight, hot and cold carcass weight were higher in CBK compared with JNC and BCBK. Weight of bones, boneless meat, ribs, excluded rib meat, retailed cut meat, tender loin, sir loin, strip loin, sticking, top round, bottom round, fore leg, shank, and thin-flank were higher in CBK than in BCBK and JNC. Fat weight in these carcass cuts and kidney fat was similar in JNC and its crossbreds. *Logissimus dorsi* and its ratio were higher in CBK compared with BCBK and JNC. Percent moisture, crude protein, and ash contents of beef were similar in JNC and its crossbreds. Percent beef fat was higher in JNC and BCBK than in CBK. Cooking loss and water holding capacity of beef was similar in JNC and its crossbreds. Sheer force was lower in BCBK compared with JNC and CBK. Juiciness, tenderness and flavor of beef were higher in BCBK compared with JNC and CBK. In conclusion, CBK has shown higher growth rate and produced heavier carcasses with good degree of fatness compared with JNC and BCBK. However, fattening for longer period could increase the maintenance cost in CBK and BCBK because of their higher BW which they attained during growing period. (**Key Words :** Jeju Native Cattle, Growth, Carcass, Beef, Crossbreds)

INTRODUCTION

Jeju native cattle (JNC) belong to Jeju Island of the South Korea. Black or yellowish brown coat colored JNC is closely related with Wagyu (Japanese black cattle) and Hanwoo (Korean Native cattle). However, JNC has never been bred to improve its ability to grow rapidly and thus it posses a short body stature and grow slowly than Hanwoo or Wagyu cattle. Reproductive ability of JNC is also poor than other specialized regional and western beef breeds (Paek et al., 1993; Lee et al., 2007). Selection to improve growth and reproductive performance or crossbreeding to develop a synthetic breed can help make JNC viable for better economic returns (Lee et al., 2006; Wang et al., 2006). However, selection is a long and steady process and crossbreeding is always preferable to take advantage from heterosis to produce commercial beef cattle (Wheeler et al., 2004).

The JNC was bred to charolais and Brahman in an attempt to produce a synthetic breed with higher growth performance and better marbling ability. In this attempt, JNC cows were first crossed to Brahman semen to produce G_1. Brahman was used because of her unique abilities to tolerate high environmental temperature and tick resistance (Peacock et al., 1981). These qualities can help improve beef cattle performance under sub-tropical conditions of Jeju Island. The G_1 animals have not shown enough good growth performance and their meat quality was also lower than JNC when compared according to Korean beef grading system. Thus the G_1 animals were crossed with charolais to produce CBK (25 JNC:50 charolais:25 Brahman) and the CBK was back crossed to JNC to produce a three breed

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Table 1. Ingredients and chemical composition of concentrate and Italian ryegrass (*Lolium multiflorum*)

Ingredients (% of DM)	Growing ration	Fattening ration	Italian rye grass
Corn	30.00	30.98	
Wheat bran	16.40	10.05	
Rice bran	5.14	7.12	
Cassava meal	5.15	13.77	
Cotton seed meal	5.00	-	
Corn germ meal	7.11	7.00	
Gluten feed	11.00	7.75	
Palm kernel meal	9.00	14.00	
Molasses	7.00	6.00	
Vitamin mineral mixture	0.20	0.20	
Lime stone	3.00	2.10	
Salt	0.50	0.50	
Monensin	-	0.03	
$NaHCO_3$	0.50	0.50	
Chemical composition			
Dry matter	86.92	86.60	88.30
Crude protein	15.99	12.70	8.53
Ether extract	2.58	3.86	1.86
Neutral detergent fiber	20.80	26.30	58.95
Acid detergent fiber	10.70	10.30	35.71
Ash	6.80	4.55	8.42
Ca	1.55	0.34	-
P	0.60	0.30	-
TDN[1]	70.00	74.00	53.8

[1] Total digestible nutrient was calculated using equation of NRC (2001).

synthetic named as BCBK which is 62.5 JNC:25 charolais: 12.5 Brahman. The charolais breed was used to produce crossbred of JNC because of its higher birth weight and fast growth rate (Cundiff et al., 1993). Heavier weight of charolais compared with Brahman and other tropical cattle are also well established (Peacock et al., 1981).

