VITAMIN C SUPPLEMENTS INFLUENCE ZINC UPTAKE AND DISTRIBUTION IN RATS

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Abstract

Wistar rats were fed for 28 d a diet comprising vitamin C administered in drinking water in a concentration of 1 g/L, concomitantly with traces of zinc 65 given intragastrically. The body weight gains, organ to body ratios, blood values, and carcass and organ concentrations of zinc 65 were examined within 28 days postdosing. The supplement of vitamin C decreased significantly zinc 65 carcass retention, especially 4, 7, 14, and 28 d after administration. Comparable decreases in zinc 65 concentrations, calculated from the AUC values, were found in the liver, testicles, muscles, spleen, heart, and brain in rats maintained on the diet supplemented with vitamin C. On the contrary, the duodenum and kidneys of rats supplemented with vitamin C increased their zinc 65 concentrations. The vitamin C additive did not affect feed intake, body growth, organ to body ratios, and blood values.

Key words: rat, vitamin C, zinc, carcass, organs.

Vitamin C is considered to be the most important water-soluble antioxidant in animals and humans. Investigations into the effects of vitamin C supplementation have shown its beneficial role for the prevention of cancer and cardiovascular diseases (10). Moreover, several studies have demonstrated that vitamin C may protect against the toxic effects of cadmium, lead, mercury, chromium, and tellurium (1, 2, 4, 7, 13). It was also found that vitamin C may be involved in the metabolism of toxic elements. Kapl et al. (8) found that supplements of vitamin C reduced markedly hepatic and renal cadmium burden in pigs. Similar evidence was provided in experiments with broiler chicken and turkeys (7, 14). More recent data showed that vitamin C decreased cadmium retention in the liver, kidneys, testicles, and muscles in rats exposed to moderate levels of cadmium (5).

The effects of vitamin C on the absorption of trace elements were described in numerous studies (6, 9, 12, 14, 16, 17). Findings indicated that high amounts of dietary vitamin C inhibited intestinal copper absorption causing impaired copper status (18, 19). On the contrary, Olivares and Cori (12) demonstrated an increased iron absorption following dietary supplements of vitamin C. In the case of selenium, it was found that small amounts of vitamin C enhanced dietary selenium absorption and retention in rats, but the increase depended on the dose of vitamin C and showed a decreasing tendency when vitamin C dose increased (9).

The interaction between vitamin C and zinc is not known in details. There are some suggestions that metabolism of vitamin C and zinc may be linked (11, 20). The goal of the presented studies was to examine the effects of a dietary vitamin C supplement on zinc bioavailability in rats.

Material and Methods

Ninety male Wistar rats weighing 201 g ±10 g were housed in groups of five animals in plastic cages (Tecniplast) in a room with controlled temperature (about 22°C). After an acclimatisation period of one week, the animals were randomly assigned into two dietary groups each of 45 rats: the controls and vitamin C-exposed animals. All rats were offered tap water (less than 1 µg Zn/L) and a standard rodent chow LSM ad libitum (Fodder Manufacture Motycz, Poland) containing 23.3 g Zn/kg according to the manufacturer’s information, except that the rats in vitamin C group received tap water fortified with vitamin C in a concentration of 1 g/L of (Merck, for foodstuffs). The water solution of vitamin C was prepared daily to reduce possible oxidation of the vitamin. Body weight gains and feed and water consumption were recorded weekly during the 28 d feeding period. In addition, blood samples (1 mL) were collected weekly from day 0 through day 28 by cardiac puncture into a tube containing calcium disodium versenate as anticoagulant, and examined for erythrocyte and leukocyte counts, and haematocrit and haemoglobin level.
All rats were given intragastrically traces of zinc chloride labelled with zinc-65, (Polatom, Poland), administered in a 0.5 mL of water solution, that comprised about 20 kBq per rat daily, for 28 d except weekends. Animals 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), while in case of the blood, liver, kidneys, duodenum, spleen, heart, testicles, brain, and muscles the radioactive trace element was measured with the use of a gamma counter (Wallac 1480 Wizard, Cambera Packard). Reference standards for quantification of carcass zinc 65 were prepared by intraperitoneal injection of the appropriate solution to rats, which were killed 45 min thereafter. The area under the curves (AUC) of zinc 65 content versus time points was calculated by the trapezoidal rule. Data were analysed statistically using Student’s t-test at P<0.05.

**Results**

Feeding the vitamin C-supplemented diet for 4 weeks failed to produce any significant differences in water and feed intake, final body weight gains, and organ to body ratios for the liver, spleen, heart, testicles, and kidneys in comparison to those reported for the control rats (data not shown).

