Effects of Dietary Niacin Concentration and Protein Content on Gastric Acidity and Vitamin B\textsubscript{12} Binding Capacity of Gastric Mucosa in Rats

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The effects of supplementary feeding with niacin were investigated upon gastric acidity and vitamin B\textsubscript{12} binding capacity of the gastric mucosa in rats which had been placed on two kinds of basal diets: low-protein diet composed of polished rice, fermented soy bean paste and cabbage, and a normal-protein diet supplemented with casein, gelatin and several amino acids.

Five and half months after the feeding, hyperfunction of acid secreting cells associated with increased gastric acidity was observed in rats fed on the low-protein-niacin-deficient diet rather than in rats on the normal niacin-protein diet.

Vitamin B\textsubscript{12} binding capacity of the gastric mucosa of rats which has been said to be in parallel with the secretion of intrinsic factor was found to be higher in the low-protein-niacin-deficient group than in the normal-niacin-protein group.

It has been reported that achlorhydria is seen in 60\% of pellagra patients and that, in some cases, gastric acidity is restored to normal after niacin (NiA) administration.\textsuperscript{1,2} The results of the investigations\textsuperscript{3-5} on the NiA deficiency have shown that hogs fed on NiA deficient diet secrete no gastric acid. On the other hand, in dogs and rats no decrease of acid secretion by this vitamin deficiency has been reported. It is not clear whether this disagreement is due to the difference of the animal species or to other conditions.

What effect will be exerted on the gastric wall by chronic NiA deficiency in rats? The present investigation was performed in an attempt to clarify this point.

MATERIALS AND METHODS

\textit{1) Feeding.} Donryu strain male albino rats weighing 51–81 g were kept in the screen-bottom cages. As shown in Table 1, a low-protein diet and a normal-protein diet were used as basal diets. The composition of the low-protein diet was similar to what was consumed by inhabitants in the rice field area, namely consisting of polished rice, fermented soybean paste and salted vegetables. The
normal-protein diet was made so as to meet the amino acid requirement of the growing rats by adding casein, gelatin, lysine, methionine and histidine to the low-protein diet. When NiA in the diet is inadequate, intestinal biosynthesis of NiA from tryptophan (Try) occurs and then supplement of this amino acid may be affected by the NiA level in diets. The content of Try of our low-protein diet was estimated to be 0.11% and that of the normal-protein diet, 0.16%. Judging from the reports that the Try requirement of the rats are 0.11%, 0.13%, 0.15% or 0.20% to our normal-protein diet contains an adequate amount of Try and low-protein diet contains its subnormal amount.

Vitamin mixture (except for NiA) was added to the diet as an aqueous solution. Vitamins A and D were supplemented weekly by adding two drops of concentrated cod liver oil per 100 g of diet. Two groups, NiA supplemented group and NiA non-supplemented group, were prepared further using the above-mentioned two kinds of basal diets. The diet and water were given ad libitum. The feeding period was five and half months.

2) Analysis. At the end of feeding period, rats were fasted overnight. Under ether anesthesia, the abdomen was opened. The stomach was resected, opened and the inside of the stomach was washed with 5 ml of physiological saline solution. Then the washing was centrifuged and the supernatant was titrated with alkali. One half of the stomach was fixed in buffered formalin for histological investigation and the other half was used for the determination of vitamin B₁₂ binding capacity.

Vitamin B₁₂ binding capacity was measured according to the procedure devised by Gottlieb et al. as follows. Gastric mucosa homogenate was incubated with radioactive vitamin B₁₂, then free vitamin B₁₂ was adsorbed to albumin coated charcoal. The charcoal combined with free vitamin B₁₂ was precipitated by centri-
fugation, radioactivity of vitamin $B_{12}$ in the supernatant was estimated and taken for an intrinsic factor-bound vitamin $B_{12}$. The histological examination of the gastric fundus glands was made on the periodic acid-Schiff (PAS) stained sections.

**RESULTS**

The growth rate of the low-protein diet group was lower than that of the normal-protein diet group and the additional feeding of NiA caused no increase in the body weight. Even the normal-protein diet group did not attain the standard growth rate.

As compared with the normal NiA content of the liver, 16–18 mg/100 g, all of our rats showed lower values. Furthermore, rats in the NiA supplemented group unexpectedly exhibited also low values.

The gastric acid content was not low in the NiA deficient group. The lowest value was obtained in the rats of normal-protein-NiA-supplemented group.

Vitamin $B_{12}$ binding capacity, though the scatter of individual values was large, was smaller in general in the NiA supplemented group than in the NiA deficient group. As in the case of gastric acid, the normal-protein-NiA-supplemented group showed the lowest value.

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<th>Table 2. Effects of NiA and protein content in diet on the gastric acidity and vitamin $B_{12}$ binding capacity</th>
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<tr>
<td><strong>Body wt.</strong></td>
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<td>Low protein NiA def.</td>
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<td>NiA suppl.</td>
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<tr>
<td>Normal protein NiA def.</td>
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<tr>
<td>NiA suppl.</td>
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<td>*1 5 mg/100 g diet.</td>
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On the histological investigation of the gastric fundus glands, hyperplasia of gastric mucosa and an increase in number of acid secreting cells were observed in the NiA deficient group than in the NiA supplemented group both in the low-protein and normal-protein groups. This tendency was found to be most remarkable in the low-protein-NiA-deficient group (Fig. 1).
Fig. 1. Histologic findings of gastric mucosa of rats. PAS staining. 5×10.
1. Low-protein NiA-deficient group.
2. Low-protein NiA-supplemented group.
DISCUSSION

Hawk and Hundley\(^5\) have reported the effects of various vitamin deficiencies on the gastric secretion in the rats. Their data showed that when expressed as ml of gastric juice/cm\(^2\) of body surface area, thiamine or pyridoxine deficiency caused a sharply depressed gastric acid secretion, riboflavin or pantothenic acid deficiency a slight decrease and NiA deficiency no decrease. On the other hand, when evaluated by ml of gastric juice/g of body weight, NiA deficiency caused an increase in gastric secretion.

Considering these facts, it can be said that some vitamin deficiencies cause decreased gastric secretion and others its increase.

Hawk and Hundley recognized the presence of nicotinamide adenine dinucleotide (NAD) at a high concentration in the gastric acid secreting cells. Patterson and Stetten\(^14\) thought the NAD as an important constituent of the enzyme transporting hydrogen for gastric acid formation.

Hawk and Hundley kept rats in a severe NiA deficient state for three weeks. Our experimental conditions differ from those of Hawk and Handley in that the feeding period was longer (five and half months) and NiA deficiency was milder in degree. In spite of these differences, the gastric acidity was higher in the NiA deficient groups than in the NiA supplemented groups. According to the results of histological investigation, NiA deficient groups showed a picture suggestive of hyperfunction of the gastric acid secreting cells.

Vitamin B\(_{12}\) binding capacity, which reflects the intrinsic factor secretion necessary for this vitamin absorption, was also higher in the NiA deficient groups. Arakawa et al.\(^15,16\) reported that vitamin B\(_{12}\) binding capacity is low in the gastric mucosa of riboflavin deficient rats. It seems that the effect of vitamin deficiency on the gastric mucosal function varies according to the kind of vitamins lacking in diets.

Acknowledgment

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References

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