Zinc and Dry Matter Content of Tissues and Feces of Zinc-Deficient and Normal Ruminants Fed Ethylenediaminetetraacetate and Cadmium

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Abstract
In experiments involving 18 male Holstein calves and 17 male goats, zinc and dry matter content of various tissues were studied in zinc-deficient and normal animals fed purified diets containing either: no additive, 300 ppm EDTA (as disodium EDTA), or 350 ppm cadmium (as CdCl₂). All of the animals were given the same low zinc (4 ppm zinc) purified diet beginning seven days before fecal collections were initiated and 21 days before tissue samples were obtained. None of the normal animals exhibited any zinc deficiency symptoms. Addition of EDTA to the diet had little effect on fecal zinc excretions or zinc content of most tissues studied. Feeding cadmium increased fecal excretion of zinc in calves but not in the goats which were more mature. Livers of cadmium-fed zinc-deficient calves had an increased concentration of zinc, but this phenomenon was not observed in goat livers. The zinc content of heart, lung, kidney, spleen, testicles, muscle, and bone was not consistently or materially affected by cadmium feeding. Neither EDTA nor cadmium had much effect on dry matter content of most tissues. Differences in tissue zinc level between zinc-deficient and normal animals, in most instances, were nonsignificant. Samples from the epiphysial-diaphyseal junction of tibia from zinc-deficient calves contained less dry matter than those from normal calves.

An adequate amount of zinc is essential to the normal functioning of all animals and a deficiency results in many adverse effects on their health (2, 8-13, 16, 17). It is believed that one fruitful approach to further understanding of zinc metabolism in ruminants is studies with materials which affect metabolism of this element in monogastric animals. Both EDTA (ethylenediaminetetraacetate) and cadmium are known to have important effects on zinc metabolism in some species of monogastric animals (6, 7, 14, 15, 18, 19, 21). Feeding EDTA to monogastric animals, receiving diets inadequate in zinc, has resulted in increased zinc absorption or improved performance (7, 14, 19, 21). Infusions of EDTA have caused increased urinary excretion of zinc in man (20). Cadmium is highly toxic to various species, including ruminants, with one of the components of the toxicity being an antagonism to zinc (5, 15, 17).

Effects of EDTA and cadmium on ruminant tissue concentrations of zinc apparently have been studied relatively little previously (17). The work herein reported was designed to study the effects of EDTA and of cadmium on zinc and dry matter content of various tissues in zinc-deficient and normal goats and calves. It was considered important to obtain results unconfounded by differences in dietary zinc level at the time samples were collected (10). Another objective was to determine the effects of the EDTA and cadmium on fecal zinc excretion. The information obtained contributes substantially to the understanding of zinc metabolism in ruminants.

Experimental Procedure
Using a zinc-deficient purified basal diet similar to that described previously (11), 18 male Holstein calves and 17 male goats were fed either a zinc-deficient or a control diet for several weeks. Prior to the experiment, the goats and calves were fed practical-type diets, including milk replacer and calf starters, until three to four months of age.

The zinc-deficient basal diet consisted of the following per 100 kg: glucose monohydrate, 19.5 kg; cornstarch, 25.0 kg; dried whole whey (spray process), 20.0 kg; cellulose, 10.0 kg; gelatin (flake, 50 bloom), 10.0 kg; egg albumen...
(autoclaved), 3.0 kg; urea (feed grade, 42% N), 0.5 kg; KHCO$_3$, 1.5 kg; NaHCO$_3$, 2.5 kg; dicalcium phosphate (anhydrous, food grade), 2.0 kg; CaCO$_3$ (marble dust), 1.0 kg; lard (stabilized), 3.0 kg; Na$_2$SO$_4$ (anhydrous), 350 g; KCl, 550 g; NaCl, 484 kg; MgO (56% Mg), 165 g; Fe$_2$O$_3$, H$_2$O (20% Fe by assay), 22 g; MnSO$_4$, H$_2$O, 4.4 g; CuSO$_4$, 3.1 g; CoCO$_3$ (45-50% Co by assay), 22 mg; KI, 18 mg; thiamine·HCl, 0.9 g; riboflavin (50%), 2.0 g; d-Ca pantothenate (45%), 3.3 g; pyridoxine·HCl, 1.1 g; nicotinic acid (USP), 2.2 g; folic acid (USP), 0.22 g; cyanocobalamin (1 mg vitamin B$_12$ activity/g), 2.2 g; menadione sodium bisulfite (63%), 0.33 g; D-biotin, 26 mg; d-a-tocopheryl acetate (333 IU vitamin E activity/g), 2.2 g; vitamin A palmitate (325,000 IU/g), 17.6 g; vitamin D$_3$ (200,000 IU/g), 2.2 g; choline·Cl (70%), 264 g; and oxytetracycline (5.5%), 88 g. By analysis (1) the basal diet contained 4 ppm zinc. The control diet was identical, except for addition of 40 ppm of supplemental zinc as ZnO.

