

THE INFLUENCE OF VARIOUS INGREDIENTS
OF RAT FOOD ON THE ABSORPTION
OF RADIOSTRONTIUM IN RATS

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(Received for publication December 21, 1981)

The bioavailability of strontium has been studied in rats fed meat, meat supplemented with rat food or various ingredients of rat food. Rats were on the respective diets for nine days. On the sixth and seventh day of the experiment they received ^{85}Sr and ^{45}Ca in drinking water. The highest radiostrontium retention was found in the group fed meat only (52 per cent). The supplementation of meat with rat food or any of its ingredients reduced this retention (up to 9 times). Ingredients found to cause the lowest radiostrontium retention were sunflower meal, alfalfa meal, cane molasses and fish meal.

The bioavailability of several metals — (lead (1, 2) cadmium (3, 4) and strontium (5)) — has been shown to be much higher in rats fed human than standard rat diet. The decrease in retention of the aforementioned metals caused by rat diet might be related to the influence of some of the rat food ingredients on the absorptive process since intraperitoneal application of these metals produced no change in their retention.

The purpose of this preliminary investigation was to identify, if possible, the particular component or components in a standard rat diet which are responsible for the relatively low retention of one of the most dangerous fission products — radioactive strontium. The potential effect of some of the ingredients in this diet might also be relevant to the influence of rat food on the absorptive process of other toxic metals (1, 3). We have therefore studied the effect of ten important components of a rat diet when added successively to a meat diet which itself was readily accepted by the rats. Due to high radiostrontium retention in rats fed meat diet we could readily observe the reductions in the retention caused by the supplementation of meat with various rat food ingredients.

The results of these preliminary experiments are of interest to the mechanism of strontium uptake and particularly to the problem of finding an acceptable dietary additive which would reduce the absorption of radioactive strontium.

MATERIALS AND METHODS

The experiment was performed on eight-week-old female albino rats of 147 ± 1 g body weight. The animals were kept in individual plastic cages. According to the dietary treatment they were divided into 12 groups of 10 animals. The controls were fed minced meat (beef and pork), the experimental groups were fed a mixture of meat and commercial rat diet (composition given in Table 1) or various ingredients of rat diet (ground yellow corn, ground wheat, brewers dried grains, soy-bean meal, powdered milk, premix, sunflower meal, alfalfa meal, cane molasses or fish meal) in the proportion of 80 per cent of meat to 20 per cent of the above ingredients. Commercial rat food and various ingredients of rat diet were supplied by »Sljeme«, Zagreb. The treatment lasted nine days. On the sixth and seventh day of the experiment, the animals received radioactive strontium and calcium in their drinking water (92.5 kBq ^{85}Sr and 85 kBq ^{47}Ca in 100 ml). The amount of radioisotope received by each animal was determined from the amount of water consumed during the two days by weighing the bottles before and after the administration of the radioisotopes. The animals were killed by an overdose of ether on the ninth day of the experiment. The whole body radioactivity was determined in a sodium iodide, double crystal scintillation counter (Tobor, Nuclear Chicago). The results were corrected for radioactive decay, geometry of the samples and the contribution of the Compton effect and expressed as percentage of the administered dose. Group results are presented as arithmetic means and standard error of the means.

RESULTS

Table 2 presents the whole body retention of radioactive strontium and calcium in rats fed meat and meat supplemented with various ingredients of rat food.

The group of animals which was fed only meat had the highest radiostrontium retention (52 per cent dose). The retention in all the other groups was significantly lower. Thus the animals fed meat supplemented with ground yellow corn, ground wheat, brewers dried grains or soy-bean meal had retentions up to 1.8 times lower than those fed meat only. The addition of complete rat food to meat reduced the retention 2.6 times and a similar reduction was caused by the addition of powdered milk. The radiostrontium retention in animals fed premix,

Table 1.
Composition of commercial rat diet (Producer — «Sljeme», Zagreb)

