Histamine Concentration in Blood and Contents of Digestive Tract in Cattle Overfed Concentrate

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Abstract. Changes in histamine concentration were determined in the blood and contents of the digestive tract in cattle on concentrate overfeeding. Seven Holstein steers 15 weeks old were divided into two groups. One group of 4 steers (group C) was fed high concentrate and the other of 3 steers (group H) hay to serve as a control for 10 months. Histamine concentration was determined in plasma and ruminal contents collected at intervals of 2 or 3 weeks. Plasma histamine levels varied greatly in both groups during the experimental period. Their changes were almost the same in these groups. There was no significant difference in plasma histamine concentration between the two groups. The histamine level varied greatly in each group. It was more variable in group H than in group C. It was higher in group H than in group C and after 158 days of experiment. The histamine concentration was determined in the contents of the digestive tract collected from each steer at the time of slaughter. The histamine levels of the contents of the rumen and omasum were lower and those of the duodenum and ileum higher in group C than group H. There was no significant difference in the histamine concentration of the contents of the other portions of the digestive tract between both groups. The pH value of the contents of the digestive tract was generally smaller in group C than in group H. The pH value was especially small in the contents of rumen, omasum and duodenum.

Recently, the authors studied the condition of outbreak [8] and the clinico-biochemical changes [7] of a disease with stiff gait as a main symptom among growing and fattening cattle in Japan. Consequently, they found no clinico-biochemical changes related with the cause of the disease. Sonoda et al. [14] proposed that the disease with stiff gait in Japan should be the same as bovine laminitis.

Nilsson [9], Maclean [2-4], and Morrow [6] mentioned that histamine might be a precipitating factor in laminitis in cattle. They suggested that concentrate overfeeding might increase the abnormal microflora in the rumen, abomasum or intestine. These environment might be characterized by an increase in blood and ruminal fluid lactic

acid with a corresponding decrease in blood and ruminal fluid pH and increase in ruminal fluid histamine. Furthermore, they suggested that the production of a large amount of histamine might result in an engorgement of the vascular laminar area of the foot in cattle.

The etiology of laminitis, however, is not well understood. In any case, it was assumed that concentrate overfeeding for a short term might be a cause of this disease. If one of the causes of this disease is the action of histamine produced in the digestive tract of cattle, it will be necessary to study the condition of production of histamine in cattle on concentrate overfeeding.

In this study, changes in histamine concentration were determined in the blood

Table 1. Amount and composition of rations

Group	Feed	Days of experimental feeding				Composition (%)
		0	42	87	130	
C					kg/day	
	Concentrate	4.6	6.0	8.9	9 11.0	Corn 20
	Hay	0.75	1.5	1.5	1.5	Milo 46
	TDN	3.13	4.83	6.25	6.96~8.38	Barley 7
	DCP	0.42	0.64	0.84	0.94~1.14	Rice bran 5
H						Skim milk
	Concentrate	1.5	3.0	3.0	4.0	Linseed oil meal } 5
	Hay	3.0	5.0	5.0	5.0	Saffron oil meal }
	TDN	2.21	4.03	4.03	4.74	False acacia powder } 7
	DCP	0.23	0.44	0.44	0.54	Gluten feed }
						Gluten meal }
						Molasses 6
						Calcium carbonate } 2.8
						Calcium phosphate }
						Sodium sulfate }
						Vitamins, minerals 0.2
						Urea 1

Fig. 1. Changes in histamine concentration in ruminal contents.

Group C: Group fed concentrate.

Group H: Group fed hay.

Fig. 2. Changes in plasma histamine concentration.

Group C: Group fed concentrate.

Group H: Group fed hay.

and contents of the digestive tract of cattle on concentrate overfeeding, as compared with those of cattle on control feeding.

