Effects of Intraruminal Infusion of Acetic Acid, Na-Acetate and Ca-Acetate on the Physiological Responses of Sheep

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Effects of Intraruminal Infusion of Acetic Acid, Na-Acetate and Ca-Acetate on the Physiological Responses of Sheep

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As a preliminary experiment to determine the metabolic rate of acetate in the sheep, acetic acid, Na-acetate and Ca-acetate was infused respectively into the rumen to observe the difference of the physiological responses on the sheep. By measuring heart rate, respiratory rate, reticuloruminal movement, VFA concentrations and pH of the blood, rumen liquor and urine, it is concluded that Ca-acetate is the less affectable solution physiologically.

It is well established that acetic acid is a major energy source in ruminant nutrition. Armstrong et al (1) found that when acetic acid was given to the fasted sheep, the heat increment was higher than those given propionic or butyric acid. They also confirmed that the reason for this is not due to the acidosis, but to the particular metabolic pattern of acetic acid itself. In order to know the less affectable intraruminal infusing solutions of acetate on the physiological function of sheep, two kinds of acetates, Na-acetate and Ca-acetate, were compared with acetic acid in this paper. Since only one experimental animal was used, the results reported here are preliminary.

Materials and Methods

An adult male sheep, weighing 36 kg, was used as an experimental animal. About a month before the experiment, the rumen was fistulated.

The sheep was kept in an environment controlled chamber where the temperature and the relative humidity were maintained at 20°C and 70% respectively. The pH of Na-acetate and Ca-acetate were adjusted by additions of 10N-NaOH to acetic acid and acetic acid to Ca-acetate respectively. The resultant pH of the Na-acetate and the Ca-acetate solutions were both 6.00 and pH of acetic acid itself was 2.46. These solutions were infused into the rumen through the rumen fistula at the rate of 200 ml/hr for 24 hrs. The total calories given to the sheep was about a half of the basal metabolism (70 (Kcal) $\times$ body weight$^{3/4}$ (Kg)) of the sheep. (2) The concentration and the infused volume of three solutions are shown

TABLE 1. *Infused Calorie, Volume, Concentration and pH of Three Solutions*

	Acetic acid	Na-acetate	Ca-acetate
Calorie (kcal/24 hr)	526.1	505.3	519.6
Concentration (N)	0.53	0.51	0.53
Volume (l/24 hr)	4.72	4.79	4.74
pH	2.46	6.00	6.00

Basal metabolism=1070 Kcal.

in Table 1. Except for water, feed was not given during the experiment.

To measure the VFA concentration and the pH of jugular blood, thirteen to fifteen ml blood samples were taken at 0, 2, 8, 14 and 22 hrs after the beginning of the experiment. Blood VFA and pH were determined by the method of steam distillation and by the use of blood gas analyser (Radiometer Co. LTD.) respectively.

The heart rate and the respiratory rate were counted by electrocardiograph and thorax pick up. The heart rate and the respiratory rate were measured for three minutes every one hour. The change of reticuloruminal movement was measured by the pressure strain gauge which was connected to an automatic polygraph recorder. The reticuloruminal movement was measured for ten minutes every one hour and it was expressed as the mean for one minute. The total rumen volume was measured by the use of polyethylenglycol at the end of the experiment. (3)

Result and Discussion

The changes of heart rate, respiratory rate and reticuloruminal movement during the infusion period of three solutions are shown in Fig. 1.

Heart rate: The heart rate increased gradually towards 16 to 18 hrs after the infusion in all three solutions. The rate of increase was the most remarkable in acetic acid infusion and the least in Ca-acetate infusion.

Respiratory rate: The infusion of three solutions did not affect the respiratory rate except the transient increase immediately after the beginning of Ca-acetate and Na-acetate infusion. For this reason, it may be due to the emotional effect of feeding the companion animal which was fed in the same chamber.

Reticuloruminal movement: The gradual decrease in frequency of movement in the case of acetic acid and Na-acetate infusions was followed by the complete and nearly complete inhibition toward the end of the infusion. The Ca-acetate solution did not affect the rate of movement. It was assumed that the lower pH of acetic acid and the sodium ion of Na-acetate may both influence the activity of the rumen movement.