Food constituents	%	
Ground yellow corn	31	
Ground wheat	18	
Powdered milk	6	
Brewers dried grains	2	
Fish meal	9.5	
Alfalfa meal	5	
Soy-bean meal	17	
Sunflower meal	7	
NaCl	0.5	
Premix	1	
Pinotan (cane molasses)	3	
Composition of premix		per 1 kg of food
Vitamin A	12 000	i.j.
" D	1 500	i.j.
" E	35	mg
" K	1	mg
" B ₁	4	mg
" B ₂	4	mg
Niacin	20	mg
Calcium pantothenate	10	mg
Vitamin B ₆	1	mg
" B ₁₂	0.1	mg
" C	60	mg
Antioxidant	100	mg
Choline	750	mg
Mn	50	mg
Zn	15	mg
Fe	40	mg
Cu	6	mg
Mg	40	mg
Co	0.4	mg
I	0.25	mg

Table 2.
The influence of various ingredients of rat food supplemented to meat on whole body retention of ⁸⁵Sr and ⁴⁵Ca in rats

Group	Dietary treatment	⁸⁵ Sr (% dose)	Ratio Group 1/2-12	⁴⁵ Ca (% dose)	Ratio Group 1/2-12	Ca absorbed per 100 g of food (mg)
1	Meat	52.4 ± 3.3	—	67.2 ± 4.2	—	10 ± 0.1
2	Meat + yellow corn	42.6 ± 2.2	1.2	59.5 ± 2.6	1.1	14 ± 0.6
3	Meat + ground wheat	42.2 ± 1.6	1.2	52.9 ± 2.0	1.3	7 ± 0.3
4	Meat + brewers grains	32.4 ± 1.7	1.6	59.8 ± 1.5	1.1	50 ± 1.3
5	Meat + soy-bean meal	28.5 ± 1.5	1.8	55.5 ± 2.5	1.2	44 ± 2.0
6	Meat + powdered milk	24.8 ± 2.1	2.1	38.7 ± 2.6	1.7	93 ± 6.3
7	Meat + rat food	19.9 ± 1.1	2.6	44.6 ± 1.3	1.5	118 ± 3.3
8	Meat + premix	16.5 ± 1.1	3.2	48.3 ± 1.4	1.4	21 ± 0.6
9	Meat ± sunflower meal	15.4 ± 0.7	3.4	49.2 ± 1.3	1.4	52 ± 1.4
10	Meat + alfalfa meal	12.6 ± 0.6	4.2	36.7 ± 1.8	1.8	121 ± 6.1
11	Meat + cane molasses	7.6 ± 0.4	6.9	19.7 ± 0.9	3.4	118 ± 5.4
12	Meat + fish meal	5.6 ± 0.4	9.4	20.2 ± 0.7	3.3	138 ± 4.7

Results are presented as arithmetic means of ten animals in each group ± SEM. Groups 2-12 were fed meat (80%) supplemented with various ingredients of rat food (20%).

Table 3.
Food constituents per 100 g of experimental food

Group	Dietary treatment	Protein g	Fats g	Carbohydrate g	Joule	Fibres g	Ca mg	P mg
1	Meat	13.0	27.0	5.5	1310	0	15	200
2	Meat + yellow corn	12.2	22.3	18.6	1327	0.58	23	198
3	Meat + ground wheat	13.1	22.0	17.9	1306	0.60	14	197
4	Meat + brewers grains	16.0	23.1	12.7	1247	2.52	83	232
5	Meat + soy-bean meal	20.1	21.7	10.7	1247	0.60	80	263
6	Meat + powdered milk	17.0	21.7	14.4	1256	0	240	299
7	Meat + rat food	14.0	22.5	16.4	1377	1.60	264	257
8	Meat + premix ^a	10.0	21.0	4.4	1048	0	44	189
9	Meat + sunflower meal	17.4	21.8	10.4	1193	4.00	105	342
10	Meat + alfalfa meal	13.8	22.2	12.3	1184	4.80	331	209
11	Meat + cane molasses ^a	10.0	21.0	4.4	1048	0	596	161
12	Meat + fish meal	24.8	23.6	4.4	1297	0.20	684	494
13	Rat food ^b	18.0	4.5	60.0	1651	8.0	1260	487

Experimental foods consisted of 80% meat and 20% of various ingredients of rat food. Values for meat and rat food are taken from »Composition of foods«, McCance, R. A. and Widdowson, E.M., 1978; values for various ingredients of rat food are taken from Ingredient analysis table (Allen, R. D.), »Feedstuffs«, 1976.

