Effect of Abomasal Administration of L-Glutamine on Nitrogen Balance and Plasma Amino Acid Concentrations in Young Calves

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Abstract Holstein bull calves maintaining reflex closure of the esophageal groove after early-weaning were used to examine the effect of abomasal administration of 0.288 g/kg BW/d of L-glutamine (Gln) on nitrogen (N) balance and plasma amino acid concentrations. In Experiment 1, comparisons with the administration of iso-nitrogenous diammonium citrate (DAC) were made from 9 wk of age using 10 calves in a reversal method with five replicates and 2 wk-period. In Experiment 2, comparisons with that of DAC or iso-nitrogenous mixture of 0.111 g/kg BW/d of DL-methionine (Met) and 0.333 g/kg BW/d of L-lysine monohydrochloride (LysHCl) were made from 14 wk of age using 6 calves in a 3×3 Latin square design with two replicates and 2 wk-period. Basal ration based on corn, soybean meal and rice straw was fed at 27 g/kg BW/d in Experiment 1, and at 20 g/kg BW/d in Experiment 2. In both experiments, administration of L-Gln increased plasma Gln concentration only in the absorptive state, but N balance was not affected by abomasal N supplements. Plasma concentrations of branched-chain amino acids did not differ between the supplements of L-Gln and DAC except for leucine, but were decreased by administration of DL-Met and L-LysHCl in Experiment 2.

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A series of our experiments^{1,2)} indicated that plasma concentrations of branched-chain amino acids (BCAA) such as leucine (Leu), isoleucine (Ile) and valine (Val) were decreased by abomasal administration of DL-methionine (Met) independent of nitrogen (N) balance. Some workers also reported linear decreases in plasma BCAA concentrations with abomasal infusion of increasing quantities of DL-Met or L-Met in sheep²⁰⁾ and steers²⁵⁾. These results strongly suggest an antagonistic interaction between Met and BCAA in ruminants, like the well-known antagonism within BCAA in chicks²⁴⁾ and rats⁷⁾. However, another possi-

bility that abomasal supplement of L-glutamine (Gln) increased plasma BCAA concentrations is not neglected so far as our studies are concerned, because L-Gln was used as a control or for adjustment of N intake in all N balance trials^{1,2)}. The small intestine is the only one tissue where all the enzymes required to construct citrulline (Cit) from glutamatic acid (Glu) are assembled²⁷⁾. Although both Gln and Glu are major respiratory fuels of enterocytes^{28,29)}, activity of phosphate dependent glutaminase (GLNase) that converts Gln to Glu is the rate limiting step of Gln metabolism in the enterocytes^{28,29)}. When an exces-

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sive amount of exogenous Gln is supplied to enterocytes, a part of Gln escaped from the conversion may enter the portal vein. In the liver, Gln is once degraded by GLNase to give Glu and ammonia, but a part of the periportally consumed Gln is regenerated in the perivenous hepatocytes from the Glu and ammonia escaped from detoxification through the urea cycle^{8, 29)}. On the other hand, Gln is synthesized by transamination between BCAA and 2-oxoglutarate in the peripheral tissues such as skeletal muscle and adipose tissue^{24, 27, 29)}. Thus, a large amount of exogenous Gln may increase plasma BCAA concentrations as a result of reduced uptake of BCAA by peripheral tissues for the endogenous Gln synthesis.

This study was conducted to compare the effects of a large amount of exogenous L-Gln and the iso-nitrogenous diammonium citrate (DAC) on N balance and plasma concentrations of amino acids, especially BCAA. The citrate is one of the metabolites of Gln carbons in the enterocytes^{27, 28)}, and not metabolized further in the enterocytes but easily converted to 2-oxoglutarate in the liver.