After the animals receiving the deficient diet developed typical symptoms of a zinc deficiency (2, 8, 12), they and the controls were randomly assigned to one of the following three treatment diets: a) basal, b) basal + 300 ppm EDTA (as disodium EDTA), or c) basal + 350 ppm cadmium (as CdCl$_2$). (In each replication, initially three animals were assigned to the control diet and a like number to the deficient diet. During the time required for the deficiency to develop, a number of animals were lost, but generally not due to reasons associated with the treatments. In such instances, arbitrarily the cadmium treatment was left out in the randomization of animals to dietary treatments.) To avoid confounding the metabolic effects of the zinc deficiency with the dietary effects due to differences in zinc level, all of the basal experimental diets were zinc-deficient.

The calves weighed from 56 to 91 kg (avg 76 kg) and were 11 to 20 weeks of age (avg 17 weeks) when euthanized. The goats were 18 to 21 weeks of age (avg 20 weeks) and weighed from 10 to 26 kg (avg 15 kg). Animals were fed the experimental diets for a one-week adjustment period, prior to two weeks of total fecal collections in metabolism crates. Blood samples were obtained from the jugular vein at specified intervals and heparin was used to prevent coagulation. Washed red blood cells were obtained as follows: 50-ml aliquots were centrifuged, the plasma removed, and the red blood cells resuspended and centrifuged three times in 30 ml of saline. Serum was obtained from blood samples collected without an anticoagulant.

Twenty-one days following initiation of the experimental diets, the animals were anesthetized by injection of sodium pentobarbital and euthanized by cannulation of the carotid artery to remove blood from the organs and tissues. Tissue samples were taken and frozen until analyzed for zinc by atomic absorption spectrophotometry (1) with nitric-perchloric-sulfuric acid wet washing. The tissues were sampled in the following manner: a) liver, 1 g from lower center of reticular impression; b) spleen, 2 g from cross section at one fourth of the distance from the tip to the other end; c) kidney, 1 g from the medulla; d) tibia, 1.5-2.0 g (calves) and 0.5-1.2 g (goats) of bone (cortex) from the area of the epiphyseal-diaphyseal junction; e) testicles, 2-g sample from center cross section after the visceral layer and the tunica albuginea were removed; f) muscle, 2-g section from the semitendinosus (round); g) heart muscle, 2 g from apex; and h) lung, 2 g from center cross section, avoiding major blood vessels. Dry matter was determined on the tissues prior to digestion for zinc analysis by placing in an oven for 48-72 hr at 93-95 C.

Results and Discussion

The feeding of 300 ppm of EDTA did not materially affect zinc content of the feces in either goats or calves (Table 1). Calves fed 350 ppm cadmium excreted more zinc via feces than the others. Even though only three calves received the cadmium, this increased excretion was significant (5% level). Goats given cadmium did not excrete more zinc than the others. However, the goats were more mature, which may be responsible for the failure of the cadmium to have an effect. The cadmium had less influence on the appetite in goats than in calves. Both the effects of EDTA and those of cadmium feeding are consistent with other work, in which fecal excretion of $^6$Zn from a single oral dose was studied (16). The mechanism whereby cadmium feeding increased fecal losses of $^6$Zn (16) and stable zinc in the calves is not known. Whether it is a direct effect on the digestive tract or an indirect one working through some homeostatic control or other mechanism is not known.

