Bull. vet. Inst. Pulawy 36, 39-44, 1992

DECONTAMINATION EFFECTIVENESS OF BENTONITE AFTER A SINGLE ADMINISTRATION OF RADIOCAESIUM

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Decontamination effectiveness of bentonite was investigated in male Wistar rats contaminated intragastrically with Cs-137. The contaminated animals were fed a granulated LSM diet with 10% addition of bentonite for 1, 3 and 5 days after the contamination. The results revealed that rats fed bentonite showed a significant decrease in the radioactivity in examined organs and tissues as early as one day after the contamination, which was intensified with the feeding period.

One of the main actions to be taken into account by the veterinary radiological protection in case of the internal radioactive contamination of animals is to decrease the absorption of radioisotopes from the digestive tract and to increase their elimination from the organism. A high attention is paid to radiocaesium (Cs-137) which has a long half-life, and is usually completely absorbed from the digestive tract and accumulated in the internal organs. Thus, it is only natural that as early as in the 60's investigations were undertaken into the internal decontamination of the animals contaminated with radiocaesium as a result of nuclear disasters. The importance and intensity of these investigations increased greatly after the nuclear fallout at Chernobyl.

As follows foreign (9, 12, 17, 18) and Polish studies (10, 14, 15), the most effective agents of decontamination in the case of internal radiocaesium contaminations are ferrocyanides, especially ferric ferrocyanide and ammonium-ferriccyano-ferrate. In domestic animals a high decontamination effectiveness was obtained by supplementing the diet with zeolites such as chabazites, clinoptyolites and modernites featuring high affinity to caesium (2). Bentonite shows also properties similar to those of zeolites. Bentonite is a mixture of clay minerals with their main component montmorylonite [$Al_2Si_4O_{10}(OH)_2 \cdot nH_2O$] determining the biological activity of bentonite (20).

Since the decontamination effectiveness of bentonite depends on its chemical composition, which differs from region to region, the respective investigations were undertaken with the use of the bentonite occurring in Polish geological deposits.

Material and Methods

The investigations were carried out on 78 male Wistar rats (190±12g) adjusted to the laboratory conditions for seven days. They included the following groups: I - rats contaminated with Cs-137 and fed a granulated LSM diet (control group), II - rats contaminated and fed for one day a LSM diet with 10% addition of bentonite, III - rats contaminated and fed this diet for three days, IV - rats contaminated and fed this diet for five days. Six rats were kept in a cage; the diet and tap water were given *ad libitum*. The consumption of diet was checked every day by the determination of non-consumed amounts. Bentonite was introduced to the diet during the production process of the granulate. The certified chemical composition of bentonite was as follows (percent): silicon 67.0-70.0, aluminium 17.0-19.0, calcium 3.0-4.0, magnesium 1.4-3.1, iron 1.5-2.5, sodium 1.1-2.4, potassium 0.6-1.9, small amounts of zinc, titanium, copper, phosphorus and trace amounts of arsenic, mercury, cadmium and lead. The content of montmorylonite was 38.0-45.0%. Radiocaesium as ^{137}CsCl was given intragastrically in a dose of 13.6 kBq/rat disolved in 0.2 ml of water.

The rats from groups I and II were examined after 1, 3, 5 and 7 days after contamination with Cs-137, those of group III - after 3, 5 and 7 days and group IV - after 5 and 7 days. For radiometric measurements 1 g samples were collected from the following organs: stomach, small intestine, large intestine (without contents), liver, kidneys, heart, lungs, spleen, scapular muscles, thigh muscles, blood, brain, testicles, prostate and skin (without fur). The radiometric measurements of samples were repeated three times, one minute each, by means of a ZM-701 set equipped with a NaJ/Tl crystal scintillation detector type SSU-70. The results were analysed by Student's t-test, at $p \leq 0.05$.

Results

The daily consumption in the control group of rats was 18.9-32.3 g (aver. 21.1 g), in the group fed the diet supplemented with bentonite for one day 26.6-33.3 g (aver. 30.0 g), for three days 26.9-32.8 (aver. 29.8 g) and for five days 28.3-31.1 g (aver. 29.2 g). The average daily consumption of bentonite by rats was 2.9-3.0 g. The average body weight in control rats increased from 210.0 to 235.6 g during 7 days, in the rats fed bentonite diet for one day, from 199.2 to 235.3 g, for three days from 212.5 to 238.5 g and for five days, from 215.0 to 240.4 g. Body weight gains in all examined rats were from 25.4 to 36.1 g.

Table 1

Decrease in radioactivity levels (%) in organs of control rats and of rats treated with bentonite[x].

