EFFECTS OF DIETARY CALCIUM LEVELS ON PERFORMANCE OF KOREAN NATIVE CATTLE

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Summary

Sixteen Korean native bulls weighing about 211 kg were randomly allotted to investigate the effect of different dietary calcium levels on performance. Feeding period was divided into growing period and fattening period for 180 days. Four calcium levels (0.44, 0.58, 0.72 and 0.86%) were used to each period.

Bulls fed the diet containing 0.72% calcium had greater body weight gain and consumed more feed than bulls fed diets containing 0.44, 0.58 and 0.86% calcium and improved in feed efficiency. Bulls fed the diet containing 0.44% calcium were worst in performance.

It can be concluded that Korean native bulls in growing and fattening period required no more than 0.72% calcium in diet that contained 0.55% phosphorus, and appeared that when ratio of calcium to phosphorus intake was 1.45, performance of Korean native bulls was most beneficial.

(**Key Words**: Korean Native Bull, Calcium Level, Body Weight Gain, Feed Intake, Feed Efficiency)

Introduction

Many feeds do not provide all essential minerals in amounts which maximize performance of animal. An adequate calcium supply was intimately associated with increasing animal performance. Calcium deficiency may occur when finishing cattle are fed heavily on concentrates and limited quantities of nonlegume roughage, especially young cattle for a long period. Adding calcium to such a ration increased the rate of gain, and improved feed utilization (Ensminger, 1987). Even nonlegume forages contain more calcium than cereal grains, this indicates that an inorganic source of calcium is less necessary when large quantities of roughage are being consumed. Although a sufficient calcium was offered, unbalanced to phosphorus or magnesium et al., on the contrary, adverse effects or no benefits may be occurred. The higher level of phosphorus reduced weight gains, but additional calcium overcomed this depression. Calculi incidence was reduced by increasing dietary calcium, withdrawal of calcium from the skeleton occurs whenever dietary supplies are inadequate to meet physiological requirements (Hoar et al., 1970). Calcium-deficient lambs did not consume adequate calcium, offered free choice, to maintain total bone calcium (Pamp et al., 1977). Limestone supplementation of high-concentrate diets to supply more calcium than needed for growth and development of cattle has been received considerable attention (Russell et al., 1980; Zinn and Owens, 1980; Haaland and Tyrrell, 1982; Rust and Owens, 1982; Goetsch and Owens, 1985).

Under the condition of Korean farm which largely offered much formulated ration to animals, optimal calcium supply to ration is very important. Therefore, this experiment was carried out to determine the optimal calcium level necessary to meet the performance of Korean native bull.

Materials and Methods

Sixteen Korean native bulls, 211 kg initially, were randomly allotted to one of four diets containing 0.44, 0.58, 0.72 and 0.86% calcium. Feeding trial was divided into 2 periods of growing period, 210 kg initial body weight and fattening period, 310 kg initial body weight at an interval of 3 months. Concentrate and rou-

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ghage (rice straw) were fed *ad libitum* in individual feed container throughout the experimental period. Water was available to the bulls by water cup at all times. Dietary calcium levels were adjusted by limestone supplementation to the basal ration and the dietary phosphorus level was adjusted to 0.55% by the addition of tricalcium phosphate. Basal rations were formulated to contain 2.6 Mcal metabolizable energy per kg, and dietary crude protein content in growing and fattening period was 14% and 11%, respectively. Composition of experimental diets are shown in table 1. Bulls were weighed at 15-day intervals before the morning feeding and feed intake was recorded daily.

Data were analyzed by analysis of variance as described by Steel and Torrie (1960). Significant differences among means were detected by least significant difference.