Within the dietary treatments, the zinc-deficient animals excreted somewhat less zinc via feces than the normal animals, which had received the same experimental diets for seven days at the beginning of fecal collections. These results are in agreement with previous studies.
TABLE 1
Influence of feeding 300 ppm EDTA or 350 ppm cadmium on fecal zinc content of zinc-deficient and normal calves and goats with all animals fed the zinc-deficient diet beginning seven days before collections initiated

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Normal</th>
<th>Deficient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No additive</td>
<td>EDTA</td>
</tr>
<tr>
<td>Week</td>
<td>No. animals</td>
<td>Feces</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(mg Zn/kg of dm)</td>
</tr>
<tr>
<td>Calves</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>No. animals</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>(mg Zn/kg of dm)</td>
<td></td>
<td>19.87</td>
</tr>
<tr>
<td>(mg Zn/kg of dm)</td>
<td></td>
<td>2.64</td>
</tr>
<tr>
<td>Feed</td>
<td></td>
<td>23.25</td>
</tr>
<tr>
<td>(mg Zn/kg of dm)</td>
<td></td>
<td>9.45</td>
</tr>
<tr>
<td>(mg Zn/kg of dm)</td>
<td></td>
<td>0.74</td>
</tr>
<tr>
<td>Goats</td>
<td></td>
<td>4.0</td>
</tr>
<tr>
<td>No. animals</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Feces</td>
<td></td>
<td>20.22</td>
</tr>
<tr>
<td>(mg Zn/kg of dm)</td>
<td></td>
<td>12.70</td>
</tr>
<tr>
<td>(mg Zn/kg of dm)</td>
<td></td>
<td>16.46</td>
</tr>
<tr>
<td>Feed</td>
<td></td>
<td>1.03</td>
</tr>
<tr>
<td>(mg Zn/kg of dm)</td>
<td></td>
<td>0.86</td>
</tr>
<tr>
<td>(mg Zn/kg of dm)</td>
<td></td>
<td>0.92</td>
</tr>
<tr>
<td>Feed</td>
<td></td>
<td>1.5</td>
</tr>
</tbody>
</table>

(10). There was an appreciable decline in level of zinc in feces from the first to the second week, suggesting that the fecal zinc level had not stabilized during the one-week adjustment period. For the normal animals the diet had been changed, with the zinc level decreased from 44 to 4 ppm beginning one week before collections started. However, there had been no change in the diet of deficient animals.

Levels of zinc in feces of all animals were far below (about 6% as large) that observed previously when calves were fed approximately 11 times as much zinc as in this study (8). However, fecal zinc content was about one-third lower than that of another study in which dietary zinc level was approximately one and one-half times that used here (10). Thus, zinc content of feces is strongly influenced by zinc level of the feed. These data are in harmony with other evidence which indicates that animals have homeostatic control mechanism(s) for zinc that operate through the gastrointestinal tract (9, 11). It is visualized that there may be a lower limit to the fecal zinc level which is importantly influenced by endogenous fecal losses (11).

Zinc content of whole blood was lower in normal goats fed EDTA than in comparable animals given no additive (significant at 5% level) (Table 2). A similar but nonsignificant trend was noted in whole blood, plasma, and red blood cells of normal calves fed EDTA. In deficient animals of both species there was a small but nonsignificant average elevation in whole blood zinc of animals given EDTA. Feeding cadmium did not have a notable effect on the zinc content of blood from normal animals (Table 2). By contrast, zinc level of whole blood of cadmium-fed zinc deficient animals was higher than in those fed no additive. In both species the effect just failed to reach the 5% level of significance. However, when data for the two species were combined for analyses the influence of the cadmium on whole blood zinc was significant (5% level).

In general, average blood zinc values were lower in zinc-deficient than in normal animals (the only significant effect at the 5% level was
TABLE 2
Influence of feeding 300 ppm EDTA or 350 ppm cadmium on blood zinc content of zinc-deficient and normal calves and goats

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Normal</th>
<th>Deficient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No additive</td>
<td>EDTA</td>
</tr>
<tr>
<td>Calves</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. animals</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Whole blood ($\mu g,\text{zinc/g}$)</td>
<td>Average</td>
<td>1.64 (36)</td>
</tr>
<tr>
<td>Range of animals</td>
<td>(1.02-2.32)</td>
<td>(0.80-1.78)</td>
</tr>
<tr>
<td>Blood plasma ($\mu g,\text{zinc/g}$)</td>
<td>Average</td>
<td>1.26 (27)</td>
</tr>
<tr>
<td>Range of animals</td>
<td>(0.67-1.51)</td>
<td>(0.62-1.33)</td>
</tr>
<tr>
<td>Washed R.B.C.'s ($\mu g,\text{zinc/g}$)</td>
<td>Average</td>
<td>3.60 (27)</td>
</tr>
<tr>
<td>Range of animals</td>
<td>(2.08-4.45)</td>
<td>(2.03-2.92)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goats</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. animals</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Whole blood ($\mu g,\text{zinc/g}$)</td>
<td>Average</td>
<td>1.76 (27)</td>
</tr>
<tr>
<td>Range of animals</td>
<td>(1.55-2.16)</td>
<td>(1.02-1.81)</td>
</tr>
<tr>
<td>Blood serum ($\mu g,\text{zinc/g}$)</td>
<td>Average</td>
<td>0.66 (9)</td>
</tr>
<tr>
<td>Range of animals</td>
<td>(0.46-1.10)</td>
<td>(0.22-0.80)</td>
</tr>
</tbody>
</table>