Organ	Control rats: Radioactivity in Bq, after 1d	3d	5d	7d	Rats fed bentonite: for 1 day, after 1d	3d	5d	7d	for 3 days: 3d	5d	7d	for 5 days: 5d	7d
Stomach	95.1	49.6	68.7	77.1	53.0	45.2	42.6	28.6	73.2	60.3	48.5	78.7	63.7
S. intestine	88.1	47.8	67.2	75.6	52.0	43.1	37.6	24.2	74.3	58.1	37.1	79.4	59.4
L. intestine	94.8	43.5	65.7	75.2	48.4	47.3	47.8	30.5	73.9	61.7	48.2	77.5	63.4
Liver	79.9	45.7	63.1	72.6	43.5	38.7	44.9	28.3	72.2	61.2	49.4	79.2	63.1
Kidneys	122.1	48.1	65.5	75.6	56.4	44.1	41.8	24.2	72.8	62.2	40.9	79.9	59.9
Heart	76.7	49.5	70.1	76.7	51.7	41.4	32.2	27.4	73.3	57.3	36.6	74.8	57.0
Lungs	56.9	47.6	65.9	75.8	49.1	46.6	44.6	34.7	74.4	64.7	45.1	77.3	61.1
Muscles	57.1	+16.3	0.9[a]	16.4	35.4	45.1	51.5	34.6	59.0	56.9	53.5	63.9	59.5
Spleen	70.6	47.8	70.2	76.9	45.4	44.5	35.2	21.9	70.7	60.2	43.4	74.6	62.7
Blood	11.2	19.4	49.1	16.9	36.8	36.2	41.4	62.4	62.5	54.2	72.8	70.1	80.3
Brain	14.7	+24.7	+19.2	+0.8[a]	29.1	35.8	46.2	22.6	50.4	53.9	50.5	61.9	59.2
Skin	33.7	35.0	57.8	67.0	49.7	41.5	46.3	27.9	64.2	57.9	54.1	68.4	62.5
Testicles	39.6	+13.3[a]	3.0[a]	21.1	37.9	42.2	46.7	24.4	54.8	58.3	51.5	62.5	61.6
Prostate	22.7	27.1	59.8	69.3	16.9[a]	51.4	46.3	32.8	74.4	58.1	49.2	75.5	64.2
Tongue	86.0	44.3	64.1	72.2	43.0	43.3	46.2	31.5	71.1	61.8	49.6	78.5	64.8

x - difference in comparison to corresponding values found in control rats
a - statistically insignificant differences
+ - positive difference

The Cs-137 distribution in organs of control rats is presented in Table 1. The results indicate that one day after the contamination the highest radiocaesium concentration was found in the kidneys, stomach, large intestine, and then in the decreasing order in the small intestine, tongue, liver, heart, spleen lungs, muscles, testicles, skin, prostate, brain and blood. With time there was a biological elimination of the radioactivities in most of the examined organs. In the muscles, an increase in the radioactivities was observed after three days, followed by a decrease after 5 and 7 days. A similar pattern of the increase occurred in the testicles. In the brain Cs-137 concentration increased after three days and then remained quite constant, with a slight decrease after seven days.

In rats fed for one day the diet enriched with bentonite a significant decrease of Cs-137 concentration was found in all examined organs (Table 1). In comparison to the results obtained with non-treated rats, a decrease after one day in the organs ranged from 16.9% to 56.4% in the muscles, 20.1% in the brain and 37.9% in the testicles. Again, after 3, 2 and 7 days a decrease in the radioactivity was observed. After seven days it was 21.9% to 34.7% in the organs, 34.6% in the muscles, 22.6% in the brain and 24.4% in the testicles.

Discussion

The results of investigations upon Cs-137 distribution in control rats are in agreement with the data from the previous studies (16). A characteristic feature of radiocaesium metabolism in rats is its accumulation in the sceletal muscles and in the testicles for about three days and an increase of the radioactivity in the brain for about seven days. In the other organs a biological elimination of radioactivity can be observed as quickly as after one day. These differences were a result of different metabolic processes of these organs which influence among others the half-life of Cs-137 in man (13), domestic animals (27) and laboratory animals (25).

Rats contaminated with Cs-137 were given bentonite as a 10% addition to their diet, which was the amount reccomended by other authors (21, 26). The addition of bentonite did not influence the daily diet consumption, which confirms observations reported by Pivy et al. (19). The daily weight gains in control rats and in rats treated with bentonite prove that bentonite in the administered amounts did not affect the normal metabolism. When used by Dembinski (4) as a preventive addition in cattle diet, bentonite improved the intake of nutrition constituents and body weight gains.

In rats fed bentonite diet for one day after the Cs-137 contamination a significant decrease in the radioactivity was observed in all examined organs as quickly as after one day. The effect was even more dramatic when the rats were fed bentonite for three and five days. The total decontamination after seven days in rats fed bentonite diet was similar to that reported by Van der Hoek (26) who found that bentonite reduces radiocaesium absorption from the digestive tract by 60-80%. Inturn, Fusconi (8) reported that 6% addition of bentonite to the diet decreased radiocaesium concentration in the muscles, liver and kidneys in the range of 73.0%-78.0%. Pivy et al. (19) reported that bentonite decreased the transfer coefficient of Cs-137 to milk by about 25%.