TABLE 1. COMPOSITION OF DIET

Period	Growing				Fattening			
Calcium level (%)	0.44	0.58	0.72	0.86	0.44	0.58	0.72	0.86
Ingredient composition (%)								
Yellow corn	32.00	31.70	35.70	40.00	35.00	36.00	37.70	37.70
Wheat	20.00	20.00	14.50	10.00	20.00	20.00	20.00	20.00
Wheat bran	32.80	32.90	33.30	32.20	38.30	36.90	34.80	34.50
Soybean meal	8.50	8.40	9.10	10.00	–	–	–	–
Tapioca	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Limestone	0.70	1.00	1.40	1.80	0.70	1.10	1.50	1.80
Tricalcium phosphate	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Trace mineralize salt[1]	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Vitamin[2]	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Chemical composition								
Crude protein (%)	14.06	14.01	14.01	14.02	11.36	11.23	11.05	11.00
Crude fat (%)	2.61	2.60	2.68	2.74	2.75	2.74	2.73	2.72
Crude fiber (%)	4.75	4.75	4.79	4.74	4.81	4.72	4.58	4.55
Crude ash (%)	4.59	4.88	5.30	5.67	4.35	4.69	5.01	5.29
Calcium (%)	0.46	0.57	0.72	0.87	0.44	0.59	0.74	0.85
Phosphorus (%)	0.55	0.55	0.55	0.54	0.55	0.54	0.53	0.52
ME (Mcal/kg)	2.62	2.61	2.60	2.60	2.60	2.60	2.60	2.59

[1] NaCl, 94%; Mn, 0.2%; Mg, 0.1%; S, 0.05%; Cu, 0.025%; Co, 0.01%; Zn, 0.008%; I, 0.007%.
[2] Contains the following ingredients per kg: vitamin A, 3,300 IU; vitamin D, 330 IU; vitamin E, 221 IU/kg

Results and Discussion

Daily body weight gain, daily feed intake, feed efficiency and daily calcium intake for bulls fed the diets containing 4 levels of calcium in growing, fattening and overall periods are presented in table 2, 3 and 4, respectively.

Daily body gains of Korean bulls in growing and overall periods were not affected by dietary calcium levels, but bulls fed the diet containing 0.72% calcium gained significantly ($p < .05$) greater among all treatments in fattening period and bulls fed the diets containing 0.44 or 0.58 % calcium gained significantly ($p < .05$) less than bulls fed the diet containing 0.72% calcium. Although no significant differences in body weight gain of bulls during the growing or overall period were observed, these data followed the same tendency as was observed in fattening period. It tended that bulls fed the diet containing 0.72 % calcium had a greater body gain. This result was similar with the finding of Wheeler et al. (1981) who observed that Simmental crossbred steers (average weight, 263 kg) fed diets containing

TABLE 2. EFFECTS OF DIETARY CALCIUM LEVELS ON PERFORMANCE OF KOREAN NATIVE BULLS IN GROWING PERIOD

Item	Calcium levels, %				F test
	0.44	0.58	0.72	0.86	
Initial body wt. (kg)	212.5	211.0	211.5	211.0	
Final body wt. (kg)	305.3	314.8	322.0	313.8	
Total body gain (kg)	92.8	103.8	110.5	102.8	
Daily body gain (kg)	1.03	1.15	1.23	1.14	NS
Concentrate intake (DCI) (kg/d)	5.33	5.45	5.55	5.42	NS
Roughage intake (DRI) (kg/d)	1.97	2.01	2.30	2.02	NS
DCI/DRI	2.71	2.71	2.41	2.68	NS
Feed intake (kg/d)	7.30	7.46	7.85	7.43	NS
Feed/gain	7.24^{a}	6.49^{b}	6.38^{b}	6.54^{ab}	5%
CP intake (kg/d)	0.85	0.87	0.90	0.86	NS
ME intake (Mcal/d)	16.54	16.90	17.56	16.84	NS
Calcium intake (g/d)	30.35^{d}	38.65^{c}	48.01^{b}	53.68^{a}	1%
Calcium/phosphorus[1]	0.96^{d}	1.20^{c}	1.45^{b}	1.68^{a}	1%

Means in the same row with different superscripts differ.
NS: Not significant.
[1] Ratio of calcium intake to phosphorus intake per day.

