

CHARACTERISTICS OF THE SECRETION FROM DIFFERENT PORTIONS OF THE INTESTINE IN DOGS

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The attention of physiologists has long been directed towards the fact that the intestinal juice consists of two components: a liquid and a solid part, given the name of "mucous granules" [9]. The solid portion of the intestinal juice was formerly ascribed the role of acting as a framework for the feces. It was later discovered in the laboratory of the physiology of digestion of the Institute of Nutrition that the bulk of the enzymes: enterokinases, phosphatases, peptidase, lipases and saccharases — are secreted as components of the solid portion of the intestinal juice [10, 11, 8, 3], which was also confirmed by histochemical investigations [6].

N. P. Shepov'nikov further found [9] that the solid portion of the secretion of the small intestine contains occasional degenerating cells from the intestinal epithelium, cholesterol crystals and pigments. L. S. Fomina [8] confirmed that the solid portion of the intestinal juice consists mainly of desquamated, disintegrating intestinal epithelial cells from the mucous membrane, and in addition contains a small number of lymphocytes and polymorphonuclear leucocytes. M. I. Razumov [4] described the morphological aspects of the processes concerned with the formation of the solid portion of the intestinal juice in dogs.

The secretion of enzymes by the large intestine has received very little study until recent times [1, 7]. We were unable to find in the literature any information about the secretion of the large intestine.

Only recently one of us [2] carried out an investigation of the juice of the caecum and the middle part of the large intestine, by the use of quantitative methods of enzyme estimation. The main results obtained in this experiment are given below.

In the present work our aim was to make comparative histological investigations of the secretion obtained from different divisions of the intestine, both small and large.

EXPERIMENTAL METHOD

The work was carried out on 9 dogs, with portions of various divisions of the intestine isolated by the Thiry method: in 3 animals segments of the duodenum and caecum were isolated; in 2 others, the duodenum and the middle part of the large intestine and in 4 animals, segments of the lower portion of the ileum.

The intestinal juice obtained during periodical secretion was examined. Its enzyme content: enterokinase, alkaline phosphatase, saccharase, lipase and peptidase — was determined by the methods adopted in the laboratory of the physiology of digestion [8, 12]. For the morphological examinations, intestinal juice was fixed without centrifuging in Zenker's fluid, formalin and alcohol. The fixed granules of the juice were embedded in paraffin wax. Sections, 6 μ in thickness, were stained with hematoxylin-eosin and thionine, and the distribution of desoxyribonucleic acid (DNA) was studied also, for which purpose Feulgen's histochemical reaction was used. Altogether 17 portions of juice were fixed and treated from the duodenum, 20 from the small intestine, 20 from the caecum and 12 from the middle portion of the large intestine.

EXPERIMENTAL RESULTS

During secretion without any local mechanical stimulation, in 5 hours from 0.2 to 1 ml of juice is produced by the caecum and by the isolated segment of the middle part of the large intestine — from 0.15 to 1.35 ml. The juice from both parts of the large intestine consists of a transparent fluid with greyish yellow granules and an admixture of a gelatinous, transparent mucus. The liquid and solid portions of the juice in these divisions are usually in the proportion of 1 : 1. Since the volume of juice during periodic secretion is very small, for the investigation of the individual enzyme contents of the liquid and solid portions we used juice obtained as a result of local mechanical stimulation.

TABLE 1

Enzyme Content of Intestinal Secretion (in units of 1 g) Obtained by Local Mechanical Stimulation

Dog No.	1		2		3		4	
Liquid or solid portion of juice	liquid	solid	liquid	solid	liquid	solid	liquid	solid
Amount of secretion in 5 hours (in g) . .	0,5	0,45	2,5	0,45	2,05	0,5	4,15	1,8
Phosphatase	300	2 400	185	1 500	350	3 930	300	3 370
Peptidases	0,0	120	0,0	41	14,5	82	7,2	50
Lipase	0,0	33	0,0	0,0	traces	52	traces	50

It can be seen from Table 1 that the bulk of the alkaline phosphatase, peptidase and lipase in the caecum and the middle part of the large intestine is secreted as components of the solid portion of the juice. This fact suggests that the process of enzyme secretion in the large intestine is of the same character as in the small intestine, consisting of the accumulation of enzymes in the epithelial cells. These then become desquamated into the lumen of the bowel, where they undergo disintegration and the enzymes are liberated into the chyme.