The blood values including erythrocytes, haematocrit, haemoglobin, and leukocytes for the rats exposed to the diet supplemented with vitamin C were comparable to those in the controls. Moreover, these values were also similar to the corresponding values in normal rats (data not shown).

The percentage recovery of orally administered zinc 65 in the carcass within 28 d after the exposure is shown in Fig. 1. The addition of vitamin C to drinking water at a concentration of 1 g/L caused a systematic decrease in the retention of zinc 65 in the carcass as compared to that in the controls. The carcass retention in the rats supplemented with vitamin C, calculated from the AUC values, was lower by about 30%. The differences induced by vitamin C were statistically significant within the last 24 d of the experiment.

The content of zinc-65 in selected organs expressed as the AUC values is presented in Table 1. These values including integrated exposure to zinc 65 in rats exposed to vitamin C indicate that vitamin C decreased zinc 65 concentrations in all examined organs except for the kidneys and duodenum. Considering the AUC values, a decrease in the content of zinc 65 ranged from 7% to 9% in the blood, muscles, heart, spleen, brain, testicles, and liver. By contrast, duodenal and renal zinc 65 content increased by about 11% and 10%, respectively.

![Fig. 1. Zinc content in the carcass (% of total dose). Data are represented as mean ± SD. Asterisk indicates significant difference at P<0.05.](image)

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<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>
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<tbody>
<tr>
<td>Control</td>
<td>6.2</td>
<td>15.3</td>
<td>5.3</td>
<td>132</td>
<td>13.5</td>
<td>5.0</td>
<td>5.3</td>
<td>4.1</td>
<td>16.2</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>5.6</td>
<td>18.1</td>
<td>4.8</td>
<td>106</td>
<td>14.1</td>
<td>4.7</td>
<td>4.9</td>
<td>3.8</td>
<td>13.6</td>
</tr>
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Liver, kidneys, testicles, heart, and spleen as a whole organ; brain, duodenum, and muscles as 1 g samples; blood as 1 mL sample.
Discussion

Vitamin C is very popular as a nutritional supplement and potentially harmful side-effects have been reported when vitamin C doses are very high (5, 19). The rats in this experiment consumed vitamin C at a level of 1 g/L of drinking water. No alterations in feed intake, body gains, blood values, and organ to body ratios in rats exposed to this dose for 28 d were observed, suggesting that the used dose of vitamin C was nontoxic to the animals. Comparable amounts of vitamin C in experiments involving rats were used by other authors (18, 19).

Considering vitamin C and zinc interrelations, it was suggested that the effects of an insufficient content of dietary vitamin C in the diet are similar to those associated with zinc deficiency. It was also postulated that zinc absorption and vitamin C intake are linked (11, 20). However, information about the influence of vitamin C on zinc bioavailability and metabolism are is still scarce. The results of the presented study showed that the consumption of vitamin C via the drinking water produced a systematic decrease in carcass retention of zinc 65 administered intragastrically. Moreover, corresponding decreases in zinc 65 content calculated from the AUC values were found in the liver, blood, muscles, heart, brain, spleen, and testicles. On the contrary, the renal and duodenal zinc 65 retention was distinctly higher in the rats fed vitamin C supplement. The direct causes of these effects are rather difficult to explain because of the lack of experiments describing the metabolic relationship between vitamin C and zinc in animals exposed to dietary supplements of vitamin C. However, the results corresponded well with those reported for vitamin C and copper interaction. Thus, it seems reasonable to compare the present data with findings of other authors, who demonstrated the influence of vitamin C on the metabolism of copper, which is an element metabolically related to zinc (20). Smith and Bidlack (16) found that supplements of ascorbic acid decreased copper levels in the blood and liver of guinea pigs. Van der Berg et al. (18, 19) demonstrated that dietary ascorbic acid reduces tissue copper concentration in many organs of rats fed a diet containing 1 g or 10 g of vitamin C. The authors postulated that high amounts of dietary vitamin C inhibit copper absorption causing impaired copper status. Evans et al. (3) provided evidence that vitamin C decreases the binding of copper to metallothionein (Mt), and suggested that vitamin C may alter the copper binding sites on Mt and affect the absorption and hepatic storage of copper.

The data presented in this paper indicate moderate inhibitory effects of vitamin C with regard to zinc bioavailability. However, the frequency of the use of vitamin C supplements and zinc marginal intake may result in alterations in zinc status in people and animals. Thus, it seems reasonable to pay attention to diet composition to obtain the optimal zinc and vitamin C status.

References