Demand for highly marbled beef is increasing with growing per capita income in South Korea. The JNC, Wagyu and Hanwoo are known for their unique genetic ability to deposit copious amounts of interfasicular fat, or marbling (Lee et al., 2003; Seo et al., 2006). Further the Koreans and Japanese use a unique management program to obtain this highly marbled beef, which includes feeding the cattle a ration high in roughage for long periods of time.

In this paper we are reporting comparative body weight gain and carcass evaluation of JNC, CBK and BCBK fed for longer fattening periods on similar feeding regimen.

MATERIALS AND METHODS

Animals and feeding

All experimental procedures were approved by the ethics committee for the use of animals in experiments, Sub-tropical Agriculture Research Institute, South Korea.

Eight male calves of each JNC, CBK and BCBK were weaned at 4 month of age and were raised using similar feeding regimen for 24 months of their age. All animals grazed a pasture (mixed grass and legume) between 5 to 10 months of age then they were fed growing ration at the rate of 1.5% of their BW along with *ad libitum* supply of Italian ryegrass (*Lolium multiflorum*) hay between 11 to 16 months of age and thereafter switched to *ad libitum* feeding of finishing ration and Italian rye grass hay between 17 to 24 months of age. Chemical composition of growing and fattening rations and Italian rye grass is presented in Table 1. All animals were weight at 4, 10, 16 and 24 months of age. Concentrate and roughage intake was monitored weekly for two consecutive days.

Slaughtering and carcass evaluation

All animals were slaughtered at 24 months of age for carcass evaluation. Animal were transferred to a slaughter house 2 days prior to slaughtering and were offered only water for 48 h before they were stunned using capital bolt. After complete bleeding, skin and internal organs were removed. Weights of blood, head, legs, hide and internal organs (heart, lungs, liver, kidney, sexual organs, rumen, reticulum, abomasums, small and large intestine) were measured immediately after evisceration. Digestive tract was emptied before weighing.

Each carcass was weighed and 2% of the carcass weight was subtracted to determine the cold carcass weight. Then carcasses were chilled for 24 h at 4°C and were dissected into two sides for the following assessments and measurements were on left half. Carcass length, chest length, femur length, chest width, hip width, femur width, chest girth, chest depth and femur depth were measured. Length and perimeter measurements were taken by tape measure, whereas width and depth measurements were taken by calliper. Each carcass was weighed and jointed into wholesale cuts, then dissected into muscle, fat, bone and the other tissues. Total weight and fat weight of kidney, loin, strip loin, sir loin, sticking, top-round, bottom-round, fore leg, shank, flank and rib were measured separately on left half of the each carcass.

Chemical, physical and sensory evaluation

Samples of loin muscles at the 8th-13th thoracic vertebrae from both carcass sides were removed, and transported to meat science laboratory. Loin samples were carefully trimmed of all subcutaneous fat, epimysium and peripheral muscles so that only the completely trimmed *longissimus dorsi* muscle was left. Samples from the right carcass side were used to evaluate meat quality characteristics, and samples from the left carcass side were used to evaluate eating quality. The samples were packaged in polyethylene bag using a chamber-type heat sealing vacuum packaging system, stored in the dark at 2°C in a chilling room and evaluated after 2 days.

