Influence of Long-Term Administration of Naturally Occurring Sorbents on the Ultrastructure of Small Intestine Enterocytes in Rats

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Translated from *Byulleten' Eksperimental'noi Biologii i Meditsiny*, Vol. 125, No. 6, pp. 702-704, June, 1998
Original article submitted June 30, 1997

Long-term consumption of diet with the naturally occurring sorbent zeolite and diadomite has no effect on structural integrity of epithelial lining in the small intestine and increases the absorbing surface area by lengthening enterocyte microvilli and increasing their number. The tendency toward high density of the mitochondria, high superficial density of their internal membranes, high density of attached ribosomes may be indicative of increased adaptive abilities of enterocytes.

Key Words: *naturally occurring sorbents; enterocytes; ultrastructure*

Naturally occurring sorbents have been used in medicine since the ancient times. Beneficial effects of the naturally occurring minerals zeolite and diatomite in poisoning with Malathion insecticide and accumulation of radioactive cesium were confirmed experimentally [1]. However, the effects of these sorbents on epithelial lining of the gastrointestinal tract are poorly investigated.

Our objective was to study the ultrastructure of the small intestine enterocytes in rats maintained for a long time on a diet supplemented with naturally occurring sorbents.

MATERIALS AND METHODS

Experiments were carried out on male Wistar rats. Control rats were maintained on standard diet. The diet of experimental rats was supplemented with zeolite and diatomite (6% dry weight). Zeolite was from Kholinskii deposit of the Chita region and diatomite (opalite) was from the Eastern Ural region.

Material for investigation was collected 24 h after the last feeding during the period of relative rest in the processes of absorption in the small intestine [2].

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For electron microscopy, fragments of small intestine were fixed in 1% OsO_4 in phosphate buffer and embedded in Epon. Ultrathin sections were studied in a JEM-1010 electron microscope. Morphometry was performed by the method [5] using square grids. The differences were considered as significant at $p<0.05$ (Student's t test).

RESULTS

Zeolite and diatomite have medium-size pores and differ in the ability to absorb vitamin B_{12}, a marker of medium-molecular-weight toxins, and methylene blue, a marker of low-molecular-weight toxins [3], as well as in chemical and mineral composition.

Both sorbents caused no damage to the endothelial lining of small intestine after administration for 35 days.

Enterocytes in the crypts of different parts of the villus have different ultrastructural and functional organization [2]. We studied enterocytes located at the crypt basis and in the middle part of the villus.

Morphometric analysis showed that both sorbents induce no significant changes in the structure of poorly differentiated enterocytes in the crypt (Table 1). A tendency toward an increase in the volume density of the rough endoplasmic reticulum due to

