# Effect of Zinc Deficiency on Digestibility and Utilization of Nutrients

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Zinc deficiency reduces food consumption and weight gain of growing rats very considerably. Pair-fed control groups also grow better than the deficient animals (5, 7). Therefore in a metabolic experiment (6) the effect of zinc deficiency on the digestibility and the utilization of some nutrients was tested.

## Materials and Methods

Two groups each of 8 weaned male SPF-Sprague-Dawley-Rats were kept individually in metal-free metabolic cages for 35 days. At the beginning of the experiment the mean weight of the rats in each group was 31 g. The zinc deficient rats received a purified semisynthetic casein-starch-diet (5) containing 1.0 mg Zn/kg dry matter (DM). To the pair-fed control diet $ZnSO_4 \cdot H_2O$ was added to get 50 mg Zn/kg DM. This can be assumed to meet the requirement fully (4). Aqua bidest. was given as drinking water. The rats were fed five times daily at 4 hour intervals. During the first days all animals received 15 mg Zn/kg DM. The experiment was then carried out over 6 periods of five days each. Faeces and urine were collected separately. The experimental parameters measured were: the apparent digestibility of the DM, of the crude ash, of the organic matter and of the crude protein, the apparent absorption and the retention of Zn, the digestible and metabolizable energy and the N-balance. At the end of the experiment all the animals were killed and analyzed for the Zn-content of the os femoris and the blood-serum. The activity of the alkaline phosphatase in the blood-serum was also measured.

## Results

The results of the chemical analysis of the diet were in % of DM: 23.8 crude protein, 8.6 crude fat, 4.0 crude fibre and 3.5 ash. Gross energy was 20.7 kJ/g DM.
With the rats fed the low Zn-diet, typical deficiency symptoms such as apathy, reduced food intake, growth retardation and loss of hair were observed. At the beginning the food consumption was about 3 g DM/animal/day whereas it decreased to less than 2 g towards the end of the experiment. After 10 days the growth of the Zn-deficient rats, fed ad libitum, stopped and thereafter their weight decreased (Table 1).

The food conversion efficiency (FCE) in the deficient group was already two times lower than that of the pair-fed controls during the first experimental period. In the Zn-deficient group at the end of the experiment the Zn-concentration of the os femoris

was 31.0 ± 1.9 µg Zn/g fresh matter (FM), i.e. 38 % of the controls; in the blood-serum 0.74 ± 0.03 µg Zn/ml, i.e. 53 % of the controls and the activity of the alkaline phosphatase in the serum 24.1 ± 1.7 mU/ml, i.e. 17 % of the controls. Therewith a severe Zn-deficiency was established.

Table 1. Body-weight at the end of each period and food conversion efficiency (FCE) of Zn-deficient rats and pair-fed controls (Mean ± S.E., n = 8)

| Experimental period | Body-weight | | Signif. of diff. | FCE[+)] | | Signif. of diff. |
|---|---|---|---|---|---|---|
| | Zn-deficient rats | pair-fed control rats | | Zn-deficient rats | pair-fed control rats | |
| | g | g | P < | | | P < |
| 0 | 39.0 ± 1.02 | 39.0 ± 1.06 | - | | | |
| 1 | 45.2 ± 0.92 | 49.9 ± 1.38 | 0.05 | 2.89 ± 0.30 | 1.40 ± 0.06 | 0.001 |
| 2 | 47.3 ± 0.85 | 53.5 ± 1.17 | 0.001 | 5.83 ± 0.61 | 3.44 ± 0.39 | 0.05 |
| 3 | 45.6 ± 0.95 | 54.2 ± 1.59 | 0.001 | no | 14.7 | 0.001 |
| 4 | 44.6 ± 1.13 | 55.6 ± 1.94 | 0.001 | weight | no | - |
| 5 | 43.1 ± 1.13 | 54.9 ± 1.98 | 0.001 | gain | weight | - |
| 6 | 38.8 ± 1.38 | 54.0 ± 1.66 | 0.001 | " | gain | - |

[+)] FCE = g food DM/g weight gain

The results of the balance-calculation are given in Table 2. The diet was highly digestible. All the criteria measured, except for the apparent digestibility of the gross energy, showed significant differences between the two treatments.

## Discussion

The results concerning the reduced FCE of growing rats caused by Zn-deficiency agree with those found by other authors (2, 8). There are similar observations with other species (see 6).

When calves and kids were fed Zn-deficient diets, Hiers et al. (1) observed reduced digestibility of the DM and the organic matter. However other authors did not find corresponding results, probably due to a less severe Zn-deficient diet (see 6). The reduction in the apparent digestibility of the crude protein of about 3 % may be explained by a lower true digestibility or by an increase of the endogeneous N-excretion with the faeces. The same applies to the 14 % decrease in the ash-digestibility. N-retention reduces to the same extent with Zn deficiency. Similar observations were reported for sheep (9). This may be caused by a severe disturbance of the protein-

Table 2. Apparent digestibility and retention of nutrients and metabolizable energy of Zn-deficient rats and their pair-fed controls on average over all periods (Mean ± S.D., n = 8)

| | Zn-deficient rats | Pair-fed control rats | Signif. of diff. P< |
|---|---|---|---|
| Apparent digestibility (%): | | | |
| Dry matter | 92.6 ± 0.95 | 94.0 ± 0.53 | 0.01 |
| Organic matter | 93.2 ± 0.85 | 94.1 ± 0.49 | 0.05 |
| Crude ash | 76.6 ± 6.22 | 90.8 ± 1.66 | 0.001 |
| Crude protein | 93.3 ± 1.55 | 96.2 ± 0.56 | 0.001 |
| Apparent absorption of Zn (%) | -132 ±25 | 38 ± 5.5 | 0.001 |
| Retention of Zn (% dietary Zn) | -460 ±60 | 25 ± 6.3 | 0.001 |
| Retention of N (% dietary N) | 14.7 ± 8.83 | 30.5 ± 7.52 | 0.01 |
| Metabol. energy (% gross energy) | 85.6 ± 1.59 | 88.7 ± 0.95 | 0.01 |

metabolism (3). The reduced amount of about 3 % in metabolizable energy is not sufficient to explain completely the decreases in FCE and weight. Hence for Zn-deficient animals it is assumed that all the nutrients measured are metabolized less than within the pair-fed controls. This agrees with observations made in biochemical studies (3) on the effect of Zn-deficiency in the intermediary nutrient utilization.


## Summary

In a metabolic experiment 16 weaned male rats were used to investigate the digestibility of crude nutrients, the N-retention, the metabolizable energy and the FCE under conditions of severe zinc deficiency (1 mg Zn/kg dietary DM) as compared to pair-fed controls (50 mg Zn/kg dietary DM). With the Zn-deficient diet the apparent digestibility of the dry matter, of the organic matter and the ash as well as the N-retention were reduced significantly. The reduction of the FCE may be explained only to a small extent by the decrease in the metabolizable energy. Hence it is shown that the nutrients which were investigated are metabolized less in Zn-deficient animals than in their pair-fed controls.


## References


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