The VFA concentrations in blood, rumen liquor and urine during the experiment are shown in Fig. 2. Due to the acetic acid infusion, the VFA concentration

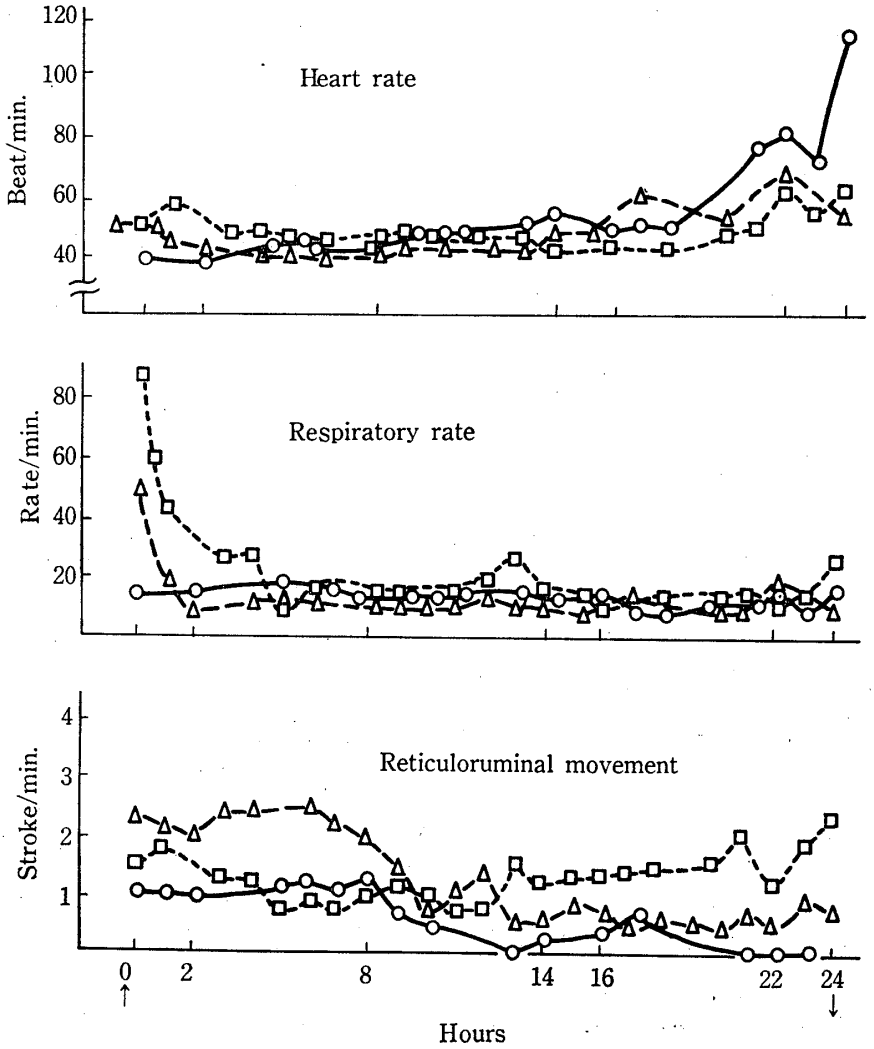

FIG. 1. The physiological responses when acetic acid, Na-acetate or Ca-acetate was continuously infused into the rumen of sheep for 24 hours. (↑): at the start of the infusion and (↓): at the end of the infusion, (○—○): acetic acid, (△—△): Na-acetate and (□—□): Ca-acetate.

in the blood abruptly rose from the initial level by three times in the 2 hrs after the start of infusion and increased thereafter gradually toward the end of infusion. The extent of increase with the other acid infusions was quite less than that of acetic acid.

At the end of infusion, however, the VFA level of blood was the same in both acetic acid and Na-acetate infusion.