The decontamination effectiveness of bentonite is connected with its biological activity (20) which is determined by an ion exchange capacity, adsorption of particles of different charges and different structures and an ability to form colloidal gels. An interesting property of bentonite is also its ability to gather microelements in the form of different chemical compounds (11). The mentioned properties make bentonite more and more popular in prevention and treatment (5, 7, 24). Selectivity of bentonite towards different cations depends upon the degree of porosity (1). Bentonite is non-toxic (22, 23, 28). It is worth for mentioning that new investigations have been lately undertaken into the decontamination effectiveness of artificial zeolites, e.g. modernite (6). Attempts were also made to introduce bentonite by spreading it in pasture (3) which gave poor effects and was likely to have a negative influence on the soil, including possible changes in the ecosystem.

To summarize, it can be stated that the local bentonite administered to rats after a single per os application of radiocaesium showed a high decontamination effectiveness. This fact is of a substantial clinical significance as bentonite considerably lowers the exposition of internal organs to the ionizing radiation emitted by radiocaesium. It has also a sanitary value as it lowers radioactivity levels in muscles which results in a quicker slaughtering fitness of animals.

References

1. **Amphlett C.B.**: Inorganic Ion Exchangers. Elsevier Publ. Comp. Amsterdam 1964. 2. **Arnek R., Forberg A.**: Report PRAV 3. 19. National Council for Radioactive Waste. S-10240 Stockholm 1979. 3. **Beresford N.A., Lamb C.S., Mayes R.W., Howard B.J., Colgrove P.M.**: J. Environm. Radioactivity 9, 251, 1989. 4. **Dembiński Z.**: Medycyna Wet. 41, 177, 1985. 5. **Dembiński Z., Więckowski W., Kulińska A.**: Medycyna Wet. 41, 359, 1985. 6. **Forberg S., Jones B., Westermark T.**: The Science of the Total Environment 79, 37, 1989. 7. **Forster D., Rossow N.**: Mh. Vet.-Med. 45, 538, 1990. 8. **Fusconi G., Morlacchini M., Masoero F., Fabbri S., Lusardi E.**: Documenti Veterinari 2, 62, 1989. 9. **Giese W.W.**: Br. vet. J. 144, 363, 1988. 10. **Gorzkowski B., Majle T., Sobociński L.**: Rocz. PZH 36, 335, 1985. 11. **Hampel I., Jacobi U.**: Mh. Vet.-Med. 41, 238, 1986. 12. **Havlicek F., Kleisner I., Dvorak P., Pospisil J.**: Strahlentherapie 134, 123, 1967. 13. **Inuma T.A., Naga T., Izava M., Watari K., Ishibara T.**: Ann. Reo. Natl. Inst. Rad. Sci. Japan NIRS 4, 3, 1964. 14.

Klimaszewski J.: Doctoral Dissertation, Veterinary Faculty, Agricultural Academy, Lublin 1977. **15. Kossakowski S., Dziura A., Grosicki A.**: Isotopenpraxis 27, 36, 1991. **16. Kossakowski S., Dziura A.**: Bull. vet Inst. Pulawy, (in print). **17. Nielsen P., Fischer R., Heinrich H.C., Pfan A.A.**: Experientia (Basel) 44, 502, 1988. **18. Nigrovic V.**: Phys. Med. Biol. 10, 81, 1965. **19. Piva G., Fusconi G., Fabbri S., Lusardi E., Stefanini L., Modenesi R.**: Health Phys. 57, 181, 1989. **20. Rösler H.J.**: Lehrbuch der Mineralogie 2 Aufl. VEB Deutscher Verlag für Grundstoffindustrie, Leipzig 1981. **21. Rindsig R.B., Schults L.H.**: J. Dairy Science 53. 888. 1970. **22. Schwarz Th., Hampel I., Wernwr E.**: Mengen-u. Spurenelemente Arb. tagung Dez. 1984 Leipzig. **23. Schwarz Th., Werner E.**: Arch. exper. Vet. Med. (Leipzig) 44, 493, 1990. **24. Slanina L.**: Dtsch. tierärztl. Wschr. 81, 552, 1974. **25. Stora J.E.**: Health Phys. 11, 1195, 1965. **26. Van der Hoek J.**: Zeitschr. Tierphysiol. tierernährg. u. Futtermittelkde 43, 101, 1980. **27. Wirth E.**: Leizing CWAVFH-Report on inter. round table conf. Accidental radiat. contam. of food of animal origin. Vol. II, p. 110, 1987. **28. Zalewska E., Krasucki J., Cąkała S.**: Medycyna Wet. 41, 122, 1985.