Materials and Methods

Calves

Two N balance experiments were conducted using a total of sixteen Holstein bull calves weaned at 5 wk of age. They were trained after weaning to maintain reflex closure of the esophageal groove by offering warm water at the same time (08 : 30 and 16 : 30 h) and by the same method (nipple feeding) under the same auditory environment (noise of routine and music from tape-recorder) as those at offering liquid milk replacer during the suckling period^{1, 2)}. Water to quench thirst was offered by buckets at noon without music in order to discriminate motives of drinking liquid. Experiment 1 started from 9 wk of age using 10 calves, whereas Experiment 2 started from 13 wk of age using 6 calves, after calves were

stalled in individual cages. Mean BW of calves at the start of experiments was 74.5 ± 7.0 kg in Experiment 1, and 116.1 ± 8.3 kg in Experiment 2.

Basal ration

The basal ration used in two experiments in common was similar to that used in the previous works^{1, 2)}, and consisted of 90% concentrate and 10% rice straw by as-fed weight. The concentrate consisted of 84% flaked corn, 14% rolled soy bean meal (SBM), and 2% minerals and vitamins (A and D), and contained 15.6% CP of DM¹⁾. Rice straw contained 4.5% CP of DM. In Experiment 1, the basal ration was given at the level of 27 g on as-fed basis per kg BW in even portions at 08 : 30 and 19 : 30 h, so that daily CP intake was equivalent to 3.4 g/kg BW. In Experiment 2, however, daily CP intake was limited to 2.5 g/kg BW by restricting the feeding level of basal ration to 20 g/kg BW/d, because the CP intake of 3.4 g/kg was a little too high to identify limiting amino acids in Holstein bull calves above 3 mo of age, or more than 90 kg BW, according to our previous studies^{10, 11)}.

Experiments

In Experiment 1, N balance and plasma concentrations of free amino acids were compared using 10 calves in a reversal design with five replicates and 2 wk-period between the two treatments : abomasal administration of 0.288 g/kg BW/d of L-Gln and that of the iso-nitrogenous 0.444 g/kg BW/d of diammonium citrate (DAC). In Experiment 2, comparisons were made using 6 calves in a 3×3 Latin square design with 2 replicates and 2 wk-period among the three treatments : administration of 0.288 g/kg BW/d of L-Gln, that of 0.444 g/kg BW/d of DAC, and that of the iso-nitrogenous mixture of 0.111 g/kg BW/d of DL-Met and 0.333 g/kg BW/d of L-LysHCl. The supplemental N sources were administered through the esophageal groove by offering warm water dissolved each N source at 08 : 30 and 16 : 30 h in even portions with nipple under the same

auditory condition as that before experiments. Feces and urine were collected for the last 5 d in every period. Jugular blood samples were also taken from every calf immediately before (0 h) and 3 h after the morning feeding and administration on the last day of each period.

Analyses

The N contents of feed, supplemental N sources, feces and urine were determined by Kjeldahl method. Free amino acids in the plasma were determined by the method previously described⁹. Data were analyzed by ANOVA using the GLM procedure of SAS²³. When treatment effect was significant ($P < 0.05$) or tended to be significant ($P < 0.10$) in Experiment 2, the differences among means were tested for significance ($P < 0.05$) or trend of significance ($P < 0.10$) by Duncan's multiple range

test.

Results and Discussion

N Balance

Tables 1 and 2 present the N balance in Experiments 1 and 2, respectively. In Experiment 1, any difference was not detected in N balance between the two treatments. In Experiment 2, the N retained and the % proportion of N retained to N intake tended to be lower with abomasal supplement of DAC among the three treatments. However, the tendency to decrease was due to a higher fecal N when DAC was supplemented, though not significant ($P > 0.10$) and the reasons are unknown. The % proportion of retained N to N absorbed did not differ in Experiment 2, indicating a similar availability of N absorbed

Table 1. Body weight (BW) and daily gain of calves and nitrogen (N) balance in Experiment 1

Item	Treatment		SEM	P <
	DAC ¹⁾	L-Gln ²⁾		
n	10	10		
Initial BW ³⁾ , kg	78.2	77.2	0.4	NS
Final BW ⁴⁾ , kg	84.4	84.3	0.5	NS
Daily gain, kg	0.44	0.51	0.05	NS
N balance, g/d				
N intake ⁵⁾	46.5	45.3	0.3	NS
N in feces	13.9	13.1	0.5	NS
N absorbed	32.6	32.2	0.5	NS
N in urine	8.9	9.5	0.7	NS
N retained	23.7	22.7	0.7	NS
N excreted into urine				
% of N intake	19.4	20.9	1.6	NS
% of N absorbed	27.5	29.4	2.0	NS
N retention				
% of N intake	51.0	50.1	1.4	NS
% of N absorbed	72.5	70.6	2.0	NS

NS : $P > 0.10$.