* SE = Standard error of a treatment mean. Values given are for four animals per treatment for calves and three for goats.

b C.V. = Coefficient of variation.
on goat whole blood) (Table 2). However, as discussed in more detail relative to previous data (10), which showed the same phenomenon, there was considerable overlapping between values for normal and deficient animals. Thus, it is apparent that in many instances one could not have reliably determined which animals were deficient and which were normal from blood zinc values.

Feeding EDTA had very little effect on zinc content of the tissues studied (Tables 3 and 5). The amount of EDTA absorbed is not known. However, since feeding EDTA has a marked effect on urinary \(^{65}\)Zn excretion from a single oral dose the EDTA must, at least partially, be absorbed (16).

Liver zinc content of zinc-deficient calves was considerably increased by cadmium feeding (Table 5). In contrast, there was a much smaller and nonsignificant increase in the liver zinc of cadmium-fed goats (Table 3). Previously, Bunn and Matrone (3) observed an increased zinc content in the livers and testicles of rats fed cadmium. In zinc-deficient goats, cadmium feeding resulted in higher tibia zinc content than in those not given cadmium (Table

### Table 3

Influence of feeding 300 ppm EDTA or 350 ppm cadmium on zinc content of tissues in zinc-deficient and normal goats

<table>
<thead>
<tr>
<th>Tissue</th>
<th>Normal</th>
<th>Deficient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No additive</td>
<td>EDTA</td>
</tr>
<tr>
<td></td>
<td>(3 goats)</td>
<td>(3 goats)</td>
</tr>
<tr>
<td>Heart</td>
<td>78.3 (^a)</td>
<td>75.4 (^a)</td>
</tr>
<tr>
<td>Lung</td>
<td>99.8 (^b)</td>
<td>83.6 (^b)</td>
</tr>
<tr>
<td>Liver</td>
<td>91.8 (^a)</td>
<td>91.6 (^a)</td>
</tr>
<tr>
<td>Kidney</td>
<td>78.1 (^b)</td>
<td>75.9 (^b)</td>
</tr>
<tr>
<td>Spleen</td>
<td>81.5 (^b)</td>
<td>71.6 (^b)</td>
</tr>
<tr>
<td>Testicles</td>
<td>82.6 (^a)</td>
<td>93.4 (^a)</td>
</tr>
<tr>
<td>Muscle</td>
<td>151.6 (^a)</td>
<td>114.9 (^a)</td>
</tr>
<tr>
<td>Bone (tibia)</td>
<td>65.8 (^a)</td>
<td>64.1 (^a)</td>
</tr>
<tr>
<td>Avg</td>
<td>92.1</td>
<td>82.6</td>
</tr>
<tr>
<td>Weighted avg</td>
<td>92.1</td>
<td>82.6</td>
</tr>
</tbody>
</table>


### Table 4

Influence of feeding 300 ppm EDTA or 350 ppm cadmium on dry matter content of tissues in zinc-deficient and normal goats

<table>
<thead>
<tr>
<th>Tissue</th>
<th>Normal</th>
<th>Deficient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No additive</td>
<td>EDTA</td>
</tr>
<tr>
<td></td>
<td>(3 goats)</td>
<td>(3 goats)</td>
</tr>
<tr>
<td>Heart</td>
<td>19.5 (^a)</td>
<td>20.5 (^a)</td>
</tr>
<tr>
<td>Lung</td>
<td>18.3 (^a)</td>
<td>19.5 (^a)</td>
</tr>
<tr>
<td>Liver</td>
<td>26.5 (^a)</td>
<td>26.2 (^a)</td>
</tr>
<tr>
<td>Kidney</td>
<td>18.7 (^a)</td>
<td>20.1 (^a)</td>
</tr>
<tr>
<td>Spleen</td>
<td>22.8 (^a)</td>
<td>22.9 (^a)</td>
</tr>
<tr>
<td>Testicles</td>
<td>12.3 (^a)</td>
<td>13.8 (^a)</td>
</tr>
<tr>
<td>Muscle</td>
<td>22.4 (^a)</td>
<td>22.4 (^a)</td>
</tr>
<tr>
<td>Bone (tibia)</td>
<td>64.5 (^a)</td>
<td>69.1 (^a)</td>
</tr>
<tr>
<td>Avg</td>
<td>25.6</td>
<td>26.8</td>
</tr>
</tbody>
</table>

\(^a,b\) Values not followed in the same horizontal line by the same letter are significantly different at the 5% level.

