PHYSICO-CHEMICAL STATE OF Sr^{90} IN CONTENTS OF THE GASTRO-INTESTINAL TRACT

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The solubility of radiostrontium Sr^{90} in the contents of the stomach and small intestine of pigs and rats is 30-50% and is independent of the concentration of calcium present. The proportion of complex Sr^{90} in the filtrate of the contents falls with an increase in calcium concentration in the medium. Addition of pectin and alginic acid to the food reduces the solubility of Sr^{90} and Ca^{45} in all divisions of the gastro-intestinal tract, alginic acid acting mainly on the solubility of radiostrontium.

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The object of this investigation was to study Sr^{90} in the contents of the gastro-intestinal tract and also certain parameters of its physico-chemical state: its solubility and its binding with complexes.

EXPERIMENTAL METHOD

Experiments were carried out on pigs and rats. In the experiments on pigs the content of Sr^{90} was determined in various parts of the gastro-intestinal tract and its solubility and binding with complexes studied at various time intervals after feeding and with different calcium contents in the food. In the experiments on rats the effect of certain complexing agents on the solubility of Sr^{90} and Ca^{45} in the contents of the gastro-intestinal tract was studied.

Sixteen pigs received a normal mixed diet consisting of uncleaned potato, carrot, oatmeal, wheat, and meat. The animals were fasted 24 h before the experiment began. Sr^{90} was given as a component of food products obtained in a special agronomic experiment. Chalk in various concentrations was added to the food received by some animals. The animals was sacrificed 1-10 h after feeding. Experiments on rats were carried out under similar conditions. $Sr^{90}Cl_2$ and $Ca^{45}Cl_2$ were given with the food as a solution. Pectin or alginic acid was added to the food given to some rats. The animals were sacrificed 2 h after feeding.

Solubility of Sr^{90} was determined by the method of Moore and Tyler [4] with slight modifications. To determine the degree of binding of Sr^{90} in the filtrate with complexes, 100 g of contents was centrifuged for 1.5-2 h at 5000-6000 rpm, the supernatant was filtered, an aliquot part of it was incinerated, and part was passed through KU-2 resin in the NH_4-form. The proportion of complex Sr^{90} was estimated from the activity not combined with resin. The insoluble ash was determined quantitatively from the ash residue of the insoluble part of the specimens submitted to analysis.

EXPERIMENTAL RESULTS

Data showing the quantity of Sr^{90} in the contents of the gastro-intestinal tract of pigs at different times after feeding, and information on the quantity of insoluble ash are given in Table 1.

It will be noted that Sr^{90} disappeared from the stomach more rapidly than most of the food consumed, as is clear from comparison of the content of Sr^{90} in the insoluble ash at the same time. A similar fact for Ca has been described elsewhere [4]. From the data given in Table 1 the rate of disappearance of Sr^{90} from the proximal portion of the gastro-intestinal tract was calculated. It can be expressed by the sum of 2 exponential equations:

$$y_{st} = 62e^{-\frac{0.693t}{0.5}} + 38e^{-\frac{0.693t}{3.5}} \quad \text{and} \qquad (1)$$

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TABLE 1. Content of Sr^{90} and Insoluble Ash in Gastro-Intestinal Tract of Pigs at Various Times After Feeding

Time after feeding (in hours)	Number of animals	Sr^{90} (in % of intake with food)				Percent of insoluble ash in stomach	Percent of insoluble ash in small intestine	Percent of Sr^{90} in stomach (percent of insoluble ash in stomach)
		in stomach	in small intestine		total in stomach and small intestine			
			proximal portion	distal portion				
1	1	53	7	1	61	78	19	0.68
2	1	27	6	18	51	52	28	0.52
4	4	18	3	14	35	52	40	0.35
10	1	5	1	8	14	24	10	0.21

TABLE 2. Solubility of Sr^{90} and Ca^{45} in Contents of Gastro-Intestinal Tract of Rats After Addition of Complexing Agents to the Food (in % of Total Quantity Found in Investigated Portion)