¹⁾ Administration of 0.444 g/kg BW/d of diammonium citrate through the esophageal groove.

²⁾ Administration of 0.288 g/kg BW/d of L-Gln through the esophageal groove.

³⁾ Mean BW at the start of one treatment of the two.

⁴⁾ Mean BW at the end of one treatment for 2 wk.

⁵⁾ Including supplemental N sources.

Table 2. Body weight (BW) and daily gain of calves and nitrogen (N) balance in Experiment 2

Item	Treatment			SEM	P <
	DAC ¹⁾	L-Gln ²⁾	DL-Met+ L-Lys HCl ³⁾		
n	6	6	6		
Initial BW ⁴⁾ , kg	118.0	116.5	117.0	0.8	NS
Final BW ⁵⁾ , kg	122.9	121.8	123.8	0.7	NS
Daily gain, kg	0.34	0.38	0.49	0.06	NS
N balance, g/d					
N intake ⁶⁾	50.2	50.4	50.3	0.8	NS
N in feces	16.4	14.9	14.2	0.7	NS
N absorbed	33.8	35.5	36.1	0.8	NS
N in urine	15.1	15.7	16.1	0.6	NS
N retained	18.7 ^b	19.8 ^a	20.0 ^a	0.4	0.08
N excreted into urine					
% of N intake	30.2	31.2	31.9	0.9	NS
% of N absorbed	44.8	44.2	44.5	0.7	NS
N retention					
% of N intake	37.2 ^b	39.3 ^a	39.8 ^a	0.7	0.07
% of N absorbed	55.2	55.8	55.5	0.7	NS

NS : P > 0.10.

^{a, b} Means in the same row with different superscripts tend to differ (P < 0.10).¹⁾ Administration of 0.444 g/kg BW/d of diammonium citrate through the esophageal groove.²⁾ Administration of 0.288 g/kg BW/d of L-Gln through the esophageal groove.³⁾ Administration of 0.111 g/kg BW/d of DL-Met and 0.333 g/kg BW/d of L-LysHCl through the esophageal groove.⁴⁾ Mean BW at the start of one treatment of the three.⁵⁾ Mean BW at the end of one treatment for 2 wk.⁶⁾ Including supplemental N sources.

among the three treatments.

In Experiment 2 using calves above 3 mo of age, N balance was not improved by abomasal administration of both DL-Met and L-LysHCl, in contrast to our previous studies^{1,2)} which showed that Met was first limiting and Lys second limiting for the similar diet as that used in this study under 3 mo of age. Reasons for the discrepancy are unclear, but it may be related to a rapid development of the rumen function after early-weaning. Leibholz¹⁷⁾ reported that microbial N as a percentage of total N flowing to the small intestine increased from 32% in the first week after weaning at 6 wk of age to 74% by 7 wk after the weaning. Quigley *et al.*¹⁹⁾ estimated that the proportion

of microbial N flowing to the duodenum increased from 52.6% at 5 wk of age to 71.2% at 11 wk of age in calves weaned at 4 wk of age, although the increase was not statistically significant. In addition, Vazquez-Anon *et al.*²⁶⁾ reported that feedstuffs high in degradable protein such as SBM and corn gluten feed had lower ruminal degradation rates during the first 4 wk after weaning at 5 wk of age than they did at 8 wk after the weaning, although ruminal degradation rates of low degradable proteins did not change for 8 wk after the weaning.