Table 2. Mean (±standard error) body weight (BW), BW gain and feed conversion efficiency of Jeju native cattle and its crossbreds during growing and fattening period

Parameters (kg)	Breeds		
	JNC[1]	CBK[2]	BCBK[3]
BW (4 months age)	88.20±10.2[b]	113.50±12.3[a]	90.3±10.5[b]
BW (10 months age)	179.00±11.2[c]	369.30±12.1[a]	256.0±13.2[b]
BW (16 months age)	352.00±20.5[c]	557.8±15.4[a]	470.0±18.0[b]
BW (24 months)	564.50±25.5[b]	698.00±30.5[a]	582.75±22.2[b]
BW gain (between 4 to 10 months)	90.8±7.2[c]	255.8±10.4[a]	165.7±8.5[b]
BW gain (between 11 to 16 months)	173.0±18.6[b]	188.5±11.8[b]	214.0±14.0[a]
BW gain (between 17 to 24 months)	212.5±15.2[a]	140.2±12.5[b]	112.75±17.8[c]
BW gain (between 11 to 24 months)	385.5±25.6[a]	328.7±18.4[b]	326.8±26.4[b]
Intake[4] (between 11 to 24 months)	2,067.5±110.5	2,153.8±132.0	2,283.3±105.4
FCR[5] (between 11 to 24 months)	5.36±0.14[c]	6.55±0.12[b]	6.98±0.20[a]

[a-c] Means with in a row followed by different letter are significantly different ($p<0.05$).

All animals grazed a pasture (mixed grass and legume) between 5 to 10 months of age then they were fed growing ration at the rate of 1.5% of their BW along with *ad libitum* supply of Italian ryegrass hay between 11 to 16 months of age and thereafter switched to *ad libitum* feeding of finishing ration and Italian rye grass hay between 17 to 24 months of age.

[1] Jeju native cattle. [2] CBK = 25% JNC:50% Chorales:25% Brahman. [3] BCBK = 62.5% JNC:25% Chorales:12.5% Brahman.

[4] Overall concentrate DM intake between 11 to 24 months. [5] Feed conversion ration = Total concentrate DM intake/total body weight gain.

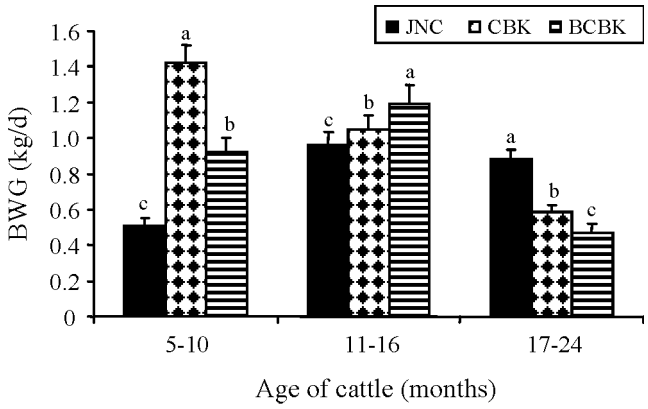

Figure 1. Mean (±standard error) daily body weight gain (BWG) of Jeju native cattle and its crossbreds during growing and fattening periods. [a-c] Mean bars in a given period bearing different letter are significantly different ($p<0.05$). JNC = Jeju native cattle, CBK = 25% JNC:50% Chorales:25% Brahman; BCBK = 62.5% JNC:25% Chorales:12.5% Brahman.

Moisture, protein and lipid contents in each sample were determined according to AOAC methods (AOAC, 1995). Ash content was determined as the residue after combustion at 650°C for 6 h.

At 24 h postmortem, the 1.5-cm thick steaks of about 100 g were put in a polyethylene bag. The packages were heated in a water bath at 70°C for 45 min and cooled at room temperature for 45 min. Cooking loss percentage was determined by use of steak weights taken before and after cooking.

Six representative 1.30 cm diameter cores were removed from each steak parallel to the muscle fiber after cooling. Shear force values were determined with a Warner-Bratzler (load cell, 50 kg, cross-head speed, 200 mm/min). Each core sample was sheared once across the center of the core perpendicular to the muscle fiber. The shear force value was the mean of the maximum forces required to shear each set of core samples.

Water holding capacity (WHC) was measured at 24 h postmortem by a modification of the procedure of Grau and Hamm (1953). Briefly, a 300-mg sample of muscle was placed in a filter-press device and compressed for 2 min. WHC was calculated from triplicate samples as a ratio of the meat film area to the total area; hence, a larger value suggests a higher WHC.

