Effects of Feeding Method of Compound Feed on the Development of the Digestive Organs and Other Internal Organs of Hanwoo Steers

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ABSTRACT : A study was conducted to investigate the development of the digestive organs (rumen, reticulum, abomasums, small intestine, large intestine and rectum) and other internal organs (liver, spleen, lungs and heart) of Hanwoo (Korean cattle) steers fed diets of compound feed and rice straw by the age from 6 to 30 months old. In the experiment, Two hundreds of Hanwoo steers were allocated in one of two compound feed feeding treatments. The treatment groups were 1) feeding level 1 group fed 1.2 to 1.5% compound feed per kg body weight (BW) in the growing period, 1.7 to 1.8% compound feed per kg BW in the early fattening period, and compound feed *ad libitum* in the late fattening period and 2) feeding level 2 group fed compound feed *ad libitum* through the whole period. In every two months, eight steers in each group were slaughtered and the length and weight of the organs of the animals were measured. The weight of the reticulo-rumen was higher ($p<0.05$) in the group 2 at the age of 14 months. The abomasum weight of group 2 was higher than that of group 1 at the ages of 12 ($p<0.01$) and 20 months ($p<0.05$). The weights of the liver, lung and heart of steers in the group 2 were higher ($p<0.05$) than those in group 1 before 18 months old. At the ages of 8 ($p<0.1$), 10 ($p<0.001$), 12 ($p<0.01$), 16 ($p<0.01$) and 24 months ($p<0.05$), the abomasum of steers in the group 1 was longer than that in the group 2. The length of liver in both groups was sharply increased from 6 to 8 months old and then the increase was steady, while the length in the group 2 at the age of 12 months was significantly longer ($p<0.01$) than that in the group 1. The results indicate that the most organs examined showed the higher development in the feeding level 2 than in the feeding level 1 until the age before 18 months when the steers in the feeding level group 1 were given the compound feed *ad libitum.* ***(Asian-Aust. J. Anim. Sci. 2003. Vol 16, No. 9 : 1315-1319)***

Key Words : Digestive Organs, Hanwoo Steers, Compound Feed, Rice Straw

INTRODUCTION

The development of the ruminant digestive system begins in very early stages of embryonic growth and progresses in formation, growth, and function to adulthood. Several factors affect the growth and development of digestive organs of ruminants. Cessation of growth reduces the weight of the digestive tract tissues. Murray et al. (1977) observed reductions in the tissue weights of all the digestive organs of 300 to 440 kg beef cattle when a period of active growth (0.8 kg/d) was followed by a 150 day period of maintenance (no growth). The small intestines decreased 32% in weight while the omasum, rumino-reticulum, large intestine and abomasum decreased by 18, 8, 7 and 5%.

Again, the normal growth and development of the ruminant stomach may be altered by feeds ingested, their physical form and the animal's nutritional status. Including or excluding concentrates or forages and the processing of forages may enhance or retard the rate of forestomach growth in size, muscle and epithelial development. However, little or no forestomach development occurs in the absence of solid food intake common to some feeding management programs (Thivand et al., 1980). Altering concentrate feed intake may alter digestive organ growth. The inclusion of concentrates into roughage-based rations of calves (Nocek et al., 1984), goats (Hamada et al., 1976) and domestic buffalo (Nangia et al., 1982) increases the rate of rumen epithelial formation and animal growth but retards the development of stomach size and musculature. The present study was carried out to investigate the development of the digestive system of Hanwoo steers affected by feeding method which was restricted or freely accessible feeding of compound feed.

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MATERIALS AND METHODS

Animals and diets

An experiment was conducted for 27 months at National Livestock Research Institute (NLRI), Korea. Two hundreds bull calves (100 kg average body weight) at 3 to 4 months old were purchased at local livestock markets and castrated before beginning of the experiment. Following a two to three week adjustment period, the calves were assigned randomly to one of two compound feed feeding treatments and housed in total confinement with a individual feeding system (Calan System, American Calan Inc., U.S.A.) in a sawdust bedded barn.

