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EFFECTIVENESS AND ADAPTATION TO FOOD QUALITY OF THE STARCH-GLUCOSE CONVEYOR AFTER LIGATION OF THE BILE AND PANCREATIC DUCTS IN RATS

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Membrane hydrolysis and carbohydrate transport were determined in different segments of the small intestine of rats 2 h after the animals had been fed with bread or meat, on the 4th, 7th, and 14th days after ligation of the bile and pancreatic ducts. The results showed that even when the amylolytic activity of the mucosal surface was sharply reduced, the transport of glucose liberated during contact hydrolysis of starch was inhibited to a much lesser degree. For 2 weeks the intensity of transport of starch glucose rose sharply in preparations from the intestine of rats fed on bread but fell in rats fed on meat. The differences between the levels of hydrolysis of starch and transport of free glucose in the rats of the two groups were not significant.

KEY WORDS: *contact digestion; carbohydrates; ligation of the bile and pancreatic ducts.*

The hypothesis of the digestive transport conveyor as a structural-functional system of the enterocyte [5-7] affords fresh opportunities for the study of the adaptive reactions of the small intestine. It has been shown, in particular, that the mechanism of coupling of hydrolytic and transport processes not only ensures the high efficiency of work of the digestive system, but also plays an important role in adaptive reactions [1, 3-6]. The participation of a coupling mechanism in the adaption of the starch-glucose conveyor to food quality after a single feeding was demonstrated previously [2] in intact rats. Considering the changes in the regulatory properties of the enterocytes in certain forms of pathology [7, 8], it was decided to study the adaptive reactions of the systems of membrane hydrolysis and transport against the background of various food stimuli after disturbance of luminal digestion.

Digestive and transport activity of the intestinal epithelium was investigated in rats after ligation of the bile and pancreatic ducts.

EXPERIMENTAL METHOD

Adult rats were kept on a mixed diet and, after starvation for 18-20 h, they were fed with bread or cooked meat. The rats were decapitated 2 h after the beginning of feeding. The level of membrane hydrolysis and of carbohydrate transport was determined in the proximal, middle, and distal segments of the small intestine.

Hydrolysis of sucrose and soluble starch (2% solution) in everted pieces of small intestine was determined by a modified Nelson's method [8, 10]. Absorption was studied with the aid of accumulating preparations of the mucosa [9], which were incubated in an 11.1 mM

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TABLE 1. Hydrolysis and Transport of Carbohydrates in Middle Segment of Small Intestine of Satiated Rats after Ligation of Bile and Pancreatic Ducts (M ± m)

Day after operation	Food stimulus	Hydrolysis of starch, mmoles hexoses/cm	Hydrolysis of sucrose, mmoles hexoses/cm	Accumulation of S glucose, mmoles		Accumulation of G glucose, mmoles	
				30 min	60 min*	30 min	60 min*
Control	Bread	29,9±3,9	2,8±0,3	21,9±2,2	150	35,6±2,6	126
	Meat	34,0±5,1	2,9±0,4	30,2±5,4	105	26,8±3,5	117
4th	Bread	2,4±0,2	3,5±0,5	5,5±0,9	80	26,6±1,6	131
	Meat	2,5±0,5	3,3±0,2	2,5±0,3	302	32,4±5,1	115
7th	Bread	4,4±0,7	2,7±0,3	6,5±1,6	158	22,3±3,3	162
	Meat	11,3±1,9	2,3±0,2	7,9±1,9	137	39,8±5,0	104
14th	Bread	7,5±1,8	3,0±0,3	30,2±5,2	93	27,6±1,1	134
	Meat	8,1±0,8	3,5±0,2	1,0±0,2	454	29,7±3,1	150

*Transport activity (in % of that after incubation for 30 min).

solution of glucose and soluble starch for 30 and 60 min, with constant aeration, and subsequent determination of the glucose concentration in the tissues [10]. The substrates were prepared in Ringer's solution, pH 7.4. The functions of the small intestine of the control rats were studied on the fourth day after laparotomy.

EXPERIMENTAL RESULTS

The data on hydrolysis and transport of carbohydrates in the middle segments of the small intestine are given in Table 1. The principal patterns described below were also observed in the experiments with the other segments, and the few differences that were found confirm the heterogeneity of the properties of the cell population along the intestine [2, 8]. During the first days after ligation of the ducts membrane hydrolysis of starch was sharply inhibited. Signs of compensatory reactions were observed by the end of the first week. Between the 7th and 14th days after the operation the properties of the systems for hydrolysis of starch showed different changes in rats fed with bread and meat; in the latter group of rats there was a tendency toward retardation of the hydrolysis of polysaccharides.

Changes in invertase activity in the rats of both groups were not significant and only a tendency toward phasic reactions was observed in the course of the period.

The dynamics of the change in absorption of glucose liberated during membrane hydrolysis of starch (S glucose) was largely the same as that for the systems of polysaccharide hydrolysis. After a sharp fall on the fourth day after the operation the accumulation of S glucose rose progressively in the rats fed with bread. In rats fed with meat the increase took place from the fourth to the seventh day, after which absorption again slowed down considerably. Transport of glucose as such (G glucose) after ligation of the ducts averaged 70% of the initial level in the rats fed with bread, but on the other hand showed a tendency to increase in rats fed with meat.

The sharpest changes were thus observed in the properties of the systems of contact hydrolysis of starch and transmembrane transport of S glucose. A more important fact was that the dependence of the effects on the quality of the food stimulus was particularly marked in the case of transport processes coupled with preliminary hydrolysis.

The ratio between the activity of the systems for hydrolysis of starch and accumulation of S glucose in rats receiving bread and meat changed differently in the postoperative period. For instance, in rats fed with bread, on the fourth day after the operation the hydrolysis of starch was 8% of its initial level and transport of S glucose was almost 25%; on the 14th day the corresponding figures were 25 and 137%. In rats fed with meat, although the level of starch hydrolysis was similar, the rate of absorption of S glucose was about 8 and 3% on the 4th and 14th days after the operation.

The results confirm that the coupling of hydrolytic and transport processes in the small intestine is controllable and they are indirect evidence that the effectiveness of the digestive-transport conveyor is due primarily to the method of interaction between these processes [6, 7]. Under pathological conditions the effectiveness of the starch-

glucose conveyor rose sharply after carbohydrate feeding but fell after protein feeding.

On the basis of Ugolev's hypothesis of the plastic organization of the conveyor [5-7] it can be postulated that at least some of the phenomena described above are due to changes in the relative contributions of the hydrolytic and transport components of the conveyor. To test this hypothesis, the dynamics of transport of S and G glucose was compared with an increase in the duration of incubation from 30 to 60 min. Clearly at certain times of observation an increase in the duration of incubation had little effect on the level of absorption of S glucose in rats fed with bread, but sharply increased its absorption after protein feeding.

The activity of the systems of general transport (G glucose) decreased after the operation in rats fed with bread but increased in rats fed with meat. Between 3 and 60 min of incubation the accumulation of G glucose in the tissue was particularly considerably increased in rats fed with bread.

The reorganization in the starch-glucose conveyor after a single meal thus depends on the type of food and it is particularly marked at the level of coupling of hydrolysis and transport processes. The mechanisms of this reorganization require further study.

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