In the Ca-acetate infusion, the VFA concentration in the blood was constantly maintained with a little higher level than that of initial value. The VFA concentration in the rumen liquor was not so different in the three acids. It is reasonable to assume that the high concentration of VFA in the rumen in the case of Ca-acetate infusion may account for the lower concentration of VFA in the blood due to the lower rate of absorption of Ca-acetate. The cumulative VFA amount

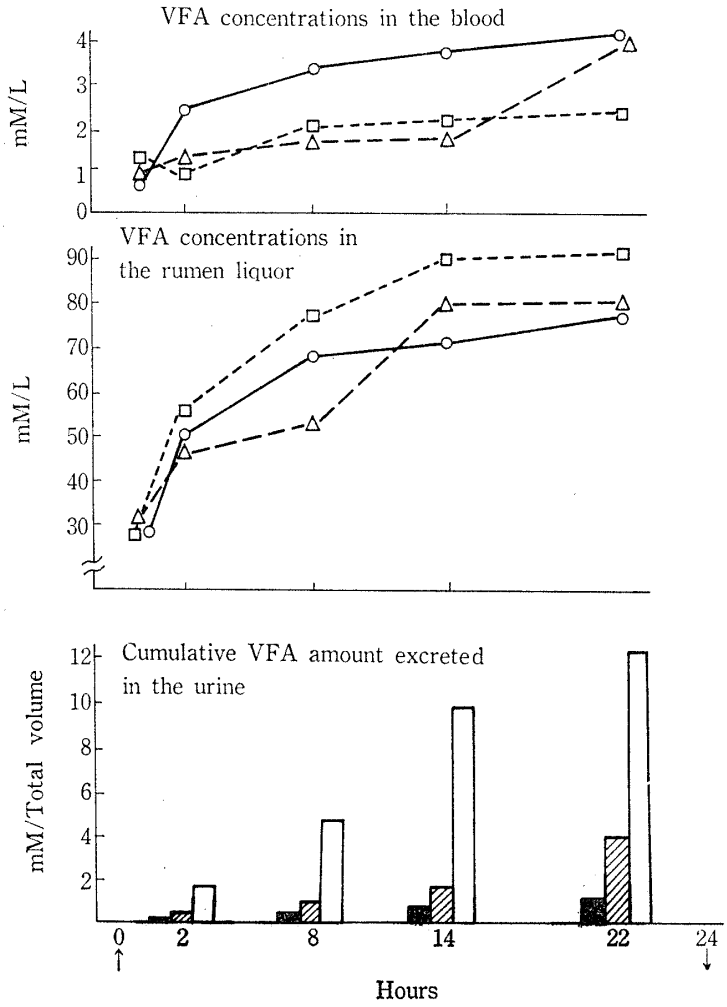

FIG. 2. Physiological effects when acetic acid, Na-acetate or Ca-acetate was continuosly infused into the rumen of the sheep for 24 hours. (o—o or ■): acetic acid, (▵—▵ or ▨): Na-acetate and (▫—▫ or □): Ca-acetate. (↑): at the start of the infusion and (↓): at the stop of the infusion.

excreted in the urine was the largest in the infusion of Ca-acetate and the smallest in that of acetic acid. Though the part of excreted VFA was within a few percent of the total infused amount, acetic acid may be the most rapidly metabolizable within three tested solutions under present experimental conditions.

The change of pH in blood, rumen liquor and urine are shown in Fig. 3. During the acetic acid infusion, the blood pH decreased gradually from 7.40, the initial value, to the level of 7.31 at the end of experiment. The animal showed the symptoms of acidosis at that moment. On the other hand, the Na-acetate infusion made the blood pH inclined to the alkaline side and the Ca-acetate infusion exhibited no significant change through the whole experimental period.

The most remarkable change of rumen pH was shown in acetic acid infusion in which the final pH was decreased to 4.9. The other two solutions did not induce any noticeable rumen pH change. That the higher rumen pH than that of