Proteins in corn gluten meal (CGM) are known to be highly resistant against ruminal degradation¹⁸⁾. When a diet containing CGM

as a main protein source is fed to early-weaned calves, less degradable intake protein (DIP) would be supplied to rumen microbes as a N source independent of age after weaning. When a ration based on corn and CGM was fed to Holstein bull calves before 3 mo of age or under 90 kg BW, Lys was first limiting even if the CP intake from the ration was as high as 3.9 g/kg BW/d⁽¹⁰⁾. However, in calves after 3 mo of age or above 90 kg in BW, Lys was not limiting when CP intake from the corn-CGM ration was more than 3.9 g/kg BW/d⁽¹¹⁾, but limiting when the CP intake was restricted to 3.0 g/kg BW/d⁽¹²⁾. These results suggest that Lys becomes limiting when ruminal microbial synthesis is restricted, and that the restriction is obliged by underdevelopment of rumen function under 3 mo of age but by dietary factors such as the deficiency of DIP as a N source for microbes above 3 mo of age.

In Experiment 2, the basal ration based on corn and SBM was fed at the daily CP intake of 2.6 g/kg BW to restrict microbial protein synthesis in the rumen. However, abomasal administration of DL-Met and L-LysHCL did not improve N balance, in contrast to calves under 3 mo of age^(1,2). It suggests that amino acids supplied by microbial protein and undegraded intake protein from corn and SBM were well utilized by the host, although the supply of total amino acids was not enough to the highest growth rate judging from lower daily gains shown in Table 2. Some workers have reported that Met was first limiting for steers when some dietary protein was furnished by SBM^(5,17), but Zinn⁽³⁰⁾ reported that amino acid requirements for the daily gain of 1.48 kg in steers weighing 163 to 267 kg were fully met by the CP intake of 659 g/d, independent of the protein source of diets. Titgemeyer and Merchen⁽²⁵⁾ indicated that the requirement of sulfur-containing amino acids in 294 kg steers gaining 1.3 kg daily was less than the amount that would be supplied by diets containing corn based proteins. Although Met has been

assumed to be first limiting in microbial protein^(16,22), Buttery and Foulds⁽⁴⁾ stated that microbial protein would not have any sole and strong limiting amino acid for dairy and growing cattle. Further studies are warranted to clarify the limiting amino acids for corn and SBM diets in calves above 3 mo of age.

Plasma Free Amino Acids

Tables 3 and 4 present plasma concentrations of free amino acids in Experiments 1 and 2, respectively. Free amino acid concentrations in the plasma at 0 h were regarded as the representative reflection of post-absorptive state, whereas those at 3 h as that of absorptive state.

Only a little difference was detected between the abomasal supplements of DAC and L-Gln. In both experiments, plasma Gln concentration was increased by abomasal administration of L-Gln only in the absorptive state, suggesting the escape of L-Gln at least in part from conversion to Glu in the enterocytes. On the other hand, plasma concentrations of urea cycle constituents such as arginine (Arg), ornithine (Orn) and Cit tended to be higher with abomasal supplement of DAC with an exception of Orn in the absorptive state in Experiment 1, although urinary N excretion was not increased by the supplement of DAC (Tables 1 and 2).

Plasma BCAA concentrations did not differ between the supplements of L-Gln and DAC, except for Leu in the post-absorptive state in Experiment 1 and in the absorptive state in Experiment 2. However, the effect of L-Gln on plasma Leu concentration was different between the experiments. Plasma Leu was increased in Experiment 1 but decreased in Experiment 2 by abomasal supplement of L-Gln compared with that of DAC. Although reasons for the difference between experiments are unknown, the results suggest that the effect of exogenous Gln sparing plasma BCAA as precursors of endogenous Gln is quite limited, if possible.

