INFLUENCE OF BENTONITE ON TRACE ELEMENT KINETICS IN RATS. IV. ZINC

ANDRZEJ GROSICKI AND JAROSLAW RACHUBIK

Laboratory of Radiological Protection and Isotopic Research, National Veterinary Research Institute, 24-100 Pulawy, Poland
grosicki@piwet.pulawy.pl

Received for publication September 8, 2009

Abstract

Dietary bentonite (2% additive) given to rats for 28 d, together with traces of zinc chloride (zinc-65), produced moderate increases in radiozinc absorption and organ content. Furthermore, the bentonite additive did not influence feed intake, organ to body ratios, or haematological values although a visible decrease in body weight gains following bentonite feeding was found.

Key words: rat, carcass, organs, bentonite, radiozinc, distribution.

The use of clays by humans is as old as our civilisation itself. It was found that the diets of people from the high Andes and Central Africa, and the Aborigines of Australia, included clays comprising morsels of food. (2, 3, 15) Beneficial effects of dietary bentonite on the health of people and domestic animals have been examined by numerous researchers (4-6, 11, 12, 18, 19, 21, 22). The protective actions of bentonite may result from absorbing organic and inorganic substances on its external surfaces or within its inner laminar spaces by interaction with or substitution for the exchange cations present in these spaces (12, 13). Bentonite given as a feed additive can interfere with contaminants (1, 7, 11, 16, 17, 19) and indispensable trace elements including iron, calcium, selenium, and manganese (8-10, 20). On the other hand, little is known about the interaction between bentonite on zinc. Ma and Uren (13) reported in in vitro experiments an interlayer diffusion and entrapment of zinc in ditrigonal cavities of bentonite, making it less available for other processes. This finding was supported by experiments by Schwarz and Werner (20), who found that prolonged oral application of high doses of bentonite reduced zinc incorporation into the liver and kidneys of goats.

The purpose of the present study was to investigate the effect of dietary bentonite on the zinc metabolism in rats including its whole body retention and distribution within several organs in which zinc is needed for physiological processes. It is worth stressing that these studies are complementary to our earlier reports considering iron, manganese, selenium, and calcium uptake in rats fed a bentonite fortified diet (8, 10).

Material and Methods

Ninety male Wistar rats weighing 207g ±11 g were used. The animals were randomly assigned into two dietary groups, each of 45 rats, after an acclimatisation period of one week. Group I (control) was offered tap water and a standard rodent chow LSM ad libitum (Fodder Manufacture Motycz, Poland). Group II received the same diet but fortified with 2% of bentonite. The total zinc content of the LSM diet was 23.3 mg/kg according to the manufacturer. The bentonite used originated from Polish geological sources. The animals were on these diets for the whole experimental period. Body weight gains and feed and water consumption were recorded weekly during the feeding period.

Zinc chloride (labelled with zinc-65, Polatom, Poland) in a 0.5 mL water solution comprising about 20 kBq per rat was given daily for 28 d except weekends by an intragastric tube to all the rats. The blood was collected weekly by cardiac puncture at a volume of 1 mL into a tube containing calcium disodium versenate as anticoagulant from day 0 through day 28. The blood samples were analysed for erythrocyte and leukocyte counts, haematocrit value, and haemoglobin level. The rats were killed by immersion in gaseous carbon dioxide 3 h, 6 h, 1 d, 2 d, 4 d, 7 d, 14 d, and 28 d after dosing. Radiozinc in the carcass (whole body without the stomach and intestines) was measured using a whole-body counter ZM 701 (Polon, Poland) and that in the blood, liver, kidneys, duodenum, spleen, heart, testicles, brain, and muscles in a well-type scintillation counter ZR 11 (Polon, Poland).
Table 1
The content of zinc-65 in selected organs and tissues (AUC values)

<table>
<thead>
<tr>
<th></th>
<th>Blood</th>
<th>Duodenum</th>
<th>Muscles</th>
<th>Liver</th>
<th>Kidneys</th>
<th>Heart</th>
<th>Spleen</th>
<th>Brain</th>
<th>Testicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I</td>
<td>5.0</td>
<td>11.2</td>
<td>10.2</td>
<td>261</td>
<td>33.9</td>
<td>11.7</td>
<td>8.6</td>
<td>10</td>
<td>54.6</td>
</tr>
<tr>
<td>Group II</td>
<td>5.1</td>
<td>14.4</td>
<td>10.8</td>
<td>263</td>
<td>34.2</td>
<td>14.7</td>
<td>9.7</td>
<td>13</td>
<td>69.7</td>
</tr>
</tbody>
</table>

Liver, kidneys, testicles, heart, and spleen as a whole organ
Brain, duodenum, muscles and blood as 1 g samples

Discussion

No alterations in organ-to-body ratios and blood values demonstrated in the rats fed the bentonite-enriched diet confirm results reported in other studies (8, 10). On the other hand, a lower growth response in rats fed the bentonite-enriched diet found in the present studies seems a little surprising, when compared to earlier reports showing higher body gains in several animal species fed a bentonite supplemented diet. (8,
An unfavourable effect of bentonite on body gains was also reported in animals maintained on diets containing higher amounts, including 10%, 20%, and 50% of bentonite.

The effect of bentonite on the metabolism of zinc in the body has not been studied in detail. In vitro studies revealed that decreases in the extractability of zinc retained by bentonite may be important in the availability of zinc added to soils and in the remediation of soils contaminated with zinc. Thus, it may be suggested that bentonite used as a dietary additive makes zinc less available for absorption from the gastrointestinal tract. However, slight increases in zinc retention in the carcass and examined organs of rats fed bentonite additives found in the present studies are in contrast with the above findings. The complexity of interaction between zinc and several dietary constituents indicates that zinc bioavailability may be also influenced by other feed constituents including fibres and several trace elements. Earlier findings indicated that bentonite produced moderate but persistent decreases in calcium and increases in iron organ content in rats fed a bentonite-supplemented diet. Furthermore, the two elements were evidenced to affect dietary zinc absorption, making it less available for uptake from the gastrointestinal tract.

Taken together, the results of earlier and present studies emphasise the role of bentonite in affecting selected trace elements’ bioavailability in rats fed a diet fortified with this agent. It seems reasonable that the relationship between bentonite and trace elements including zinc is complex and involves both chemical interaction between the structure of bentonite and individual trace elements and other factors such as interaction among trace elements themselves.

References