Each steak was cooked on pre-heated grilling units at approximately 150°C to an internal temperature of 40°C, turned, and removed when they reached 70°C internally. Temperature was monitored with a digital thermometer placed in the geometric center of the steak. Steaks were wrapped in aluminum foil and placed in a preheated oven (65°C) until served to panelists. All cooked steaks were evaluated by panelist for flavor, tenderness and juiciness. A scale of 1-9 was used for sample rating where 1 is undesirable flavor, extremely tough and dry and 9 is desirable flavor, extremely tender and juicy. Each panel member was supplied natural water to rinse in mouth. The average of the 8 panelists' values were used as the flavor, tenderness and juiciness score for each sample.

Statistical analysis

Data on all growth and carcass traits were presented as mean±standard error. Data on various growth and carcass traits were analysed as completely randomised design by analysis of GLM covariance (SAS, 1994). Initial body weight was included in the model as a covariate for the analyses of growth parameters and feed efficiency. For carcass yield analysis hot carcass weight was used as a covariant. The significant ($p<0.05$) differences among

means were separated by Duncan's Multiple Range test was applied (Steel and Torrie, 1984).

RESULTS AND DISCUSSION

Mean BW and BW gain were higher ($p<0.05$) for CBK compared with BCBK and JNC at 4, 10, 16 and 24 months of age (Table 2). Higher BW gain in CBK could be attributed to the higher inheritance of Charolais. Similar results were observed in our previous study (unpublished) where growth of JNC, CBK and BCBK was compared on an intensive concentrate feeding regimen for early finishing of cattle. Charolais was used to produce crossbred of JNC because of her higher birth weight and faster growth rate (Cundiff et al., 1993). Heavier weight of Charolais compared with Brahman, other tropical and subtropical cattle are also well established. Peacock et al. (1981) reported 20% higher weaning weight for Charolais than for Brahman calves. Average daily BW gain during 4 to 10 months of age was the highest ($p<0.05$) for CBK followed by BCBK and JNC (Figure 1). However, daily BW gain was higher ($p<0.05$) in BCBK than in CBK and JNC during 11 and 16 months of age (Table 2). Hanwoo, Wagyu and JNC are known for their genetic ability to produce high marbled beef (Yang et al., 1999; Moon et al., 2003); however they grow at lesser rate than specialized beef cattle like Charolais. Mir et al. (1999) showed that animals with continental inheritance grew faster than animals with 1/2 or ¾ Wagyu inheritance. Myers et al. (1999) also reported that Wagyu cattle grew more slowly than British cattle. During fattening period (17 to 24 months) average daily BW gain was higher ($p<0.05$) in JNC than in CBK and BCBK (Table 2). Lower BW gain during fattening period in crossbreds compared with JNC could be attributed to an early maturity and higher maintenance cost of nutrients to support higher BW in the former, which they have attained during growing period. Higher nutrients need to support a higher BW possibly has spared less nutrients for fat deposition and BW gain in crossbreds compared with JNC during fattening period. Feed conversion efficiency of JNC during 11 to 24 months of age was better in JNC compared to its crossbreds (Table 2). Furthermore, synthesis and release of GH, IGF-I, and insulin was varied among different cattle breeds and generally higher serum levels of these hormones were associated with higher body in both *Bos indicus* and *Bos Taurus* cattle (Harmon, 1992; Thomas et al., 2002). Greater serum concentrations of GH and glucose in Brangus bulls than in Angus or Brahman bulls was reported by Thomas et al. (2002). Slower growth rate in *Bos indicus* cattle than in *Bos Taurus* was attributed to low serum concentrations of GH, IGF-I, and insulin in the former (Thomas et al., 2002). In present study, possibly different serum concentrations of GH, IGF-I, and insuline might have affected the body weight gain of JNC and its crossbreds. It may be suggested from present findings that an early rapid growth advantage in crossbreds with higher Charolais inheritance could turn into a costly experience during long fattening period due to higher nutrient requirements to maintain higher BW. In