Table 3. Concentrations ($\mu\text{mol/dl}$) of plasma free amino acids (AA) immediately before (0 h) and 3 h after the morning feeding in Experiment 1

Item	0 h				3 h			
	Treatment ¹⁾		SEM	P<	Treatment		SEM	P<
	DAC	L-Gln			DAC	L-Gln		
n	10	10			10	10		
Essential AA								
Thr	11.2	10.3	0.5	NS	7.9	7.3	0.5	NS
Val	20.2	19.9	0.8	NS	16.4	16.3	0.9	NS
Met	3.3	3.2	0.2	NS	1.9	1.8	0.2	NS
Ile	9.0	8.9	0.3	NS	6.2	8.8	2.3	NS
Leu	11.6	14.8	0.9	0.04	9.3	11.9	1.0	NS
Phe	5.8	6.0	0.2	NS	4.1	4.2	0.4	NS
His	5.8	6.0	0.2	NS	5.1	4.8	0.4	NS
Lys	8.0	7.8	0.4	NS	5.6	4.8	0.5	NS
Trp	4.6	4.4	0.3	NS	3.7	3.6	0.2	NS
Arg	13.6	12.0	0.5	NS	10.6	9.7	0.5	NS
Non-essential AA								
Asp	0.95	0.80	0.04	0.03	0.86	0.67	0.13	NS
Ser	10.1	10.8	0.5	NS	8.6	8.8	0.6	NS
Glu	15.0	14.3	0.5	NS	13.6	12.6	0.8	NS
Gly	52.8	56.3	2.3	NS	40.5	40.9	3.2	NS
Ala	22.8	22.7	1.0	NS	22.9	19.0	1.5	NS
Cys	1.88	1.51	0.08	0.02	1.85	1.64	0.11	NS
Tyr	6.3	7.1	0.2	0.03	4.4	4.3	0.4	NS
Pro	10.5	10.7	0.6	NS	11.3	13.3	0.9	NS
Gln	23.3	22.2	1.2	NS	20.3	34.3	2.5	0.01
Asn	6.8	6.6	0.3	NS	5.0	5.1	0.3	NS
Cit	12.9	10.9	0.7	0.08	10.4	9.2	0.4	0.10
Orn	7.1	6.1	0.4	NS	3.7	4.9	0.4	0.09

NS : $P > 0.10$.¹⁾ See the footnotes of Table 1.

Plasma tyrosine (Tyr) concentration was higher in the post-absorptive state in Experiment 1, when L-Gln was supplemented. However, plasma concentrations of phenylalanine (Phe) and Tyr were higher with the supplement of DAC in the absorptive state in Experiment 2 compared with that of L-Gln. Plasma concentrations of aspartate (Asp) and cysteine (Cys) were lower in the post-absorptive state when DAC was supplemented in Experiment 1, but the trend as such was not detected in Experiment 2. Plasma threonine (Thr) concentration was higher in the absorptive state in Experi-

ment 2 with abomasal supplement of DAC compared with that of L-Gln, but the trend was not clear in Experiment 1. Reasons for these differences are also unknown, but the difference in age of calves and the feeding level of basal ration may be concerned with them.

As shown in Table 4, abomasal administration of both DL-Met and L-LysHCl remarkably affected plasma concentrations of free amino acids. Plasma Met and Lys were increased by the administration not only in the absorptive state but also in the post-absorptive state compared with abomasal supple-

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Table 4. Concentrations ($\mu\text{mol/dl}$) of plasma free amino acids (AA) immediately before (0 h) and 3 h after the morning feeding in Experiment 2