The animals were given the diets consisting of *ad libitum* access to rice straw and the compound feeds containing 15.1% crude protein (CP) and 68.8% total digestible nutrients (TDN) in the growing period (6 to 12 months old), 12.0% CP and 71.4% TDN in the early

Table 1. Formula (%, as fed basis) of experimental diets

Ingredients	Compound feed		
	Growing period (6-12 months)	Early fattening period (13-18 months)	Late fattening period (19-30 months)
Corn	33.8	33.1	49.8
Wheat, ground	12.5	25.0	20.0
Corn gluten meal	-	-	1.0
Wheat bran	15.0	15.0	17.0
Tapioca	6.0	9.0	-
Alfalfa	5.0	1.0	-
Soybean meal	1.0	-	0.6
Cottonseed meal	5.0	3.6	-
Rapeseed meal	8.0	4.0	5.0
Perilla meal	5.0	-	-
Linseed meal	1.3	-	-
By-passed fat	0.6	-	-
Tallow	-	0.4	-
Cane molasses	3.5	7.0	5.0
Limestone	1.5	1.3	1.0
Tricalsium phosphate	0.6	-	-
Salt	0.7	0.4	0.4
Sodium bicarbonate	0.1	0.1	0.1
Magnesium oxide	0.1	-	-
Potassium sulfate	0.2	-	-
Vitamin premix[1]	0.1	-	-
Mineral premix[2]	-	0.1	0.1
Total	100	100	100

[1] Vitamin premix contains vitamin A, 6,000 IU; and vitamin D_3, 1,200 IU (per kg of the diet).
[2] Mineral premix contains K, 0.008%; S, 0.005%; Fe, 30 ppm; Zn, 50 ppm; Mn, 40 ppm; Cu, 10 ppm; Co, 0.5 ppm; I, 0.53 ppm; Se, 0.13 ppm; and Mg, 0.03%.

fattening period (13 to 18 months old), and 11.5% CP and 72.5% TDN in the late fattening period (Table 1 and 2). Water and mineral blocks were freely accessed.

The treatment groups were 1) feeding level 1 group fed 1.2 to 1.5% compound feed per kg body weight (BW) in the growing period (6 to 12 months old), 1.7 to 1.8% compound feed per kg BW in the early fattening period (13 to 18 months old), and compound feed *ad libitum* in the late fattening period (19 to 30 months old) and 2) feeding level 2 group fed compound feed *ad libitum* through the whole period. The different feeding periods and the portions of dietary constituents fed during the periods in the present study were based on a Hanwoo feeding program for high quality beef production from NLRI.

Feed samples were taken from a daily ration, dried in a forced-air oven at 60°C, ground to pass a 1 mm screen, and analyzed for DM, nitrogen (N), ether extract, crude fiber and crude ash (AOAC., 1990). In every two months, eight steers in each group were slaughtered after fasting for 24 h and the length and weight of the organs of the animals were measured.

Procedures and measurements

Hanwoo steers were stunned with a captive bolt gun, exsanguinated and digestive (rumen, reticulum, abomasums, small intestine, large intestine and rectum) and other internal organs (liver, spleen, lungs and heart) were removed and separated from surrounding connective tissue. Reticulo-rumen complex was emptied and rinsed with warm tap water to remove digesta and then weighed. Wet weights of the abomasum, omasum, liver, spleen, lungs and heart were also recorded. Abomasum, lung, spleen, liver and heart were laid on glass plates and their lengths were measured.

Small and large intestines and rectum were separated from mesentery, rinsed with saline, blotted and total wet weight was determined. The lengths of small and large intestines were determined by looping the intestine across a board fitted with pegs attached at 1 m increments without tension applied to minimize stretching. The data were analyzed using a paired t-test using the directives of SAS (1996).

RESULTS

Figure 1 shows the weight of the digestive organs affected by feeding methods of Hanwoo steers during the growing and fattening periods. The fresh weight of the reticulo-rumen of steers in both feeding groups was gradually increased throughout the whole period. The weight of the reticulo-rumen was higher ($p<0.05$) in the group 2 at the age of 14 months while at 24 months old the weight in the group 2 was tended to be lower ($p<0.1$) than that in the group 1. The weight of the omasum of steers in the group 1 was rapidly increased until 16 months old and