\(^c\) SE = Standard error of a treatment mean. Values presented are for means with three animals. Those for other numbers would be changed by the ratios of the square roots of the number.

\(^d\) C.V. = Coefficient of variation.
TABLE 5
Influence of feeding 300 ppm EDTA or 350 ppm cadmium on zinc content of tissues in zinc-deficient and normal calves

<table>
<thead>
<tr>
<th>Tissue</th>
<th>Normal</th>
<th>Deficient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No additive EDTA</td>
<td>Cadmium</td>
</tr>
<tr>
<td></td>
<td>(4 calves)</td>
<td>(1 calf)</td>
</tr>
<tr>
<td>Heart</td>
<td>74.8a</td>
<td>70.8b,c</td>
</tr>
<tr>
<td>Lung</td>
<td>62.3a</td>
<td>57.4a</td>
</tr>
<tr>
<td>Liver</td>
<td>110.1b</td>
<td>109.5b</td>
</tr>
<tr>
<td>Kidney</td>
<td>67.3a</td>
<td>70.6a</td>
</tr>
<tr>
<td>Spleen</td>
<td>72.4a</td>
<td>69.1a</td>
</tr>
<tr>
<td>Testicles</td>
<td>74.7a</td>
<td>83.6a</td>
</tr>
<tr>
<td>Muscle</td>
<td>86.6c</td>
<td>96.9c</td>
</tr>
<tr>
<td>Bone (tibia)</td>
<td>81.1a</td>
<td>70.2a</td>
</tr>
<tr>
<td>Avg</td>
<td>78.6</td>
<td>78.5</td>
</tr>
</tbody>
</table>

Values not followed in the same horizontal line by the same letter are significantly different at the 5% level.

SE = Standard error of a treatment mean. Values presented are for means with four animals. Those for other numbers would be changed in the usual way.

C.V. = Coefficient of variation.

3). An opposite effect was noted in the lungs of the normal animals.

The results of these studies are somewhat in contrast to those of Bunn and Matrone with rats (3). In general, the large increases in testicle zinc (3) were not observed here. Likewise, the degree and consistency of the increase in liver zinc was much less than that in the rats (3). Whether differences between the studies are due to species or to other factors such as dietary pretreatments, diets, etc., is not known. Also, information is not at hand to determine whether cadmium feeding might have an influence on zinc content of tissues not investigated in each of the studies.

Over-all zinc content of tissues from zinc-deficient animals averaged somewhat lower than that of the normal animals (Tables 3 and 5). However, only the effects on hearts and testicles of calves and lungs and bones in goats were significant at the 5% level. The level of muscle zinc in calves was increased in deficient calves, but this is believed to be a random effect, as a zinc deficiency has not been shown to influence zinc contents of muscles in any of the other groups or in previous studies (4, 10).

In general, results of these experiments are consistent with previous work in which the effects of the zinc deficiency per se on tissue zinc concentrations were studied in a larger number of animals (10). In that study, it was shown that while zinc content is significantly reduced in several tissues, the effect is usually a statistical phenomenon which applies only to groups of data. There was considerable overlapping between normal and zinc-deficient animals (10). In most other previous work, in which the influence of zinc deficiency on tissue zinc has been studied, level of dietary zinc when the samples were taken usually has been confounded with the physiological effects of the deficiency. In such instances, generally, the effects of the dietary and physiological effects have been substantially larger than in those studies (10) in which dietary differences were not confounded.

In this experiment, level of zinc in some tissues was appreciably different from the zinc content of comparable tissues of a previous experiment which used a similar diet (10). In several instances these differences between experiments are considerably larger than those associated with any of the experimental treatments in either study. Thus, it appears that there are probably many other factors which affect zinc content of tissues.

