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Responses to administration of growth hormone releasing hormone and glucose in steers receiving stair-step and extended restriction on feeding

Z.H. Li [a,1], S.K. Kang [a,1], Y.C. Jin [b,f], Q.K. Zhang [a], Z.S. Hong [c], H. ThidarMyint [e], H. Kuwayama [e], J.S. Lee [b], S.B. Lee [b], T. Wang [b], E.J. Kim [d], Y.J. Choi [a], H.G. Lee [b,*]

[a] Department of Agricultural Biotechnology, Seoul National University, Seoul 151-921, Republic of Korea
[b] Department of Animal Science, Pusan National University, Miryang, Gyeongnam 627-706, Republic of Korea
[c] Department of Animal Science, Tianjin Agricultural College, Tianjin 300384, China
[d] Department of Animal Science and Biotechnology, Kyungpook National University, Sangju 742-711, Republic of Korea
[e] Department of Animal Science, Obihiro University of Agriculture and Veterinary Medicine, Obihiro 080-8555, Japan
[f] Department of Animal Science, Jilin University, Changchun 130062, P. R. China

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ABSTRACT

In this study, we assessed the temporal response of growth hormone (GH)/ghrelin to the intravenous administration of GH releasing hormone (GHRH) in 11- (period 1) and 15-month-old (period 2) Korean native steers, as well as the insulin induction response to glucose administration after completion of the feeding scheme in 11-month-old Korean native steers experiencing stair-step and extended restriction feeding schemes. The experiment was divided into periods 1, 2, 3, and 4 with durations of 3, 2, 4, and 2 months, respectively. The control group ($n=9$) was fed according to a standard feeding program during all 4 periods. The T1 ($n=9$; stair-step fed group) was fed a diet with total digestible nutrients (TDN) at concentrations 20% less and more than the TDN concentration fed to the control group in periods 1 and 3 and periods 2 and 4, respectively, whereas the T2 ($n=9$; extended restricted group) was fed increasing levels of TDN, having concentrations of 30%, 20%, 10% less than and 20% more than the TDN concentration of control group, during periods 1, 2, 3, and 4, respectively. Randomly chosen steers ($n=4$, total 12 heads) from the *C*, T1, and T2 groups were used for the experiment of GHRH and glucose administration. Compared to the control group, the T1 showed elevated levels of plasma GH and insulin after GHRH and glucose administration ($p<0.05$) and significantly greater body weight gain and feed efficiency. Although the total amounts of ghrelin in plasma were significantly decreased in the T1 group after GHRH administration ($p<0.05$), GHRH treatment did not affect the acyl ghrelin concentration in the plasma during compensatory growth. The results illustrate that stair-step feeding can promote growth performance by altering the endocrine responses associated with energy utilization, such as the production of GH, ghrelin, and insulin, in steers.

1. Introduction

Generally, animals that experience compensatory growth show an increase in weight gain, feed intake,

* Corresponding author. Tel.: +82 55 350 5516.
E-mail address: hglee66@pusan.ac.kr (H.G. Lee).
[1] These two authors have contributed equally to this research.

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and nutrient use efficiency; a decrease in required energy for basal metabolism and maintenance; and a change in body composition; these allow improvement in weight gain and feed efficiency (Choi et al., 1996; Park et al., 1988). These phenomena are also seen in ruminants, and have been observed by numerous research groups. For example, compared to Holstein steers fed with a normal diet during the pre-fattening and fattening period, Holstein steers fed with restricted total digestible nutrients (TDN) in concentrate diets during the pre-fattening period followed by compensatory feeding during the fattening period showed an improvement in daily weight gain, feed efficiency, and marbling (Sainz et al., 1995; Schoonmarker et al., 2004). These results might reflect the association between nutrition and the endocrine system (Blum et al., 1985). Growth is related to the level of growth hormone (GH), which increases accumulation of protein and decreases synthesis of fat, improving the utility of feed. For ruminants, the nutritional state is very important in determining the level of GH. The blood GH level increases when feeding is restricted or stopped, and decreases during compensatory feeding (Gregory et al., 1991; Houseknecht et al., 1988).

Ghrelin is a hormone mostly generated in the stomach and involved in the control of diverse physiological processes such as insulin secretion, cardiovascular function, and nutrients utilization (Ariyasu et al., 2001). Ghrelin exists as acyl ghrelin, an activated form, and des-acyl ghrelin, a less functional form. Ghrelin can facilitate the secretion of GH, which is a fat-consuming hormone. However, ghrelin itself decreases fat utilization and promotes fat synthesis. This lipid synthesis and appetite-inducing effect of ghrelin is unrelated to its function of stimulating GH secretion (Broglio et al., 2001). Furthermore, administration of GH to GH-deficient patients decreases the content of ghrelin in the blood (Edén et al., 2003).

Insulin is a hormone that strongly influences assimilation in internal metabolism and is closely related to carbohydrate and lipid metabolism during the fattening period. Therefore, researches on the endocrinal response to these two hormones will help to elucidate the mechanisms underlying the growth improvement during the growing period and lipid metabolism during the fattening period for the restricted-compensatory feeding system, which will provide an understanding of growth mechanisms in the stair-step and extended feed restriction systems.

In our previous report, we demonstrated, by conducting a set of programmed feeding studies, that a stair-stepped feeding program lead to improved growth efficiency and meat quality in Korean native steers (Li et al., 2010). In that study, among the experimental groups, the stair-step-fed group offered with 20% less or, more TDN in an alternating feeding pattern showed the highest growth efficiency and meat quality; therefore, we concluded that compensatory growth with stair-stepped feeding could improve the economic performance of Korean native steers. During the feeding schedule of the above study, we administered a single shot of GH releasing hormone, GHRH (at the 11th and 15th month) and glucose (at the 22nd month) into randomly selected steers ($n=4$ per group) from each feeding group by intravenous (i.v.) injection and monitored the induced levels of GH/ghrelin and insulin in the blood. In this study, we investigated the mechanism underlying the better growth performance and meat quality achieved in Korean native steers by compensatory feeding and by monitored the changes in the hormonal responses involved in growth.

2. Materials and methods

2.1. Animals and experimental procedures

Twenty-seven 11-month Korean native steers were divided into 3 groups of 9 animals each based on body weight (BW; 293 ± 22.8 kg). To avoid metabolic disorders due to excessive concentrate feeding during the stair-step growth period, the steers were put through an adaptation

Table 1
Amount of roughage and concentrate offered and the chemical compositions of the experimental diets.

Variable	Control		T1		T2	
	Roughage[a]	Concentrate	Roughage	Concentrate	Roughage	Concentrate
DM (kg/day)						
Period 1	3.0	6.0	3.0	4.5	3.0	3.8
Period 2	2.5	8.5	2.2	10.8	2.7	6.4
Period 3	1.8	10.0	1.8	7.7	1.8	8.9
Period 4	1.1	10.0	1.6	11.9	1.6	11.9
Chemical analysis, % of DM		**Roughage**			**Concentrate**	
CP		5.8			12.0	
Crude fat		0.7			2.5	
Crude fiber		29.8			15.0	
Ca		0.1			0.7	
P		0.1			0.4	
TDN		47			72	

T1: stair-step growth pattern; T2: extended restriction-compensatory growth.
DM: dry matter; CP: crude protein; TDN: total digestible nutrients.
[a] The roughage was mainly composed of *brome* hay.