EFFECTS OF THIAMINE ADMINISTRATION ON BLOOD LACTIC ACID CONCENTRATION AND MINERAL METABOLISM IN SHEEP

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Summary The object of the present experiment is to determine the effect of thiamine administration on lactic acid concentration in blood plasma and the mineral metabolism in sheep given low and high concentrate rations.
A high concentrate ration containing 90% concentrate and 10% roughage was fed to one group of sheep and a low concentrate ration containing 60% concentrate was given to the other group. Thiamine was intramuscularly injected into every sheep at a level of 50 mg of thiamine tetrahydrofurfuryl disulfide per day.
No great difference was found in the plasma lactic acid concentration between the animals fed the low and high concentrate rations, and those between the control and thiamine injection periods. Thiamine injection appeared to increase urine and fecal magnesium excretion and significantly decreased magnesium balance ($p<0.05$). It may be conceivable that endogenous magnesium excretion is enhanced by thiamine administration in sheep.

Ruminants given a high concentrate ration frequently showed symptoms of acidosis (1–4). It was indicated that rapid recovery from acidosis caused by acute overeating was accomplished with injection of thiamine (5). However, HUBER (6) reported that an intravenous injection of thiamine was not effective in increasing blood lactate clearance.

On the other hand, a change in mineral metabolism was found in ruminants in which acidosis occurred (4), especially in phosphorus excretion. Urinal phosphorus excretion increased with the lowering of blood pH.

Because microbial synthesis occurs in the rumen, ruminants are unlikely to show thiamine deficiency (7–9). Therefore, little information is available about the action of thiamine in cattle and sheep.
The present experiment was conducted to determine the effects of thiamine administration on lactic acid concentrations in blood plasma and mineral metabolism in sheep given low and high concentrate rations.

MATERIALS AND METHODS

Six sheep averaging about 38 kg weight were divided into two groups. One group was fed with a high concentrate ration containing 90% concentrate and 10% roughage, and the other group was fed with a low concentrate ration containing 60% concentrate and 40% roughage. The concentrate ration consisted of 90% flaked corn and 10% soybean meal. Rice straw was used as a roughage source. Calcium carbonate and sodium chloride was added to the concentrate ration at a level of 0.5% to obtain adequate amounts of calcium and sodium.

After feeding with experimental rations for a thirty-day control period, all sheep were injected intramuscularly at the level of 50 mg/head/day with thiamine tetrahydrofurfuryl disulfide for a fourteen-day injection period.

Urine and fecal samples were taken for the last seven days in both the control and injection periods. Blood samples were taken from the jugular vein puncture three hours after the morning feeding on the fourth day of both sampling periods. Fecal and dietary samples were ashed with nitric acid and perchloric acid.

Lactic acid in blood plasma was analyzed by the method of Barker and Summerson (10). Total thiamine in blood was assayed by the thiochrome method (11). Calcium and magnesium in urine, serum, feces and ration were determined by an atomic absorption spectrophotometer. Inorganic phosphorus of these samples were analyzed by the method of Fiske and Subbarow (12).

RESULTS

The total thiamine concentration of blood is shown in Table 1. Although little difference was found in blood thiamine between the two groups—low and high concentrate groups—the blood thiamine evidently became higher in the injection period in both groups. Thiamine concentration in the injection period was two times over than that in the control period.

| Period          | Control (µg/100 ml) | Thiamine injection (µg/100 ml) |
|-----------------|---------------------|-------------------------------|
| Group           |                     |                               |
| Low concentrate | 4.8±0.2             | 10.8±1.2**                   |
| High concentrate| 5.0±0.5             | 13.0±1.3**                   |

* Means of three sheep ±S.E.
** This symbol represents a significant difference from the control (p < 0.01).
The results of lactic acid concentration in blood plasma are presented in Table 2. There was no great difference in the plasma lactic acid concentration between the groups given the low and high concentrate rations, and between the control and thiamine periods.

Table 2. Effects of intramuscular thiamine injection on lactic acid concentrations in blood plasma.

| Period          | Control (mg/100 ml) | Thiamine injection (mg/100 ml) |
|-----------------|---------------------|-------------------------------|
| Low concentrate | 14.4 ± 1.4          | 17.0 ± 2.8                    |
| High concentrate| 14.2 ± 2.0          | 13.2 ± 0.4                    |

* Means of three sheep ± S.E.

The amount of mineral intake from rations is shown in Table 3. The data of mineral balance is shown in Table 4. Except for magnesium, no important difference was found in the mineral balance between the control and thiamine injection periods. The magnesium balance decreased by intramuscular injection of thiamine in both the low and high concentrate groups.