Obviously, a shortage of zinc must exist in some or many tissues, for the serious pathological changes that are observed in the deficiency (2, 8, 12) to occur. However, from these and previous data (10) it is apparent that the ruminant animal has the ability to remain approximately normal when zinc level in many tissues is remarkably near that observed in a condition of serious pathological deficiency. This appears to severely limit the usefulness of total tissue zinc levels in the diagnosis of whether a given animal is suffering from a zinc deficiency.

Published data concerning the effects of vari-
ous factors on zinc content of ruminant tissues are rather meager. Also, use of the published results has been handicapped, because the data are not all presented on a comparable basis; some have been presented on a fresh weight basis and others per unit of dry matter. Accordingly, the pattern of a previous study (10) is continued, in that dry matter values are presented for the tissues studied (Tables 4 and 6).

Feeding either EDTA or cadmium had no influence on the dry matter content of most tissues. The only exception was the decreased dry matter in muscles of some cadmium-fed animals. This may have been due to a reduction in fat content, as such animals appeared to be somewhat emaciated. Tibias of zinc-deficient calves contained less dry matter than those of controls. Since samples were taken at the epiphyseal-diaphyseal junction, this difference may indicate a slower ossification in the zinc-deficient animals.

Dry matter content data of most tissues were similar in calves and goats; in general, the values are in good agreement with those reported previously (10). The one notable difference between species was in the tibia. The higher dry matter level in the goat tibias was probably due to these animals being much more mature than the calves.

While it is well established that both EDTA and cadmium have important effects on zinc metabolism (6, 7, 14-19, 21), it is apparent from these results that, when fed for relatively short periods, these materials do not greatly influence zinc or dry matter content of most tissues.

References


(9) Miller, W. J., Blackmon, D. M., Gentry, R. P., Pitts, W. J., and Powell, G. W.

TABLE 6

Influence of feeding 300 ppm EDTA or 350 ppm cadmium on dry matter content of tissues in zinc-deficient and normal calves

<table>
<thead>
<tr>
<th>Tissue</th>
<th>Normal (4 calves)</th>
<th>Normal (1 calf)</th>
<th>Deficient (3 calves)</th>
<th>Deficient (2 calves)</th>
<th>Weighted avg</th>
<th>SE$^e$</th>
<th>C.V.$^d$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart</td>
<td>19.2$^a$</td>
<td>19.4$^a$</td>
<td>21.0</td>
<td>19.7$^a$</td>
<td>19.3</td>
<td>0.5</td>
<td>5.3</td>
</tr>
<tr>
<td>Lung</td>
<td>18.6$^a$</td>
<td>19.0$^a$</td>
<td>19.3</td>
<td>18.9$^a$</td>
<td>18.9</td>
<td>0.5</td>
<td>6.1</td>
</tr>
<tr>
<td>Liver</td>
<td>26.7$^a$</td>
<td>28.2$^a$</td>
<td>27.3</td>
<td>26.9$^b$</td>
<td>26.9</td>
<td>0.5</td>
<td>3.9</td>
</tr>
<tr>
<td>Kidney</td>
<td>20.2$^a$</td>
<td>20.7$^a$</td>
<td>19.8</td>
<td>19.7$^b$</td>
<td>19.9</td>
<td>0.3</td>
<td>3.7</td>
</tr>
<tr>
<td>Spleen</td>
<td>22.3$^a$</td>
<td>22.3$^a$</td>
<td>24.9</td>
<td>22.4$^b$</td>
<td>22.4</td>
<td>0.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Muscle</td>
<td>22.8$^a$</td>
<td>22.1$^b$</td>
<td>19.3</td>
<td>22.1$^b$</td>
<td>21.7</td>
<td>0.5</td>
<td>5.3</td>
</tr>
<tr>
<td>Bone (tibia)</td>
<td>57.0$^a$</td>
<td>55.8$^a$</td>
<td>46.0</td>
<td>45.8$^b$</td>
<td>47.2$^b$</td>
<td>0.5</td>
<td>6.6</td>
</tr>
<tr>
<td>Avg</td>
<td>26.7</td>
<td>26.8</td>
<td>25.4</td>
<td>25.0</td>
<td>25.2</td>
<td>0.5</td>
<td>9.9</td>
</tr>
</tbody>
</table>

$^a,b$ Values not followed in the same horizontal line by the same letter are significantly different at the 5% level.

$^e$ SE = Standard error of a treatment mean. Values presented are for means with four animals. Those for other numbers would be changed in the usual way.

$^d$ C.V. = Coefficient of variation.


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