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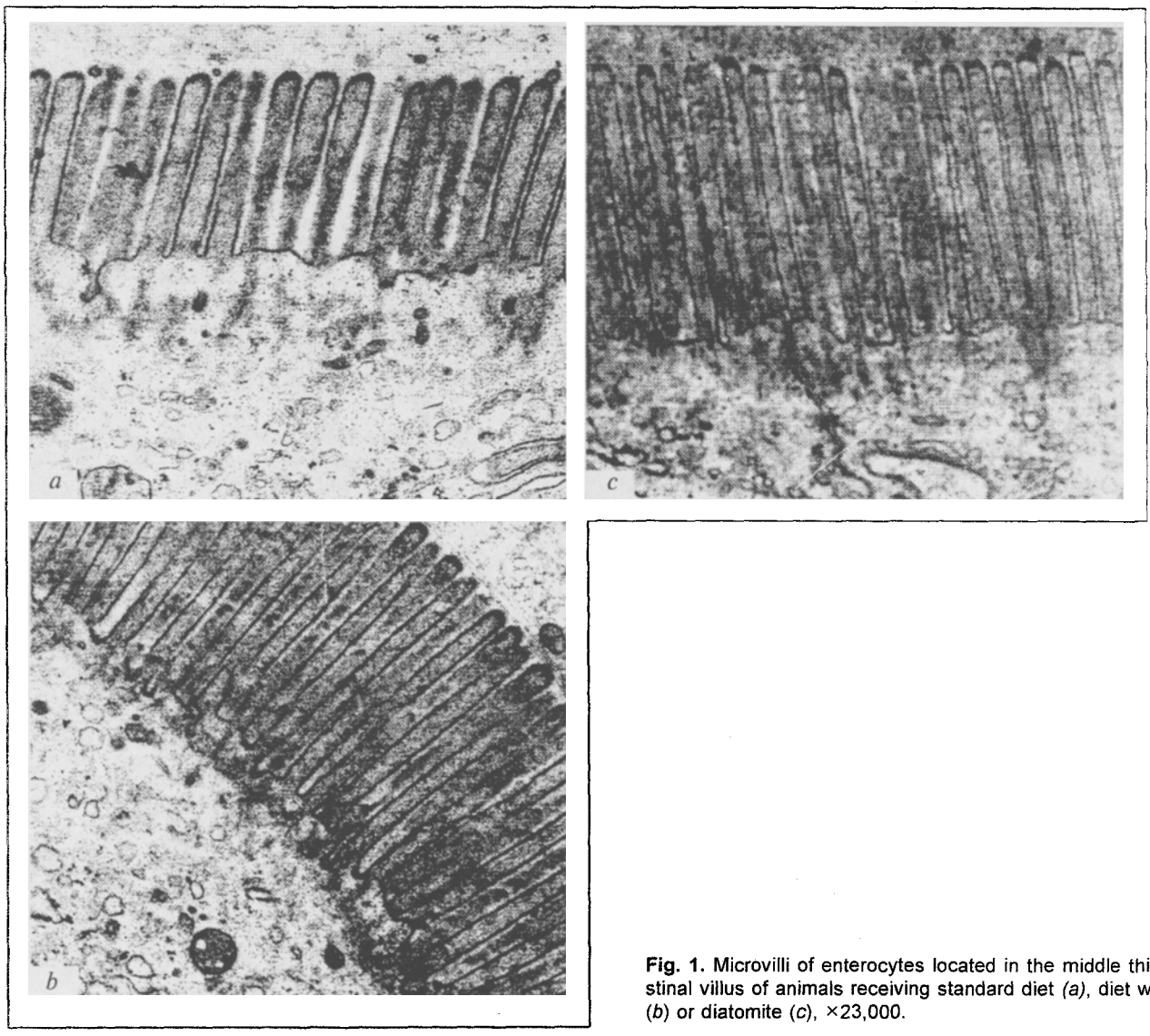

Fig. 1. Microvilli of enterocytes located in the middle third of intestinal villus of animals receiving standard diet *(a)*, diet with zeolite (*b*) or diatomite (*c*), ×23,000.

TABLE 1. Morphometric Parameters of Enterocytes in the Small Intestine Crypts in Rats Given Naturally Occurring Sorbents *(M±m)*

Parameter	Standard diet	Standard diet+zeolite	Standard diet+diatomite
Rough endoplasmic reticulum			
Vv	2.9±0.50	4.4±1.62	4.9±1.20
Sv	1.8±0.43	1.4±0.54	1.4±0.27
Mitochondria			
Vv	29.4±5.5	28.5±6.2	27.0±6.6
outer membrane (Sv)	1.5±0.23	1.4±0.25	1.4±0.27
inner membrane (Sv)	3.6±0.84	3.4±0.74	4.1±0.91
Ribosomes			
attached (Nv)	132.2±41.4	148.5±33.1	122.3±39.5
free polysomes (Nv)	298.5±80.4	367.4±88.4	318.5±98.7
Lysosomer (Vv)	1.5±1.11	1.8±0.40	1.3±0.66

Note. Here and in Tables 3 and 4: *Vv)* volume density of intracellular organelles (% of cytoplasm volume); *Sv)* surface density (μm^2 per μm^3 cytoplasm); *Nv)* numerical density of structures (number per μm^3 cytoplasm).

widening of its cisternae was observed in rats given zeolite.