Materials and Methods

As experimental animals, 7 Holstein steers were used. They were fed hay and commercial formula feed for growing calves for 3 months. When they were 15 weeks old and weighed about 120 kg, they were divided into two groups. One group of 4 steers (group C) and the other of 3 steers (group H) were fed the rations shown in Table 1.

Samples of blood and ruminal contents were collected before morning feeding. Blood samples were drawn from the jugular vein into 10 ml heparinized vacuum tubes. Samples were collected from the ruminal contents by the aid of a stomach tube in cooperation with the suction. Continuous changes were determined in the histamine level of blood and ruminal contents and in the glucose and L-lactic acid levels of blood. When the experiment was over, the 7 steers weighed 496 and 390 kg on the average in group C and H, respectively, and were slaughtered. Samples were collected from the

contents of rumen, omasum, abomasum, duodenum, jejunum, ileum, cecum, and colon of each steer. Histamine concentration and pH value were determined in these contents.

Plasma glucose was determined by the glucose oxidase method [10] and L-lactic acid by the UV method [5]. Histamine levels in the plasma and contents of each portion of the digestive tract were assayed by the procedure of Shore et al. [12]. Determination of pH value of each sample was made by the pH meter with a glass electrode.

Results

Figs. 1 and 2 show changes in the histamine level of the ruminal contents and plasma in both groups. This level was more variable in group H than in group C. In group H, it was higher than in group C at and after 158 days of experiment and the highest ($6.28 \mu\text{g/ml}$) at 227 days. The histamine concentration of plasma was about 1–10 per cent of the ruminal concentration.

Fig. 3. Changes in plasma glucose concentration.
 Group C: Group fed concentration.
 Group H: Group fed hay.

Changes in plasma histamine level were almost the same in both groups. In group C this level was higher at 158 and 185 days than in group H.

Fig. 3 shows changes in plasma glucose level in the two groups. These changes were almost the same in these groups. The glucose level was generally higher in group C than in group H. It was remarkably high at 45, 59, 87, 307 and 321 days of experiment. There was no significant difference in the L- lactic acid concentration of plasma between the two groups.

Table 2 presents the histamine concentration and pH value of the contents of each portion of the digestive tract determined at the time of slaughter. The histamine levels of the contents of the rumen and omasum were lower in group C than in group H. There was no significant difference in the histamine concentration of the contents of the abomasum between both

groups. On the other hand, the histamine level of the contents showed a tendency to be lower in the lower digestive tract than in the stomach in both groups. In group C, the histamine concentration of the duodenal contents was almost the same as that of the abomasal contents and higher than in group H. The histamine level of the ileal contents was also higher in group C than in group H. The pH value of the contents of the digestive tract was generally lower in group C than in group H. The pH value was especially low in the contents of rumen, omasum and duodenum.

Discussion

Several investigators [2-4, 6, 9] assumed that histamine might induce laminitis in cattle. Elmes et al. [1] reported the direct actions of histamine and other chemical mediators on the blood vessels of bovine foot. The results of the present experiment

Table 2. Histamine concentrations and pH values of contents of digestive tract

	Histamine ($\mu\text{g/ml}$)		pH	
	C	H	C	H
Rumen	2.21** ± 1.42	5.00 ± 1.25	5.8* ± 0.48	6.4 ± 0.15
Omasum	2.46* ± 0.16	3.56 ± 1.18	5.2** ± 0.06	5.9 ± 0.10
Abomasum	5.62 ± 0.72	5.79 ± 2.51	2.7 ± 1.10	2.7 ± 0.89
Duodenum	5.48** ± 1.38	0.50 ± 0.23	4.8 ± 0.61	5.8 ± 0.55
Jejunum	1.02 ± 0.36	0.94 ± 0.68	6.8 ± 0.40	6.9 ± 0.31
Ileum	2.63** ± 0.52	1.74 ± 0.34	6.7 ± 0.26	6.8 ± 0.00
Cecum	1.03 ± 0.12	1.57 ± 0.69	6.5 ± 0.25	6.7 ± 0.09
Colon	2.54 ± 0.16	2.04 ± 0.44	6.6 ± 0.39	6.5 ± 0.23

C: Group C fed concentrate.