Table 3. Mean (±standard error) hot, cold, boneless and retailed cut carcass weight of Jeju native cattle and its crossbreds

Parameters (kg)	Breeds		
	JNC[1]	CBK[2]	BCBK[3]
Slaughter weight	512.50±20.75[b]	621.50±34.34[a]	525.83±32.28[b]
Hot carcass weight	333.53±28.48[b]	416.38±24.60[a]	336.60±29.32[b]
Hot carcass weight (left)	168.15±20.71[b]	209.45±17.39[a]	170.00±12.92[b]
Hot carcass weight (right)	165.35±17.83[b]	206.93±12.29[a]	166.60±15.49[b]
Cold carcass weight	327.20±28.33[b]	409.15±24.23[a]	331.47±28.91[b]
Cold carcass weight (left)	165.00±11.56[b]	205.85±13.13[a]	167.40±11.74[b]
Cold carcass weight (right)	162.20±12.82[b]	203.30±12.20[a]	164.07±13.26[b]
Shrinkage weight	6.33±0.41[b]	7.23±0.59[a]	5.13±0.42[c]
Bone weight	36.68±2.75[b]	47.23±5.55[a]	34.74±3.89[b]
Bone weight ratio	11.25±0.43	11.57±0.85	10.48±0.88
Boneless meat weight	232.80±18.58[b]	300.21±27.63[a]	240.20±16.02[b]
Boneless meat ratio	71.12±1.13	73.43±0.63	72.52±0.92
Ribs weight	37.78±5.31[b]	45.23±5.85[a]	38.15±4.95[b]
Ribs weight ratio	11.53±0.42	11.06±0.14	11.50±0.21
Excluded ribs meat weight	283.43±24.38[b]	348.34±34.11[a]	282.17±21.63[b]
Excluded ribs meat weight ratio	83.93±0.95	85.19±0.60	85.16±0.75
Retailed cut weight	202.68±21.96[b]	269.29±32.26[a]	205.82±22.38[b]
Retailed cut weight ratio	62.04±1.07[b]	65.90±1.31[a]	62.14±0.51[b]
Trimmed carcass fat weight	32.13±9.88	30.93±6.17	34.38±4.12
Trimmed carcass fat weight ratio	9.09±0.55[a]	7.53±0.81[b]	10.38±0.69[a]

[1] Jeju native cattle. [2] CBK = 25% JNC:50% Chorales:25% Brahman. [3] BCBK = 62.5% JNC:25% Chorales: 12.5% Brahman.
[a-c] Means with in a row followed by different letter are significantly different ($p<0.05$).

contrast to present findings, the unpublished results from our previous study indicated higher daily BW gain and BW of CBK and BCBK compared with JNC when they were stall fed on *ad libitum* concentrate (from 4 to 12 month growing ration and from 13 to 18 months) and grass hay.

Slaughter weight, hot and cold carcass weight were higher ($p<0.05$) in CBK compared with JNC and BCBK (Table 3). The JNC and BCBK had similar slaughter weight, hot and cold carcass weights. Heavier carcass of crossbred cattle with higher Charolais inheritance compared with JNC could be ascribed to their higher slaughtering weight. Fully matured Korean Hanwoo steer was lighter than average commercial breeds (Angus, Charolais), and average Hanwoo carcass was lighter than these breeds by approximately 80 kg (Lorenzen et al., 1993, Hilton et al., 1998). Carcass shrinkage weight loss was the highest ($p<0.05$) in CBK followed by JNC and BCBK (Table 3). Weight of bones, boneless meat, ribs, excluded rib meat weight, retailed cut meat weight and its ration were higher ($p<0.05$) in CBK than in BCBK and JNC.