TABLE 3. EFFECTS OF DIETARY CALCIUM LEVELS ON PERFORMANCE OF KOREAN NATIVE BULLS IN FATTENING PERIOD

Item	Calcium levels, %				F test
	0.44	0.58	0.72	0.86	
Initial body wt. (kg)	305.3	314.8	322.0	313.8	
Final body wt. (kg)	385.3	394.5	416.3	397.3	
Total body gain (kg)	80.0	79.8	94.3	83.5	
Daily body gain (kg)	0.89^{b}	0.90^{b}	1.05^{a}	0.93^{ab}	5%
Concentrate intake (DCI) (kg/d)	5.96	6.44	6.82	6.25	NS
Roughage intake (DRI) (kg/d)	2.31	2.17	2.58	2.47	NS
DCI/DRI	2.58	2.97	2.64	2.53	NS
Feed intake (kg/d)	8.27^{b}	8.61^{ab}	9.40^{a}	8.72^{ab}	5%
Feed/gain	9.29	9.57	9.01	9.43	NS
CP intake (kg/d)	0.80^{b}	0.84^{ab}	0.89^{a}	0.82^{ab}	5%
ME intake (Mcal/d)	18.64^{b}	19.70^{ab}	21.24^{a}	19.61^{ab}	5%
Calcium intake (g/d)	34.29^{c}	44.95^{b}	58.13^{a}	62.05^{a}	1%
Calcium/phosphorus[1]	0.97^{c}	1.19^{b}	1.44^{a}	1.67^{a}	1%

Means in the same row with different superscripts differ.
NS: Not significant.
[1] Ratio of calcium intake to phosphorus intake per day.

0.70% calcium had higher average daily weight gain than for steers fed diets containing 0.35 or 1.05% calcium, although there was no significant ($p > .05$) difference. Higher ($p < .05$) average daily gains for bulls fed the diet containing 0.72% calcium in the fattening period were attributed to increase in ME intake associated with optimal level of calcium addition. ME intake was 13.9%

TABLE 4. EFFECTS OF DIETARY CALCIUM LEVELS ON PERFORMANCE OF KOREAN NATIVE BULLS IN OVERALL PERIOD

Item	Calcium levels, %				F test
	0.44	0.58	0.72	0.86	
Initial body wt. (kg)	212.5	211.0	211.5	211.0	
Final body wt. (kg)	392.3	402.5	416.3	397.3	
Total body gain (kg)	179.8	191.5	204.8	186.3	
Daily body gain (kg)	0.96	1.03	1.14	1.04	NS
Concentrate intake (DCI) (kg/d)	5.65	5.95	6.19	5.84	NS
Roughage intake (DRI) (kg/d)	2.14	2.09	2.44	2.25	NS
DCI/DRI	2.64	2.85	2.54	2.60	NS
Feed intake (kg/d)	7.79^{b}	8.04^{ab}	8.63^{a}	8.08^{ab}	5%
Feed/gain	8.11	7.81	7.57	7.77	NS
CP intake (kg/d)	0.83^{b}	0.86^{ab}	0.90^{a}	0.84^{ab}	5%
ME intake (Mcal/d)	17.88^{b}	18.19^{ab}	19.33^{a}	18.20^{ab}	5%
Calcium intake (g/d)	32.93^{d}	41.52^{c}	52.90^{b}	57.98^{a}	1%
Calcium/phosphorus[1]	0.97^{d}	1.19^{c}	1.44^{c}	1.68^{a}	1%

Means in the same row with different superscripts differ.
NS: Not significant.
[1] Ratio of calcium intake to phosphorus intake per day.

greater for bulls fed the diet containing 0.72% calcium than for bulls fed the diet containing 0.44% calcium. Vaner and Woods (1972) reported that animal performance was increased when cattle were fed a 0.41% calcium ration (dry matter basis) as compared with one containing 0.20%. However, increasing the calcium content above 0.41% did not increase gains. They concluded, when intakes are restricted as in a digestion, calcium levels higher than 0.40% might be advantageous.