Concentrations of calcium and phosphorus in rat food and various ingredients of rat food were obtained by analysis (calcium by AAS method; phosphorus by Goldenberg — Fernandez method, 1966).

^aassuming additive contains negligible protein, fat or carbohydrate

^bvalues of rat food are given for comparison

sunflower meal or alfalfa meal was even lower (3.2 to 4.2 times). The lowest retention was found in the groups fed supplements of cane molasses or fish meal.

As expected the retention of radiocalcium was highest in the group fed meat only (67 per cent dose). The addition of various rat food ingredients to meat reduced this retention up to 3.4 times. As calcium absorption is dependent on the amount of calcium in the food we have analysed calcium in all the ingredients (Table 3). The amount of calcium absorbed per 100 g of food was then calculated from the retention of radiocalcium (Table 2) and the concentration of stable calcium in the diet (Table 3). Although the retention of ^{47}Ca was reduced in rats fed meat supplemented with various ingredients of rat food, especially in groups which received cane molasses and fish meal, the total amount of calcium absorbed over the experimental period was actually increased (Table 2).

The increase in body weight was about 30 g in most groups. Significantly lower increase was observed in groups fed meat with alfalfa, brewers grains (19 g) and cane molasses (11 g).

DISCUSSION

The present results are in good agreement with our previous investigations which showed rat food to cause a considerable reduction in the availability of radiostrontium (5). Ingredients of rat food, sunflower meal, alfalfa meal, cane molasses and fish meal caused the lowest retention of radioactive strontium and are therefore possibly responsible for the aforementioned effect of the rat food.

Different values of radiostrontium retention cannot be easily related to differences in a single food component (protein (9) carbohydrate (10), phosphorus (11) as shown in Table 3. It should be emphasised that most of the separate groups of animals were in negative calcium balance since meat has only a small calcium content compared with the standard rat diet on which all animals had been feeding before the experiment (Table 3). Since the absorption of strontium is enhanced in animals on a low calcium diet (12), it is understandable that it was highest for the control animals on the meat diet. Further, the partial restoration of calcium balance when fish meal or milk are added (both comparatively rich in calcium and phosphorus) reduced the absorption of strontium. Exception to this are groups fed sunflower meal and premix which had low calcium concentration in the diet and low radiostrontium retention. Low retention of radiostrontium in groups fed sunflower meal and alfalfa meal might be related to the amount of fibre and their ability to act as ion-exchangers (13).

Most of the rat food ingredients are important components of animal food and could probably be used in humans without toxic effects. How-

ever, some of the ingredients, which were very effective in reducing radiostrontium retention were given in amounts much higher than the amount of these ingredients in the standard rat diet (premix —20 times; cane molasses — 7 times). Combination of these ingredients in proportions not very different to that in the standard rat diet could be relevant to their possible use as means of reducing radiostrontium retention as well as that of reducing the absorption of other toxic metals.

ACKNOWLEDGEMENTS

Our thanks are due to Mrs Marica Landeka for her valuable technical assistance.

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Sažetak

UTJECAJ RAZLIČITIH SASTOJAKA ŠTAKORSKE HRANE NA APSORPCIJU RADIOAKTIVNOG STRONCIJA U ŠTAKORA

Proučavali smo apsorpciju stroncija u štakora hranjenih mesom, mesom s dodatkom štakorske hrane ili različitim sastojcima štakorske hrane. Životinje su bile na odgovarajućoj prehrani devet dana. Šestog i sedmog dana pokusa primile su radioizotope ^{85}Sr i ^{47}Ca u vodi za piće. Retencija radiostroncija bila je najviša u grupi hranjenoj samo mesom (52% doze). Dodatak štakorske hrane ili bilo kojeg od njezinih sastojaka mesu smanjio je retenciju (do 9 puta). Sastojci štakorske hrane koji su uzrokovali najnižu retenciju bili su: suncokretova sačma, lucerna, pinotan i riblje brašno.

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Primljeno 21. XII 1981