Trimmed carcass fat weight was similar in JNC and its crossbreds however, trimmed carcass fat weight ratio was higher ($p<0.05$) in JNC and BCBK compared with CBK. It was demonstrated that the carcass weight was an important factor affecting meat quality through its effect on fattiness (Hilton et al., 1998). Rossi et al. (2000) noted that premium product (e.g., highly marbled meat) could offset the feed cost. Carcass length, chest length, femur length, chest width, hip width, femur width, chest girth and femur depth were higher ($p<0.05$) in CBK than in BCBK and JNC (Table 4). However, these measurements were similar in BCBK and JNC carcasses. Back fat thickness was highest in JNC

Table 4. Mean (±standard error) carcass measurements and back fat thickness of Jeju native cattle and its crossbreds

Parameters (cm)	Breeds		
	JNC[1]	CBK[2]	BCBK[3]
Carcass length	127.85±2.92[b]	133.95±3.72[a]	126.47±2.80[b]
Chest length	71.73±1.11[b]	74.45±2.06[a]	70.37±2.50[b]
Femur length	95.93±3.14[b]	101.50±5.00[a]	94.20±2.62[b]
Chest width	71.13±1.93[b]	75.55±2.63[a]	71.63±1.72[b]
Hip width	40.75±2.53[b]	44.65±1.95[a]	43.83±1.76[a]
Femur width	42.68±1.40[b]	44.65±1.07[a]	40.33±0.76[c]
Chest girth	161.15±5.21[b]	169.10±5.83[a]	158.07±4.81[b]
Chest depth	16.23±0.56	16.30±0.84	16.57±0.57
Femur depth	20.73±0.75[b]	24.20±0.23[a]	21.73±0.64[b]
Back fat thickness (11-12 vertebrae)	0.73±0.06[a]	0.30±0.08[c]	0.63±0.03[b]

[1] Jeju native cattle. [2] CBK = 25% JNC:50% Chorales:25% Brahman. [3] BCBK = 62.5% JNC:25% Chorales:12.5% Brahman.
[a-c] Means with in a row followed by different letter are significantly different ($p<0.05$).

Table 5. Mean (±standard error) weight and fat distribution in different carcass cuts of Jeju native cattle and its crossbreds

Parameters (kg)	Breeds		
	JNC[1]	CBK[2]	BCBK[3]
Tender loin weight	3.10±0.21[b]	3.85±0.28[a]	3.05±0.29[b]
Tender loin fat weight	0.55±0.12	0.51±0.14	0.42±0.11
Sir loin weight	3.88±0.37[b]	5.08±0.33[a]	4.16±0.44[b]
Strip loin weight	19.10±2.65[b]	24.13±2.22[a]	17.62±1.65[b]
Strip loin fat weight	1.43±0.25	1.44±0.50	1.33±0.31
Sticking weight	8.28±1.04[b]	12.18±0.97[a]	10.09±0.76[ab]
Top round weight	10.83±1.18[b]	14.98±1.28[b]	10.94±1.30[b]
Top round fat weight	1.16±0.24	1.15±0.32	1.47±0.38
Bottom round weight	16.63±2.18[b]	22.55±2.64[a]	17.50±1.67[b]
Bottom round fat weight	1.30±0.28	1.28±0.32	1.37±0.28
Fore leg weight	12.38±0.90[b]	15.90±1.53[a]	12.78±1.24[b]
Fore leg fat weight	0.93±0.18	0.99±0.29	1.04±0.18
Shank weight	7.55±0.73[b]	10.55±1.04[a]	7.50±0.35[b]
Shank fat weight	1.38±0.26	1.46±0.39	1.28±0.24
Thin flank weight	16.10±1.01[b]	20.95±1.52[a]	16.07±1.83[b]
Thin flank fat weight	7.39±1.09	7.00±1.11	7.37±0.65
Kidney fat weight	0.44±0.08	0.43±0.05	0.44±0.07

All measurements were on left half of the carcass.
[1] Jeju native cattle. [2] CBK = 25% JNC:50% Chorales:25% Brahman. [3] BCBK = 62.5% JNC:25% Chorales: 12.5% Brahman.
[a-c] Means with in a row followed by different letter are significantly different ($p<0.05$).