Table 2. Chemical composition of experimental diets

	Compound feed			Rice straw
	Growing period (6-12 months)	Early fattening period (13-18 months)	Late fattening period (19-30 months)	
Dry matter	88.2	87.3	83.6	12.0
Crude protein	15.1	12.0	11.5	4.5
Ether extract	3.1	2.6	2.9	2.2
Crude fiber	6.2	3.5	3.3	28.3
Crude ash	6.5	5.3	4.2	15.1
Nitrogen-free extract	57.3	63.9	65.7	38.0
TDN	68.8	71.4	72.5	37.5

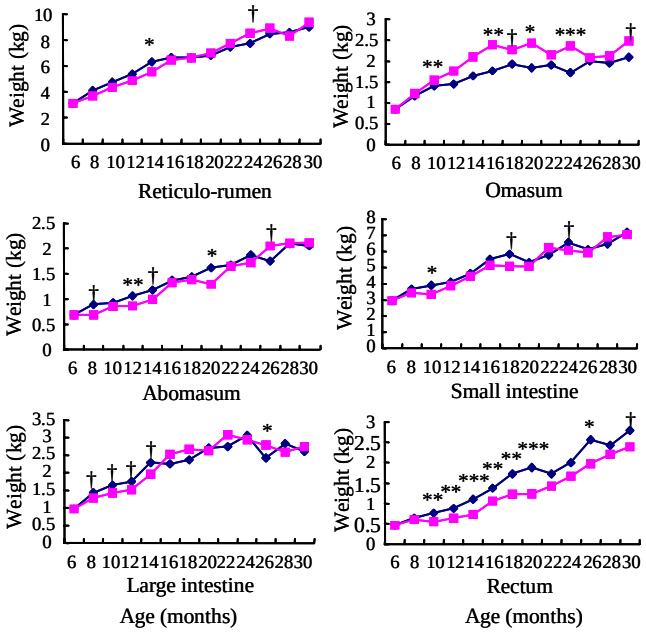

Figure 1. The development of the weight of digestive organs of Hanwoo steers either fed 1.2 to 1.5% compound feed per kg body weight (BW) in the growing period (6 to 12 months), 1.7 to 1.8% in the early fattening period (13 to 18 months) and compound feed *ad libitium* in the late fattening period (19 to 30 months) in feeding level 1 group (■), or fed compound feed *ad libitum* through the whole period in feeding level 2 group (♦). Significant differences of mean values are indicated by †, p<0.1; * p<0.05; ** p<0.01; and *** p<0.001.

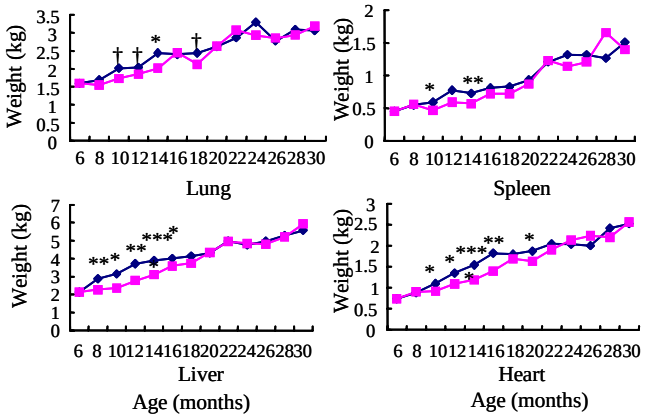

Figure 2. The development of the weight of other internal organs of Hanwoo steers either fed 1.2 to 1.5% compound feed per kg body weight (BW) in the growing period (6 to 12 months), 1.7 to 1.8% in the early fattening period (13 to 18 months) and compound feed *ad libitum* in the late fattening period (19 to 30 months) in feeding level 1 group (■), or fed compound feed *ad libitium* through the whole period in feeding level 2 group (♦). Significant differences of mean values are indicated by †, p<0.1; * p<0.05; ** p<0.01 and *** p<0.001.

