EFFECTS OF FEEDING SEVERAL DIETARY CONCENTRATIONS OF SODIUM TO BABY PIGS

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Introduction

This laboratory has reported the effects of diarrhea on sodium retention by pigs (Reber and Whitehair, 1955; Reber and Yusken, 1956). A level of 2.34% dietary sodium chloride appeared to be beneficial for baby pigs infected with transmissible gastroenteritis. This was considerably higher than the 0.5% level recommended by the National Research Council (Hughes, *et al.*, 1944) for healthy weanling pigs. These findings indicated additional investigations of the effects of feeding rations containing various levels of sodium should be made, and this is a report of such investigations. The data of this study have been combined with data from previous investigations for statistical analysis in an attempt to define the optimal level of sodium to be included in a ration fed to baby pigs.

Materials and Methods

Hampshire pigs were maintained in individual metabolism cages designed for quantitative collection of urine, feces and uneaten feed. The ration was suspended in four parts warm water, by weight, and homogenized in a Waring blendor. If the pig ate all of the feed, its allotment was increased the following day. The amount of feed offered never exceeded that of the previous day by more than 4%. Uneaten feed was collected after each feeding. Collections of urine and feces were made at various intervals ranging from 24 to 96 hours. Urine was collected in bottles which contained sulfuric acid. A portion of the urine was stored in a corked flask until sodium analysis could be performed. All uneaten feed and feces were kept refrigerated at -10° C. until they were prepared for sodium analysis. All collected material was digested with nitric acid or a mixture of nitric and sulfuric acids. Analysis for sodium was by flame photometry using lithium as an internal standard.

The composition of the ration is given in Table 1. The level of sodium in the ration was increased by adding sodium chloride at the expense of lactose and dextrose. In one experiment, rations containing 234, 272, 547 and 647 mgs. of sodium per 100 gms. were fed. Triplicate analyses for sodium were made on ration samples and the averages used to calculate sodium intakes. The diets were fed for periods ranging from 3 to 20 days before collections were made.

In another experiment sodium chloride was added to the basal ration (Table 1) to make rations that contained 300, 500 and 700 mgs. of sodium per 100 gms. The rations as fed were not analyzed for sodium. Three litters of pigs were born within a three-day period. The oldest of these were seven days of age when brought into the laboratory and housed in individual metabolism

TABLE 1.—Rations Used in Sodium Studies on Baby Pigs.[1]

Ingredients	*Weight (gms.)*
Vitamin-free casein	35.0
Lard	40.0
Lactose	10.25
Dextrose	10.25
Salts (U.S.P. XIV)	5.0
Sodium Chloride[2]	—
Vitamin A and D oil (1000 U.S.P. vit. A, 100 U.S.P. Vit. D/gm.)	0.5
Wheat germ oil (2 I.U. vit. E/gm.)	1.0

[1] Vitamins (mgs.) added to 200 gms. of dry ration: thiamine, 1.1; riboflavin, 1.8; nicotinic acid, 10.1; inositol, 26.8; choline, 260; para-amino benzoic acid, 5.0; folic acid, 0.13; biotin, 0.025; pyridoxine, 2.0; calcium pantothenate, 7.1; ascorbic acid, 130; vitamin B_{12}, 0.01; menadione, 0.29.

[2] Added at expense of lactose and dextrose.

cages. The rations were fed as a warm homogenized suspension three times a day. Some of the pigs developed a slight diarrhea which lasted only a few days. The pigs were fed their respective levels of dietary sodium for no less than 15 days before collections were made to determine sodium retentions.

The data obtained in the above two experiments were combined with the data obtained in experiments previously reported and subjected to statistical analysis. Previous reports have been made for levels of 9.4 mgs. (Yusken and Reber, 1957), 178 mgs. (Reber and Whitehair, 1955), and 920 mgs. (Reber and Yusken, 1956) of sodium per 100 gms. of ration.

RESULTS AND DISCUSSION

The results from all the experiments are summarized in Table 2. The change in average daily body weight by pigs fed the level of 9.4 mgs. of sodium varied from 122 to 259 gms., and 43 of the 45 sodium balances were negative. Those pigs which gained weight lost an average of 0.46 mgs. of sodium and those which lost weight lost an average of 0.48 mgs. of sodium per gram of body weight per day. The study of Meyer, *et al.* (1950) indicated that weight gains and feed efficiency were decreased in weanling pigs fed 5 mgs. sodium per 100 gms. of ration. No sodium balance study was conducted by Meyer, *et al.* (1950) and the degree of sodium deficiency was assessed by observing weight gain and feed efficiency.