Table 6. Mean (±standard error) Logissimus dorsi area and different organs weight of Jeju native cattle and its crossbreds

Parameters (kg)	Breeds		
	JNC[1]	CBK[2]	BCBK[3]
Logissimus dorsi area	81.93±6.30[b]	105.60±14.70[a]	84.80±12.62[b]
Logissimus muscle ratio	42.23±3.62[b]	60.03±7.73[a]	43.33±5.93[b]
Head weight	25.38±1.31[b]	28.50±2.80[a]	24.50±2.18[b]
Leg weight (fore)	4.75±0.29[b]	5.95±0.34[a]	4.47±0.32[b]
Leg weight (rear)	4.70±0.63[b]	6.30±0.74[a]	4.55±0.30[b]
Total internal organs weight	90.88±12.94	94.75±10.84	91.83±8.89
Blood weight	15.75±0.65	16.50±1.58	17.07±2.38
Hide weight	32.50±3.54	36.75±5.28	35.20±4.01
Lung weight	4.40±0.50[b]	5.70±0.56[a]	4.07±0.45[b]
Heart weight	2.20±0.18	2.43±0.33	2.27±0.25
Liver weight	6.28±1.03	6.25±1.08	6.20±0.62
Spleen weight	1.83±0.32	2.30±0.32	2.07±0.27
Rumen & reticulum weight	8.02±0.46[b]	9.05±0.42[a]	7.87±0.35[b]
Omasum weight	2.50±0.26[b]	3.15±0.22[a]	2.47±0.20[b]
Abomasum weight	1.38±0.11	1.63±0.12	1.47±0.18
Rectum weight	2.03±0.12	1.83±0.13	1.92±0.15
Small intestine weight	8.50±0.68	9.00±0.82	8.07±0.97
Large intestine weight	2.00±0.22	2.38±0.28	2.17±0.29

[1] Jeju native cattle. [2] CBK = 25% JNC:50% Chorales:25% Brahman. [3] BCBK = 62.5% JNC:25% Chorales:12.5% Brahman.
[a-c] Means with in a row followed by different letter are significantly different ($p<0.05$).

Table 7. Mean (±standard error) carcass chemical composition and sensory evaluation of Jeju native cattle and its crossbreds

Parameters	Breeds		
	JNC[1]	CBK[2]	BCBK[3]
Moisture (%)	73.72±1.39	73.85±1.31	72.43±0.66
Crude ash (%)	1.00±0.03	1.08±0.05	0.98±0.02
Crude protein (%)	20.54±0.19	20.93±0.11	20.92±0.18
Crude fat (%)	4.63±1.71[a]	3.07±1.39[b]	5.27±0.88[a]
Cooking loss (%)	37.31±2.12	36.23±3.39	39.39±2.04
Shear force (kg/cm^2)	11.19±1.90[a]	10.23±2.04[a]	8.30±1.26[b]
Water holding capacity (%)	39.52±4.83	40.71±4.13	38.53±5.35
Juiciness	3.24±0.21[b]	3.32±0.39[b]	4.29±0.28[a]
Tenderness	2.91±0.14[b]	2.93±0.18[b]	3.67±0.13[a]
Flavor	4.01±0.24[b]	3.96±0.25[b]	4.65±0.20[a]

[1] Jeju native cattle. [2] CBK = 25% JNC:50% Chorales:25% Brahman. [3] BCBK = 62.5% JNC:25% Chorales:12.5% Brahman.
[a-c] Means with in a row followed by different letter are significantly different ($p<0.05$).

followed by BCBK and CBK. Similar results were reported when specialized beef cattle or Wagyu crossbreds were compared with pure Wagyu animals (Barker et al., 1995; Chung et al., 2006). Higher back fat thickness in JNC may be attributed to her natural genetic ability to accumulate fat (Park et al., 2002). Further, in this study probably less energy was deposited as fat during fattening period because of possibly higher maintenance expenditure to support higher BW in crossbred cattle compared with JNC. It may be stated that carcass trimmed fat and back fat thickness were the function of both JNC inheritance and BW of cattle at the start of fattening period.