Item	0 h					3 h				
	Treatment ¹⁾			SEM	P <	Treatment			SEM	P <
	DAC	L-Gln	DL-Met + L-LysHCl			DAC	L-Gln	DL-Met + L-LysHCl		
n	6	6	6			6	6	6		
Essential AA										
Thr	12.7	13.5	11.4	0.7	NS	10.3 ^a	8.9 ^b	8.5 ^b	0.3	0.01
Val	25.8 ^a	25.9 ^a	19.5 ^b	1.1	0.006	23.7 ^a	21.9 ^a	15.7 ^b	0.8	0.001
Met	3.7 ^b	3.6 ^b	50.6 ^a	1.6	0.001	3.0 ^b	2.9 ^b	88.4 ^a	1.8	0.001
Ile	11.6 ^a	12.0 ^a	7.6 ^b	0.6	0.002	8.4 ^a	6.8 ^a	4.3 ^b	0.7	0.008
Leu	18.8 ^a	18.2 ^a	11.5 ^b	0.9	0.001	14.0 ^a	11.0 ^b	6.5 ^c	6.6	0.001
Phe	6.5 ^a	6.7 ^a	5.0 ^b	0.3	0.009	5.5 ^a	4.6 ^b	3.9 ^b	0.2	0.002
His	6.4	7.2	7.0	0.4	NS	6.9	6.1	7.0	0.3	NS
Lys	11.2 ^b	11.2 ^b	16.8 ^a	0.5	0.001	6.4 ^b	7.2 ^b	65.6 ^a	3.1	0.001
Trp	3.8	3.9	3.5	0.1	NS	2.8	2.8	2.5	0.1	NS
Arg	16.0	16.3	15.0	0.9	NS	15.6 ^d	12.9 ^e	15.9 ^d	0.8	0.07
Non-essential AA										
Asp	2.1	2.2	2.2	0.2	NS	1.7	1.6	1.6	0.1	NS
Ser	10.5 ^b	12.0 ^b	14.2 ^a	0.5	0.002	9.3 ^b	9.1 ^b	12.0 ^a	0.5	0.006
Glu	22.3	25.0	21.5	0.9	NS	22.9 ^a	28.5 ^a	18.7 ^b	1.4	0.003
Gly	42.7	47.9	48.3	1.7	NS	41.4	36.8	43.0	2.2	NS
Ala	27.3 ^b	29.0 ^b	33.0 ^a	1.1	0.02	29.4 ^b	25.1 ^b	34.0 ^a	1.6	0.02
Cys	2.2 ^b	2.4 ^b	2.9 ^a	0.1	0.002	2.5 ^b	2.7 ^b	3.2 ^a	0.1	0.005
Tyr	8.1	8.3	7.8	0.4	NS	6.7 ^d	4.6 ^f	5.8 ^e	0.6	0.08
Pro	10.9	10.9	11.0	0.4	NS	10.8	10.3	10.8	0.7	NS
Gln	16.1	20.3	16.9	1.9	NS	13.0 ^b	21.0 ^a	12.1 ^b	0.7	0.005
Asn	Trace	Trace	Trace	—	—	Trace	Trace	Trace	—	—
Cit	10.2	10.0	9.0	0.5	NS	11.3 ^a	9.3 ^a	7.0 ^b	0.7	0.007
Orn	9.7 ^a	8.4 ^b	7.3 ^c	0.4	0.008	6.3	6.1	7.0	0.5	NS

NS: $P > 0.10$.

^{a, b, c} Means in the same row with different superscripts differ ($P < 0.05$).

^{d, e, f} Means in the same row with different superscripts tend to differ ($P < 0.10$).

¹⁾ See the footnotes of Table 2.

ments of L-Gln and DAC. The concentrations were 1.5 to 2 times higher than when the same levels of DL-Met (0.111 g/kg BW/d) and L-LysHCl (0.333 g/kg BW/d) were supplemented in calves under 3 mo of age^{1,2)}. According to Japanese Feeding Standard for Beef Cattle (1995)¹³⁾, CP requirement per unit BW of calves decreases with advancing age or increasing BW. That is, the CP requirement of 75 and 125 kg dairy steers gaining 1.0 kg daily is 7.4 and 5.1 g/kg BW/d, respectively¹³⁾. The higher plas-

ma concentrations of Met and Lys above 3 mo of age may reflect a greater excess of these acids than under 3 mo of age, so far as DL-Met and L-LysHCl were dosed in proportion to BW. Reis *et al.*²⁰⁾ reported that abomasal infusion of 10 g/d of DL-Met in Merino wethers resulted in reduced wool growth rate in addition to an accumulation of free Met in the plasma as high as 235 $\mu\text{mol/dl}$. However, reduced feed intake and depressed BW gain as typical symptoms of harmful effects were not exerted by the ab-

omasal supplement of DL-Met and L-LysHCl in Experiment 2, suggesting the irrelevance of unimproved N balance to the excess of Met and Lys.