Complexing agent added to food	Quantity (in mg)	Solubility							
		in food		in stomach		in small intestine		in large intestine	
		Sr^{90}	Ca^{45}	Sr^{90}	Ca^{45}	Sr^{90}	Ca^{45}	Sr^{90}	Ca^{45}
Control		44	50	70	73	43	37	7	9
Alginic acid	300	4	13	43	63	7	17	6	31
Pectin	100	28	33	54	56	17	18	4	4

$$y_{st.+s.int.} = 32e^{-\frac{0.693t}{0.5}} + 68e^{-\frac{0.693t}{4}}, \qquad (2)$$

where y_{st} represents the content of Sr^{90} in the stomach (in percent of dose administered), t the time (in hours), and $y_{st+s.int}$ the content of Sr^{90} in the proximal portion of the gastro-intestinal tract. The rate of disappearance of Sr^{90} from the small intestine clearly was much lower than the rate of its disappearance from the stomach, and a large part of its activity (68%) was removed with a half-elimination period of 4 h. These equations can evidently be used to determine the time of effective action of a protective preparation in the proximal portion of the gastro-intestinal tract.

With the entry of food into the stomach the solubility of Sr^{90} gradually increased from 20-30 to 40-50% and approximately the same level of solubility of Sr^{90} was observed throughout the small intestine, falling slightly in the distal portion. In the large intestine the fraction of soluble Sr^{90} was much smaller.

However, the state of radiostrontium in the liquid phase of the contents differed in different parts of the gastro-intestinal tract. For instance, the fraction of Sr^{90} in the filtrates bound with complexes was 67 $\pm$ 10% in the food, 5 ±1% in the stomach, 16-23% in the small intestine, but only 2% in the large intestine. Most soluble Sr^{90} in the food was therefore bound in complexes. In the stomach, with its low pH, these complexes were almost completely broken down and in the intestine a secondary binding of Sr^{90} into complexes took place. The rest of the soluble Sr^{90} was either ionized or present in the form of readily dissociating compounds, easily broken down during passage through resin.

A change in Ca intake with the food from 0.47 to 11-19 g had no appreciable effect on solubility of Sr^{90} in the contents of all parts of the gastro-intestinal tract. However, the presence of Ca in the medium affected the state of Sr^{90} in the filtrate. It is clear from Fig. 1 that the percentage of Sr^{90} complexes in the contents of the gastro-intestinal tract fell appreciably with an increase in Ca content in the medium. With higher Ca concentrations the percentage of complex-bound Sr^{90} became practically constant (3-4). On the basis of these results a decrease in effectiveness of action of various complexing agents on radiostrontium can be expected in the presence of high Ca concentrations if these complexing agents are nonspecific for strontium.

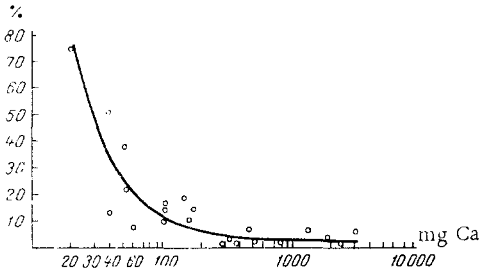

Fig. 1. Content of complex Sr^{90} (in percent) as a function of Ca concentration in sample.

Addition of alginic acid and pectin to the food appreciably lowered the solubility of Sr^{90} and Ca^{45} both in the food and in the contents of the gastro-intestinal tract. Pectin lowered the solubility of Ca^{45} to the same degree as that of Sr^{90}, while alginic acid acted mainly on radiostrontium (Table 2).

It can be concluded from the results described above that, although the method used to determine solubility of isotopes in the contents of the gastro-intestinal tract is somewhat relative, it does give a clear idea of the state of radioisotopes under various conditions. In fact, in experiments with pectin [1] and sodium alginate [5], the protective action of these substances in relation to retention of Sr^{90} in the skeleton was demonstrated, the effectiveness of lowering of the retention corresponding approximately to the decrease in solubility of Sr^{90} discovered in our experiments.

LITERATURE CITED

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