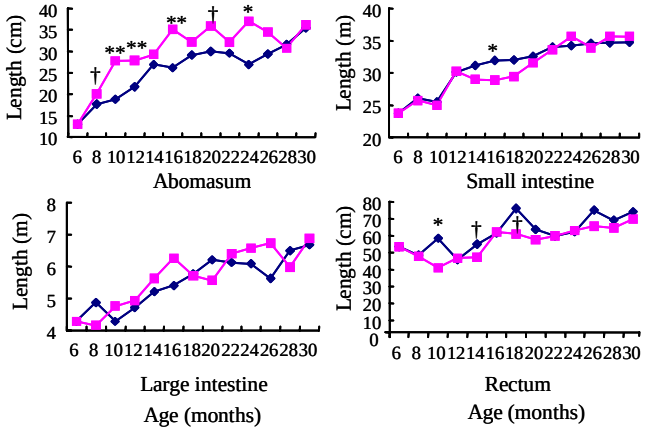

Figure 3. The development of the length of digestive organs of Hanwoo steers either fed 1.2 to 1.5% compound feed per kg body weight (BW) in the growing period (6 to 12 months), 1.7 to 1.8% in the early fattening period (13 to 18 months) and compound feed *ad libitum* in the late fattening period (19 to 30 months) in feeding level 1 group (■), or fed compound feed *ad libitum* through the whole period in feeding level 2 group (♦). Significant differences of mean values are indicated by †, p<0.1; * p<0.05; **, and p<0.01.

afterward was retained, while the weight in the group 2 was gradually increased until 18 months old and afterward the trend was similar to that in the group 1. At the ages of 12, 16, 20 and 24 months old, the weight of the omasum of steers in the group 1 was significantly higher (p<0.05) than that of steers in the group 2. Both feeding treatments gradually increased the weight of the abomasums from 0.7 to 2.1 kg throughout the whole period. The abomasum weight of group 2 was higher than that of group 1 at the ages of 12 (p<0.01) and 20 months (p<0.05). The restricted feeding of compound feed decreased the weight of the small intestine at the age of 10 months old (p<0.05) and the weight of rectum at the age of 10 (p<0.01), 12 (p<0.01), 14 (p<0.001), 16 (p<0.01), 18 (p<0.01), 20 (p<0.001) and 26 months old (p<0.05) compared with the feeding of compound feed *ad libitum* throughout the whole period. Figure 2 shows the weight of the other internal organs affected by feeding methods of Hanwoo steers during the growing and fattening periods. The weights of the lung, liver and heart of steers in the group 2 were higher than those in group 1 before 18 months old. This phenomenon was very clear in the liver weight that the weight of the liver of steers in the group 2 was significantly higher than that in group 1 at the ages of 8 (p<0.01), 10 (p<0.05), 12 (p<0.01), 14 (p<0.001) and 16 months old (p<0.05).

Figure 3 indicates the length of the digestive organs affected by feeding methods of Hanwoo steers during the growing and fattening periods. At the ages of 8 (p<0.1), 10 (p<0.001), 12 (p<0.01), 16 (p<0.01) and 24 months old (p<0.05), the abomasum of steers in the group 1 was longer than that in the group 2 in contrast to the weight

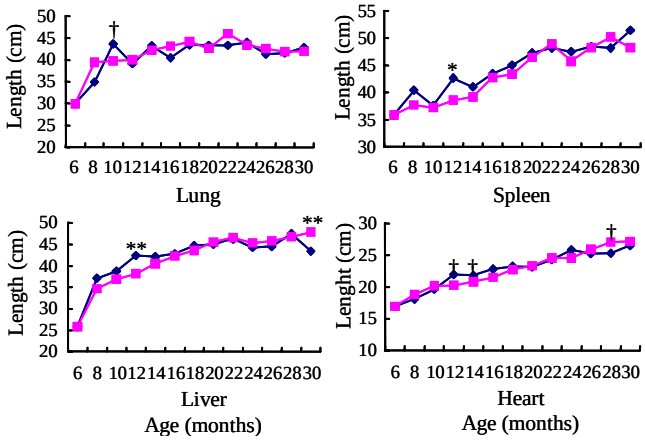

Figure 4. The development of the length of other internal organs of Hanwoo steers either fed 1.2 to 1.5% compound feed per kg body weight (BW) in the growing period (6 to 12 months), 1.7 to 1.8% in the early fattening period (13 to 18 months) and compound feed *ad libitum*in the late fattening perod (19 to 30 months) in feeding level 1 group (■), or fed compound feed *ad libitum*through through the whole period in feeding level 2 group (♦). Significant differences of mean values are indicated by †, $p<0.1$; *, $p<0.05$; **, and $p<0.01$.

development of the abomasum. The lengths of the small and large intestine and the lung were not significantly influenced by the feeding methods except that the small intestine length at 14 months old was higher ($p<0.05$) in the group 2 than in the group 1. The length of liver in both groups was sharply increased from 6 to 8 months old and then the increase was steady, while the length in the group 2 at the age of 12 months was significantly longer ($p<0.01$) than that in the group 1 (Figure 4). The length of spleen in the group 2 at the age of 12 months was significantly longer ($p<0.05$) than that in the group 1.