Abomasal administration of DL-Met and L-LysHCl decreased plasma BCAA concentrations not only in the absorptive state but also in the post-absorptive state compared with the supplement of L-Gln or DAC. Because N balance was not improved in Experiment 2, and because plasma BCAA concentrations were not affected by administration of the same level of L-LysHCl¹⁾ alone, the lowered plasma concentrations are considered to be exclusively due to supplemental DL-Met. Although an interaction between Met and BCAA has not been reported in chicks and rats, some workers also reported linear decreases in plasma BCAA concentrations with abomasal infusion of increasing quantities of L-Met or DL-Met in steers²⁵⁾ and in sheep²⁰⁾.

The administration of DL-Met and L-LysHCl increased plasma concentrations of serine (Ser), alanine (Ala) and cysteine (Cys) in both absorptive and post-absorptive states, but decreased plasma Glu concentration only in the absorptive state compared with the administration of L-Gln or DAC. Because Ser is needed for the degradation of Met *via* Cys in the liver³⁾, and because Ser is formed from Thr *via* Gly, excess of Met would often result in the Thr deficiency in rats⁶⁾ and chicks¹⁵⁾. In Experiment 2, abomasal administration of DL-Met and L-LysHCl decreased plasma Thr concentration compared with that of DAC only in the absorptive state. However, it is unclear whether the decrease may prove the interaction between Met and Thr, because the Thr concentration was not lower than with the supplement of L-Gln. On the other hand, Lys is known to antagonize Arg in chicks¹⁴⁾. However, plasma Arg concentration was not decreased by the administration of DL-Met and L-LysHCl in Experiment 2.

In conclusion, effects of exogenous L-Gln on

N balance and plasma BCAA concentrations were quite limited, if possible, at least when the dose was less than 0.288 g/kg BW/d. Antagonistic interaction between Met and BCAA was suggested to occur in calves also by the present study, in accordance with our previous studies^{1,2)}.

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幼齡子牛における L-グルタミンの第四胃内投与が窒素出納および 血漿遊離アミノ酸濃度に及ぼす影響

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食道溝反射を維持させたホルスタイン種雄子牛を用い，体重 (BW) kg 当たり 0.288 g/d の L-グルタミン (Gln) の第四胃内投与が窒素 (N) 出納，および血漿遊離アミノ酸濃度に及ぼす影響について検討した。実験 1 では 9 週齢から子牛 10 頭を供試し，1 区 5 頭，2 週間を 1 期とする反転法により等 N 量のクエン酸二アンモニウム (DAC) を投与した場合と比較した。実験 2 では 14 週齢から子牛 9 頭を供試し，1 区 2 頭，2 週間を 1 期とする 3×3 ラテン方格法により等 N 量の DAC または DL-メチオニン (Met) 0.111 g/kg BW/d と L-リジン塩酸塩 (LysHCl) 0.333 g/kg BW/d の混合物を投与した場合との 3 処理間で比較した。トウモロコシ・大豆粕・稲ワラを基本とする基礎飼料を実験 1 では 1 日に 27 g/kg BW の割合で給与したが，実験 2 では 20 g/kg BW に制限して与えた。その結果，両実験とも L-Gln の投与は吸収期にのみ血漿 Gln 濃度を増加させたが，N 出納には補足 N 源の影響が認められなかった。L-Gln と DAC の間ではロイシン (Leu) を除いて血漿側鎖アミノ酸 (BCAA) 濃度に差がなく，血漿 Leu 濃度に及ぼす影響も実験 1 と 2 とでは異なった。実験 2 において，血漿 BCAA 濃度は DL-Met と L-LysHCl の同時投与により減少した。L-Gln の第四胃内投与が N 出納および血漿 BCAA 濃度に及ぼす影響は決して大きくないことが示唆されたことに加えて，後者の減少は主として DL-Met の投与に起因するとの仮説が本研究においても支持された。

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