Enterocytes located in the middle part of the villus exhibit the highest absorbing activity and possess the longest microvilli [2]. In animals receiving the sorbents, the absorbing surface of the cells was changed (Fig. 1).

The length of microvilli increased. A tendency toward an increase in the number of microvilli per unit area and a decrease in the microvillus diameter was observed (Table 2).

Although the absorbing surface of enterocytes increased, there were no structural changes in endocytosis occurring in the apical pole of these cells (Table 3). Presumably, this was associated with a high rate of transport in this zone and the effect of fixing solution on the apical surface which prevented the formation of new endocytotic vesicles [2].

At the resting state, the organelles of enterocytes are located predominantly in the supranculear zone [4].

The tendency toward an increase in volume density of rough endoplasmic reticulum was more pronounced in rats given diatomite (Table 4). In rats receiving zeolite, the surface density of mitochondrial membranes and the number of attached ribosomes were increased (Table 4).

TABLE 2. Morphometric Parameters of Enterocyte Microvilli in the Small Intestine of Rats Given Naturally Occurring Sorbents *(M±m)*

Parameters, μm	Standard diet	Standard diet+zeolite	Standard diet+diatomite
Length of microvilli	1.2±0.28	2.0±0.40*	1.8±0.38*
Coss section area	0.17±0.020	0.13±0.018	0.13±0.011
Distance between microvilli	0.02±0.016	0.03±0.011	0.03±0.013
Number of microvilli (per 10 μm)	54.4±5.6	64.8±10.4	58.4±8.1

Note. *$p<0.05$ compared with the control.

TABLE 3. Morphometric Parameters of Apical Zone of Enterocytes *(M±m)*

Parameter	Standard diet	Standard diet+zeolite	Standard diet+diatomite
Endocytosis vesicles			
Vv	5.7±1.10	7.0±1.22	3.6±1.15
Nv	23.8±3.8	23.7±7.6	18.2±6.1
Rough endoplasmic reticulum (Vv)	2.7±0.73	1.9±0.90	2.6±0.81
Mitochondria (Vv)	4.3±2.0	3.5±1.8	3.0±1.50
Polysomes (Vv)	4.3±2.17	2.3±1.61	6.7±2.91
Lysosomes (Vv)	1.0±0.95	0.6±0.48	0.6±0.23
Desmosomes (L)	0.23±0.065	0.22±0.054	0.23±0.060

Note. *L)* length of structures, μm.

Table 4. Morphometric Parameters of Supranculear Zone of Enterocytes *(M±m)*

Parameter	Standard diet	Standard diet+zeolite	Standard diet+diatomite
Rough endoplasmic reticulum			
Vv	9.4±1.38	13.9±3.73	10.7±1.33
Sv	2.3±0.33	2.6±0.64	2.2±0.56
Mitochondria			
Vv	25.3±4.5	27.6±3.7	28.0±4.7
outer membrane (Sv)	1.4±0.35	1.5±0.37	1.5±0.48
inner membrane (Sv)	4.1±1.34	7.3±2.07	3.4±1.06
Ribosomes			
attached (Nv)	141.8±43.8	202.9±53.7	171.2±53.4
free polysomes (Nv)	266.7±67.0	222.4±82.7	257.1±85.5
Lysosomes (Vv)	2.3±1.12	1.6±0.70	1.6±0.60

Thus, long-term consumption of diet supplemented with the naturally occurring sorbents zeolite and diatomite does not affect structural integrity of epithelial lining in the small intestine and increases the absorbing surface area by lengthening microvilli and increasing their number. Both sorbents did not cause changes in organelles of enterocytes of crypts and villi. The tendency toward an increase in volume density of mitochondria, surface density of mitochondrial membrane, and numeric density of attached ribosomes in enterocytes of intestinal villi was more pronounced in rats receiving zeolite, which may point to increased adaptive potential of cells.

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