Weight of tender loin, sir loin, strip loin, sticking, top round, bottom round, fore leg, shank, thin-flank were higher ($p<0.05$) in CBK carcass than in BCBK and JNC carcasses (Table 5). Fat weight in these carcass cuts and kidney fat were similar in JNC and its crossbreds. Previous studies have demonstrated that American Wagyu (a synthetic of Angus, Hereford, Angus and Holstein) cattle exhibit adipose tissue accretion tendencies similar to those of Japanese Black cattle (Barker et al., 1995). *Logissimus dorsi* muscle area and its ratio were higher ($p<0.05$) in CBK compared with BCBK and JNC (Table 6). Although, the Korean beef grading system is a function of degree of marbling, firmness of muscle texture, fat and meat color and degree of maturity, quality grade is practically determined largely on the basis of degree of marbling. Higher carcass weight and fat are significantly beneficial in Korean beef grading system. Park et al. (2002) reported that better quality grade of Hanwoo cattle was positively linked to carcass weight. A higher (better) quality grade score was resulted from heavier carcasses with thicker back fat, larger

ribeye area, more red meat color, more white fat color and with higher degree of marbling. Weights of head, fore and rear legs, lungs, rumen and reticulum, and omasum were higher in CBK compared with BCBK and JNC. However, the weights of total internal organs, blood, hide, heart, liver, spleen, abomasums, rectum, small and large intestines were similar in JNC and its crossbreds (Table 6).

Percent moisture, crude protein and ash contents of beef were similar in JNC and its crossbreds (Table 7). Percent beef fat was higher in JNC and BCBK compared with CBK (Table 7). Fat accretion may be influenced by many factors including breed or genotype, age or live weight, physiological status or gender and feeding regime (Barker et al., 1995; Irie et al., 2006; Kim et al., 2006a). The breed effect has been reported by several authors as one of the major factors affecting carcass fat deposition (Lunt et al., 2005). In contrast to present results, previous studies have demonstrated that American Wagyu cattle exhibit adipose tissue accretion tendencies similar to those of Japanese Black cattle (Barker et al., 1995; Kim et al., 2006a). However, marbling is a prime theme in Korean beef industry, as consumer's judge meat quality on the basis of the degree of marbling, and they are willing to pay premium for highly marbled product (Animal products grading service report, 2001).

Cooking loss and WHC of beef were similar in JNC and its crossbreds. Sheer force was lower in BCBK compared with JNC and CBK (Table 7). Shear force values were slightly negatively related to intramuscular fat content in most studies (Seideman et al., 1987; Fiems et al., 2000). However, Renand et al. (2001) reported that tenderness or mechanical strength was not closely related to the intramuscular fat content. Juiciness, tenderness and flavor of beef were higher in BCBK compared with JNC and CBK (Table 7). Other workers (Dikeman et al., 1986; Van et al., 1992; Kim et al., 2006b) reported that flavor and juiciness was only slightly positively related to the intramuscular fat content. In reviewing the literature, Parrish (1981) found correlations between marbling and palatability were usually positive and significant, but low in magnitude and the relationship of marbling to flavor attributes was variable and marbling more strongly related to juiciness than tenderness.

CONCLUSIONS

In conclusion, CBK and BCBK have shown higher BW gain during growing period. However, higher nutrient cost to maintain higher BW during fattening period overshadowed the early growth advantage especially in BCBK. Slaughtering weight, fat and carcass yield were higher in CBK compared with BCBK and JNC. Juiciness, tenderness and flavor of beef were higher/better in BCBK compared with JNC and BCBK. Yield grades in Korea are influenced by muscling and carcass size as determined by loin-eye area, fat thickness and carcass weight. CBK produce heavier carcass with a fare degree of fatness.

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