DISCUSSION

Animals that undergo a period of nutritional restriction and are then refed typically exhibit compensatory growth, which is faster and more efficient than normal (Hogg, 1991). The mechanisms underlying this phenomenon are not fully understood, but they probably include increased feed intake and gastrointestinal tract (GIT) fill and decreased maintenance requirement and net energy content of gain (Carstens et al., 1991; Sainz et al., 1995; Ko et al., 2001). Thus, understanding the control of growth of digestive organs and other organs related to digestion is essential to the development of improved feeding regimes of Hanwoo.

The results of the present study indicate that the most digestive and internal organs except omasum showed the higher development in mass until the age before 18 months in the group 2 in which steers fed *ad libitum* during the whole experimental period than in the group 1 in which steers restrictively fed during the growing and early finishing periods. It is suggested that the restricted feeding of compound feed slow down the development of digestive organs of Hanwoo steers until before the feeding method is shifted to freely accessible feeding during the growing and fattening periods. The omasum responds in a similar manner to the rumen growth influenced by feeding methods (Baldwin, 2000). However, in the present study shows reversed relationship in mass between the omasum and rumen and other digestive organs. It is very difficult to explain because there is no evidence available. One thing only can be suggested that the omasum size is very small compared with other organs, so the organ size can be effectively influenced by various factors such as not only feeding methods but also ration, animals, environmental and measuring techniques etc.

Visceral organs can account for 30 to 60% of the energetic needs of the ruminant (Reynolds and Huntington, 1988; Reynolds et al., 1991). Ferrell and Jenkins (1985) reported that a large proportion of an animal's maintenance energy requirements can be attributed to the visceral organs, especially the liver and gastrointestinal tract, and seem to be associated with the high rates of protein synthesis in these tissues. Again, they mentioned that a greater proportion of total protein synthesis occurred in the combined gastrointestinal tract (19 to 23%) and liver, kidney, and pancreas (16 to 17%) than occurred in striated muscle (24 to 28%). The metabolic activity of visceral organs is related to the size of the organs. The maintenance energy requirements of organs change with the relative weights of the organs and are affected by the level of nutrition (Ferrell et al., 1986). Burrin et al. (1989) reported that the oxygen consumption in the portal-drained viscera (PDV) and liver of the lambs fed at maintenance intake was 37 and 63% lower, respectively, than in the lambs with *ad libitum* intake. The authors suggested that blood flow to the liver is regulated to ensure a constant rate of delivery of nutrients and removal of end products for a given unit of tissue, which is determined by liver mass. Therefore, as mentioned early study by Fluharty and McClure (1997), results of the present study indicate that the energy-sparing effects of restricted feeding on visceral organs occur primarily through reductions in organ size.

The organ mass of the kidneys, liver, heart and lungs (Johnson et al., 1990) of ruminant animals and the gastrointestinal tract of rats (Ferrell and Koong, 1986) increased in accordance with increased DM intake and this has been largely attributed to the concomitant increase in energy intake. Changes in liver mass of feed-restricted and re-fed lambs have been shown to occur in as little as three days (Wester et al., 1995). Further more, in feed-restricted and re-fed lambs portal drained visceral oxygen consumption returns to the consumption of fully fed control

animals in as little as 28 days (Freetly et al., 1995). In contrast, in this study restricted feeding treatment reduced the live weight of steers after refeeding for few months. The present results are consistent with those of Drouillard et al. (1991a,b), who showed that reduced liver weights of steers and lambs persisted even after prolonged refeeding.

In conclusion, the results indicate that the most organs examined showed the higher development in the steers of the group 2 fed *ad libitum* than in the group 1 when steers were in the restricted feeding scheme. From the present study, it is suggested that because visceral organs are major contributor to whole body energy expenditures, factors affecting the growth and metabolism of these organs must be understood through further research work in the present circumstances of lack of information for a Hanwoo feeding regime to achieve high meat quality and growth performance.

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