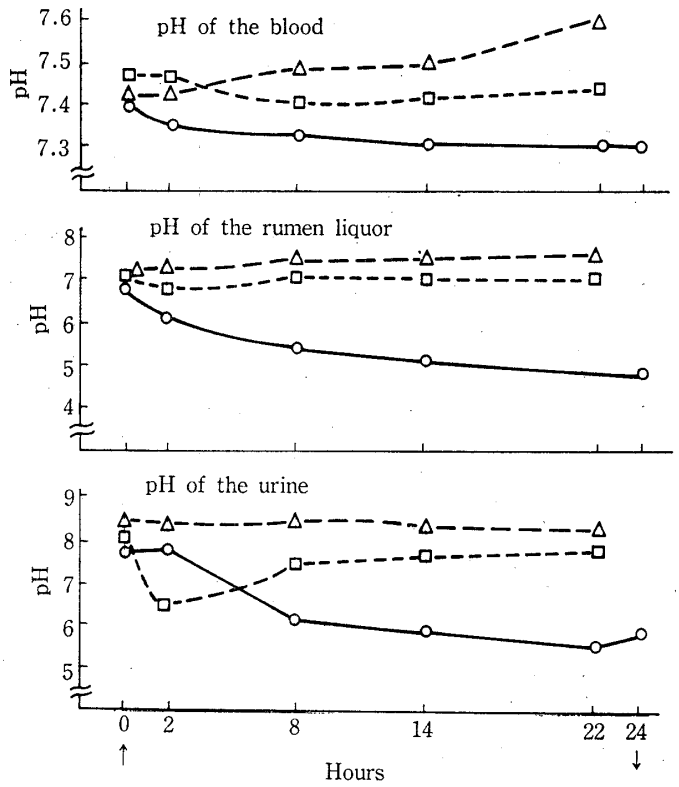

FIG. 3. The physiological effects when acetic acid, Na-acetate or Ca-acetate was continuously infused into the rumen of sheep for 24 hours. (o—o): acetic acid, (▵---▵): Na-acetate and (▫---▫): Ca-acetate., (↑): at the start of the infusion and (↓): at the end of infusion.

the infused solutions in all three infusions may be due to the acetic acid absorption, salivary inflow and bicarbonate gain from the blood. (4)

The pH of the urine was remarkably decreased in the case of acetic acid infusion. The pattern of decrease was similar to that of blood pH.

The other two salt infusions did not exert any change of pH except the second hour value of Ca-acetate infusion which decreased to the level of 6.4. The reason for this decrease was not known. At the end of the experiment, the unabsorbed VFA from the rumen which was calculated from the total fluid volume, namely 8.6 l for the Na-acetate, 7.6 l for the Ca-acetate and 5.2 l for the acetic acid, multiplied by each VFA concentration in the rumen was larger in Na-acetate and Ca-acetate than acetic acid infusion. As shown in Fig. 4, the ratio of the sum of acetate which was unabsorbed from the rumen, which remained in the whole blood and was excreted in the urine to the total administered acetate at the end of infusion was 16.6%, 29.2% and 30.2% in acetic acid, Na-acetate and Ca-acetate respectively. Therefore, the amount of acetate actually utilized was the highest in acetic acid and was the same in other two salts.

Though this experiment was carried out using only one sheep, the above result may suggest that the Ca-acetate is the least harmful intraruminal infusible

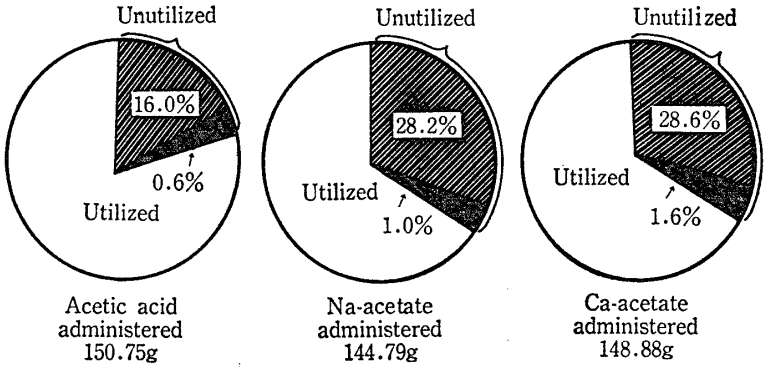

FIG. 4. Ratio of unutilized acetate which appeared in the rumen, blood, and urine to the total administered acetate at the end of 24 hours infusion. (▨): The unabsorbed acetate in the rumen liquor. (■): The accumulated acetate in the juglar blood and excreted acetate in the urine.

solution among three tested.

The reasons for this may be that: 1) the acetic acid was the most harmful due mainly to its acidity, 2) since the calcium ion is bivalence, the infused moles of calcium were resultantly half of that of sodium ion, 3) the calcium ion seems less absorbable than the sodium ion from the rumen so that the effect of these two minerals on the blood are less in Ca-acetate infusion, 4) the physiological activity of calcium is less than that of sodium as a whole.

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