Ratio of intake of concentrate to roughage ranged from 2.56 to 2.94 and concentrate intake of bulls by *ad libitum* was greater about 2.67 times than that of roughage. Although there were no significant differences among treatments in respective feeding periods, it tended that ratio of intake of concentrate to roughage was lower in bulls fed the diet containing 0.72% calcium in the growing and overall periods. However, bulls fed the diet containing 0.86% calcium was lower in the fattening period. This means that increment of dietary calcium to optimal level induced to increase of roughage intake. According to the reports of Davidson and Wood (1961) or Vaner and Wood (1972), this result is due to increase of cellulose and energy digestibilities of animal by calcium addition.

Daily feed intake was not significantly affected by dietary calcium levels in growing period, but bulls fed the diet containing 0.72% calcium consumed significantly ($p < .05$) more feed than those fed the diets containing 0.44% calcium in fattening and overall periods. This results was similar to the findings of Pond (1983) and Wheeler et al. (1981) who reported that feed consumption was not significantly affected by dietary calcium levels between 0.35 and 1.05%. However, Hoar et al. (1970) found that increasing dietary calcium level from 0.28 to 1.20% resulted in significantly ($p < .05$) greater weight gains and feed consumption. And Underwood (1966) found that dairy cattle and lambs which were fed calcium-deficient diet had depressed weight gain and lowered feed intake.

Bulls fed the diet containing 0.72% calcium in growing period improved ($p < .05$) in feed efficiency among treatments. And also, although no significant differences in feed efficiency of bulls during the fattening or overall period were observed, these data followed the same tendency as was observed in growing period. This result was similar with the finding of Wheeler et al. (1981) who observed that Simmental crossbred steers (average weight, 263 kg) fed diets containing 0.70% calcium had more efficient feed conversion

than for steers fed diets containing 0.35 or 1.05% calcium, although there was no significant ($p > .05$) difference.

Daily crude protein and metabolizable energy intakes of bulls in growing period were not significantly affected by dietary calcium level, but those of bulls in fattening and overall period increased progressively within range of 0.44% and 0.72% of dietary calcium levels and then tended to be decreased in 0.86% calcium level.

Daily calcium intake of bulls fed diets containing various levels of calcium ranged from 30 to 57 g and was progressively increased ($p < .01$) with increasing dietary calcium levels. Therefore, the data indicate that calcium intake of bulls was greatly influenced by dietary calcium levels and calcium appetite was not reduced within these calcium ranges.

From the above results, ratio of calcium to phosphorus intake of 1.45 appeared most desirable in Korean native bull. As dietary calcium level increased from 0.44 to 0.72%, performance of bulls was enhanced significantly ($p < .05$) in fattening period, but dietary calcium level higher than 0.72% had adverse effects on body weight gain. Therefore, it was shown that dietary calcium level which exceed 0.72% or lower below 0.44% for Korean native bulls between 200 and 400 kg had the deterimental effect on performance. Hence, there was a level of calcium addition above which further increases were of no benefit and, under certain conditions, had adverse effects on feed intake and weight gain. This calcium level is slightly higher than that recommended by NRC (1984) for beef cattle. Owens and Arp (1983), whereas, suggested that favorable performance responses were consistent only when the basal diet contained less than 0.35% calcium. On the other hand, Wise et al. (1963) observed better growth and more efficient feed conversion by Hereford calves fed diets containing 0.81% calcium than those by calves fed diets containing 0.27% calcium. These results mean that the effect of dietary calcium on performance can be variable due to differences in diets, breeds of cattle and experimental conditions.

According to this result, it was concluded that Korean native bulls required no more than 0.72% calcium in diet that contained 0.55% phosphorus. Particularly, it was shown that adequate calcium intake of bulls in fattening period (300-400 kg) played important role on performance.

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