Table 3. Daily amount of mineral intake from rations.

| Group   | Low concentrate | High concentrate |
|---------|-----------------|------------------|
| Minerals, mg/day |                  |                  |
| Calcium | 2,319 ± 25      | 1,623 ± 83       |
| Phosphorus | 1,816 ± 49     | 2,160 ± 148      |
| Magnesium   | 837 ± 16        | 831 ± 64         |
| Sodium      | 3,708 ± 79      | 3,456 ± 237      |
| Potassium   | 6,720 ± 128     | 4,953 ± 382      |

* Means of three sheep ± S.E.

Table 4. Effects of intramuscular thiamine injection on mineral balance.

| Group          | Low concentrate | High concentrate |
|----------------|-----------------|------------------|
| Period         | Control + Thiamine | Control + Thiamine |
| Mineral balance, mg/day |                  |                  |
| Calcium        | 373 ± 65        | 592 ± 65         | 652 ± 72         |
| Phosphorus     | 457 ± 34        | 453 ± 111        | 387 ± 239        |
| Magnesium      | 122 ± 13        | 46 ± 18          | −89 ± 42*        |
| Sodium         | 820 ± 211       | 358 ± 91         | 278 ± 328        |
| Potassium      | 689 ± 249       | 1,828 ± 272      | 1,669 ± 80       |

* Means of three sheep ± S.E.

* This symbol represents a significant difference from the control (*p < 0.05).*
Table 5. Effects of intramuscular thiamine injection on magnesium balance and serum magnesium concentrations.a

| Group Period | Low concentrate | High concentrate |
|--------------|-----------------|------------------|
|              | Control + Thiamine | Control + Thiamine |
| Magnesium balance, mg/day |  |  |
| Intake, | 837±16 | 837±16 | 831±64 | 831±64 |
| Urinal excretion, % of intake | 173±44 | 276±26 | 192±29 | 255±25 |
| Fecal excretion, % of intake | 21±6 | 33±3 | 23±4 | 30±5 |
| Retention, % of intake | 542±52 | 623±71 | 592±77 | 665±19 |
| Serum magnesium concentration, mg/100 ml | 2.9±0.1 | 2.9±0.1 | 3.1±0.1 | 3.4±0.2 |

* Means of three sheep±S.E.
* This symbol represents a significant difference from the control (p<0.05).

and serum magnesium concentrations. In both groups, thiamine injection, although not significant, appeared to increase magnesium excretion via urine and feces. Urine and fecal excretion presented with the percentage of intake also showed the same tendency. The average of magnesium retention decreased significantly (p<0.05) and became negative in the two groups when thiamine was injected. An obvious difference was not observed in the serum magnesium concentration between the control and injection periods.

DISCUSSION

It is said in general that thiamine deficiency does not occur in ruminants because microbial synthesis occurs in the rumen (7-9). However, PRESTON (12) indicated that acidosis caused by acute overeating of cereals was characterized by a deficiency of thiamine, and its decrease was cured by an injection of thiamine. OMORI et al. (13) also observed that the increase in blood lactic acid, which was induced by injection of sodium propionate, was lowered by intramuscular thiamine administration. But HUBER (6) recognized that intravenous injection was not effective in increasing blood lactate clearance. In this experiment, an apparent change was not found in the plasma lactic acid when thiamine was intramuscularly injected. Since plasma lactic acid concentrations were almost the same between low and high concentrate groups, plasma lactic acid was not expected to be used in determining whether thiamine administration lowered the increased plasma lactic acid concentration or not.

It was observed by ITOKAWA and FUJIWARA (18) that calcium and phosphorus in bone decreased in magnesium-deficient rats and these changes were more evident in the thiamine-containing group as compared with the thiamine-deficient group.
Thiamine injection did not affect calcium and phosphorus retentions in this experiment. The rations of low and high concentrate groups contained, respectively, 0.12% and 0.11% magnesium. As shown in the mineral balance data, dietary magnesium concentrations seemed to be adequate for animal requirements.

ZIEVE et al. (14, 15) and ITOKAWA et al. (16–19) have studied the relationship between magnesium and thiamine in rats. ITOKAWA et al. (16–18) observed that magnesium concentrations in serum and bone were decreased by oral administration of thiamine. Although serum magnesium concentrations were not apparently changed in this experiment, magnesium excretion via urine and feces tended to become higher as thiamine was given to sheep. From the result that a negative magnesium balance was induced by thiamine injection, it is conceivable that serum magnesium could decrease if thiamine is administered for a prolonged period. It may finally be concluded that, when a large amount of thiamine is given, there is the similar association between thiamine and magnesium metabolism in sheep as that found in rats.

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