Pigs fed the 178 mgs. sodium level retained 90.9% of their sodium intake. This was the highest percentage of sodium retention in this study. The regression coefficient of retention on intake was the highest obtained for all levels of sodium fed, and was statistically significant. The average initial weight of the pigs was 3445 gms. The average daily gain of 255 gms. was the highest observed in any of the experiments. These pigs were fed five times a day while the pigs in the other experiments were fed three times a day. The high percentage of sodium retained is probably related to the high rate of growth of these pigs. The group retained an average of 1.19 mgs. of sodium per gram of body weight gained. Higher retentions of sodium per gram of gain were observed in pigs fed higher dietary concentrations of sodium. Apparently this level of sodium can supply enough sodium for a healthy baby pig, but not enough to offset electrolytic losses in diarrhea. The protective effect of a high dietary level of sodium has

TABLE 2.—Average Daily Sodium Intake and Retention in Baby Pigs.

Na (mgs.) per 100 gms. ration	No. pigs	No. collections	Age of pigs (days)	Na intake (gms.)	Na retention (gms.)	Regression, retention on intake	Probability[1]	Na (mgs.), retention per gms. increase body wt.
9.4	5	45	41-108	4.9	—24.4	0.854	0.25	....
178	12	34	28-34	333	303	0.926	0.02	1.19
234	2	4	14-34	350	134	0.296	0.4	0.81
272	3	7	14-34	212	100	—0.298	0.5	1.60
300	4	9	19-34	393	147	0.503	0.02	1.75
500	4	7	19-34	636	180	0.129	0.6	2.02
547	4	7	14-34	600	237	0.429	0.2	2.63
647	2	4	14-34	711	109	—0.350	0.03	0.70
700	2	5	19-34	893	283	0.227	0.6	2.45
920	4	13	20-30	776	219	—0.062	0.7	2.43

[1] A probability of 0.05 or less is statistically significant.

been demonstrated by Reber and Yusken (1956), in which 920 mgs. of sodium per 100 gms. of ration counteracted potassium losses in baby pigs infected with transmissible gastroenteritis.

In the experiment in which 234, 272, 547 and 647 mgs. of sodium per 100 gms. of ration were fed, there were no consistent relations between intake and retention or between intake and sodium retained per gram of increase in body weight. None of the pigs in this experiment retained an amount of sodium equal to that retained by pigs fed the ration containing 178 mgs. per 100 gms., even though the intake values were greater.

In the experiment in which 300, 500 and 700 mgs. of sodium per 100 gms. of ration were fed, the pigs had an average daily body weight gain of 84, 89 and 115 gms., respectively. The daily sodium intake and retention increased as the concentration of the sodium in the ration increased.

The pigs fed the 920 mgs. level of sodium gained an average of 90 gms. per day. The urinary losses of sodium for these pigs averaged 545 mgs. per day, considerably higher than the average of 31 mgs. observed in those pigs fed the 178 mgs. level of sodium. The urinary volumes of these two groups of pigs were comparable. The amounts of sodium retained per gram of increase in body weight by pigs fed 700 and 920 mgs. of sodium per 100 gms. of ration were about equal. This degree of sodium retention is interpreted to mean that the pigs fed lower levels of sodium would have retained more sodium if their dietary concentration were greater.

It appears that a high level of sodium (2.34% sodium chloride) did not adversely affect body weight gains. The responses of the animals fed the diet containing 0.45% sodium chloride indicated that this level of sodium adequately met the requirements of the growing, healthy baby pig. However, the high average daily retention (90.9%) of the dietary sodium indicates there was a small margin of safety. Although the data from these experiments are limited, it appears the level of sodium included in a ration fed to baby pigs should be higher than 178 mgs. (0.45% sodium chloride). There appears to be considerable biological variation in these studies. Therefore, additional investigations should be made.

Summary

Forty-two pigs whose ages varied from 19 to 108 days, maintained in individual metabolism cages, were fed a synthetic ration in which the sodium content varied from 9.4 to 920 mgs. of sodium per 100 gms. Uneaten feed, urine, and feces were collected for periods of one to four days and daily sodium retentions were calculated. Pigs fed 9.4 mgs. of sodium per 100 gms. of ration lost an average of 24.4 mgs. of sodium and 14 gms. of body weight per day. Pigs fed levels of sodium varying from 178 to 920 mgs. of sodium per 100 gms. of ration had positive sodium retentions. The analysis of these data points out the extreme variations encountered in attempting a determination of sodium requirement. Regression coefficients for sodium retention on sodium intake were calculated for each concentra-

tion of dietary sodium. Pigs fed 178 mgs. of sodium per 100 gms. of ration retained an average of 90.9% of their sodium intake, and grew more rapidly than pigs fed any other sodium concentration. In general, sodium retained in milligrams per gram of increase in body weight increased with increasing sodium concentration, from 1.19 for pigs fed 178 mgs., to 2.44 for pigs fed rations containing 700 or 900 mgs. per 100 gms. of ration.

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