H: Group H fed hay.

The figures at the upper and lower level show mean value and standard deviation, respectively.

* $p < 0.05$, ** $p < 0.01$

suggested that histamine might have exerted a strong action on the local position and blood vessels of the foot. It is necessary to determine changes in the histamine level of the contents of the digestive tract, since the disease in question may occur under concentrate overfeeding.

In the present experiment the histamine level of the ruminal contents was lower in group C than in group H. Sjaatad et al. [13] mentioned that the histamine concentration of hay was almost the same as that of concentrate, and that ruminal histamine level was markedly dependent upon the histamine content of the diet. In their examination, the experimental feeding period

was as short as several days, experimental diets were changed at short intervals, and the histamine level of the ruminal contents was determined soon after the change of diet. In the present experiment, the experimental animals were fed the same diet for about 300 days. It is presumed that the difference in the histamine concentration of the ruminal contents between group C and H may have depended on the difference in the condition of histamine production effected by changes in the ruminal bacterial flora after feeding the same diet for a long time.

There was no difference in plasma histamine concentration between groups C and H, regardless of the time of sampling. Suber et al. [15] reported that there was no difference in plasma histamine concentration between carbohydrate-engorged steers and forage-fed steers and that there was no correlation between plasma and ruminal contents. After engorgement, the plasma histamine level exhibited a peak at 4 hours of experiment, and the histamine concentration of the ruminal contents at 12 hours. In the present experiment, it is assumed that neither changes in nor correlation between the histamine level of the ruminal contents and that of the plasma may have been clarified in detail, since samples were collected before the morning feeding time at intervals of 2 weeks. The authors found in cattle fed 10 kg of concentrate and 0.6 kg of rice straw daily that histamine levels in plasma and ruminal contents increased remarkably and the pH of ruminal contents decreased at several hours of feeding (Motoi et al., unpublished data).

At present, the histamine levels of the contents of the rumen and omasum were lower and those of the duodenum and ileum were higher in group C than in group H. Changes in the level of the ruminal fluid

were examined by several investigators. No reports, however, have been made on the histamine level of the contents of the lower digestive tract. The production of histamine in the rumen and lower digestive tract contents might be effected by the quantitative and qualitative condition of concentrate overfeeding. This point should be verified in future.

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要 約

濃厚飼料多給の肥育牛の血中および各消化管内容物におけるヒスタミン濃度: 元井葭子・小原嘉昭・林 光昭 (農林水産省家畜衛生試験場研究第四部)——濃厚飼料多給下で肥育した牛の消化管内容物および血中のヒスタミンの変動について観察した。実験には 15 週齢のホルスタイン系去勢雄牛 7 頭を用い, 4 頭 (C 群) には濃厚飼料を, 3 頭 (H 群) には対照として粗飼料をそれぞれ多給し, 約 10 カ月間飼育した。第一胃内容物と血液は 2~3 週間ごとに採材し, ヒスタミン濃度を測定した。血中ヒスタミンは両群とも大きな変動を示し, その変動は両群ともほぼ同様であった。全体的に両群間に有意差は認められなかった。第一胃内容物のヒスタミン濃度も両群で大きく変動し, 変動幅は H 群で大きかった。H 群におけるヒスタミン濃度は, 実験期間の中期以降から, C 群に比べて有意に高い値を示した。試験終了時に各牛をと殺し, 消化管内容物のヒスタミン濃度を測定したところ, C 群は H 群に比較して, 第一胃と第三胃で低く, 十二指腸と回腸内容物は高かった。その他の部位では有意差は認められなかった。これら消化管内容物の pH は, 全般的に C 群が低い傾向にあったが, とくに第一胃, 第三胃および十二指腸内容物において著しく低下していた。