TABLE 2

Quantity of Enzymes in 1 g of the Solid Portion and the Quantity of Enzymes Produced During 1 Hour's Secretion From Various Areas of the Intestine During Periodic Secretion

Composition of secretion	During secretion for 1 hour				Enzyme content of 1 g of mucous granules			
	caecum		duodenum		caecum		duodenum	
	limits of variation	mean	limits of variation	mean	limits of variation	mean	limits of variation	mean
Phosphatase	96—380	187	1350—8100	5070	500—3620	2107	11000—54000	32300
Peptidase	5,1—9,1	7,0	39,8—398	114,9	42,0—95,9	69,8	239—1199	616
Lipase	1,6—5,0	3,0	22,2—132	64,0	25,0—105,6	56	180—600	378
Saccharase	0,04—0,26	0,15	0,23—1,94	0,75	—	—	—	—
Liquid portion	0,0—0,13	0,06	0,15—1,62	0,57	—	—	—	—
Mucus granules	0,04—0,13	0,09	0,06—0,32	0,18	—	—	—	—

However, the solid portion of the juice of the caecum contains 15-20 times less phosphatase and 10 times less lipase and peptidase than the solid portion of the duodenal juice. The rate of separation of the enzymes into

the composition of the juice of the caecum was also many times lower than that into the composition of the duodenal juice (Table 2).

The same relationships were observed also during a comparison of the duodenal juice with the juice secreted by the isolated segment of the middle part of the large intestine (Table 3).

TABLE 3

Quantity of Enzymes in 1 g of Mucous Granules and During 1 Hour's Secretion in Various Areas of the Intestine During Periodic Secretion

Composition of secretion	During secretion for 1 hour		Enzyme content of 1 g of mucous granules					
	middle part of the large intestine		duodenum		middle part of the large intestine		duodenum	
	limits of variation	mean	limits of variation	mean	limits of variation	mean	limits of variation	mean
Phosphatase . .	33,7—1 340	232	6 120—12 260	8670	940—8 930	2 650	16290—72000	39 870
Peptidase . . .	3,6—21,8	12	58—123,6	90,5	36,2—109	68,3	156—1060	452
Lipase	3,8—9,4	6,6	35,7—102,1	59,1	47—56,4	51,7	121—695	280
Saccharase . .	0,05—0,27	0,17	0,4—0,94	0,69	—	—	—	—
Liquid portion . . .	0,0—0,11	0,09	0,25—0,65	0,45	—	—	—	—
Mucus granules . . .	0,02—0,25	0,08	0,09—0,39	0,24	—	—	—	—

The morphological investigations showed that the solid portion of the intestinal juice from the duodenum and the lower part of the ileum have the same structure. It consists of accumulations of desquamated epithelial cells in various stages of disintegration, and of a small number of lymphoid cells. Sometimes in the mass of the

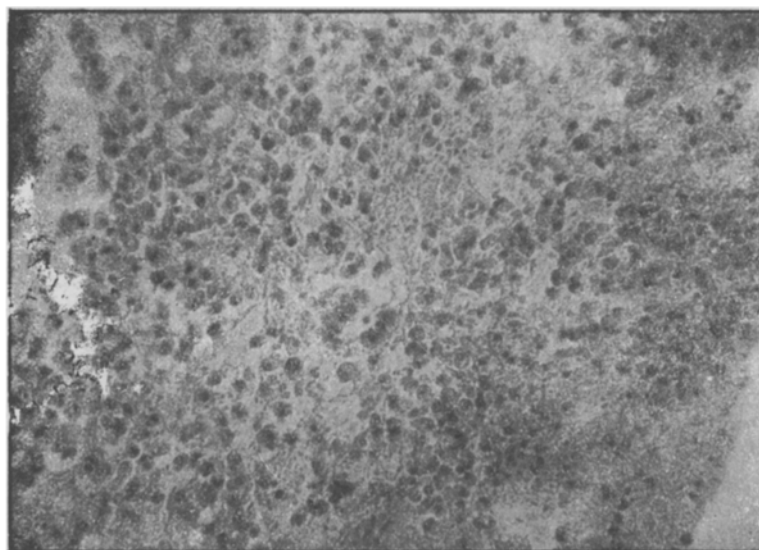


Fig. 1. Duodenal secretion in the experiment dated July 10, 1955. Stained with hematoxylin-eosin. Magnification 3 x 40. In the center of the film is seen a layer of epithelial cells which are not yet destroyed.

solid portion of the intestinal juice can be seen a small number of cells which have not yet been destroyed. They are arranged in the form of a layer or of a fragment of an epithelial tube, as described by M. I. Razumov (Fig. 1).

The nuclei of these cells often keep their normal size, intensity of staining and arrangement of chromatin, and the cells themselves retain their prismatic shape and well stained protoplasm. In the process of further conversion in the lumen of the intestine, the nuclei of the epithelial cells may retain their structure even when the protoplasm is destroyed. In contrast to the epithelial cells, the cytoplasm of the lymphoid cells as a rule does not stain, but the nucleus and the arrangement of the chromatin inside it are well preserved.

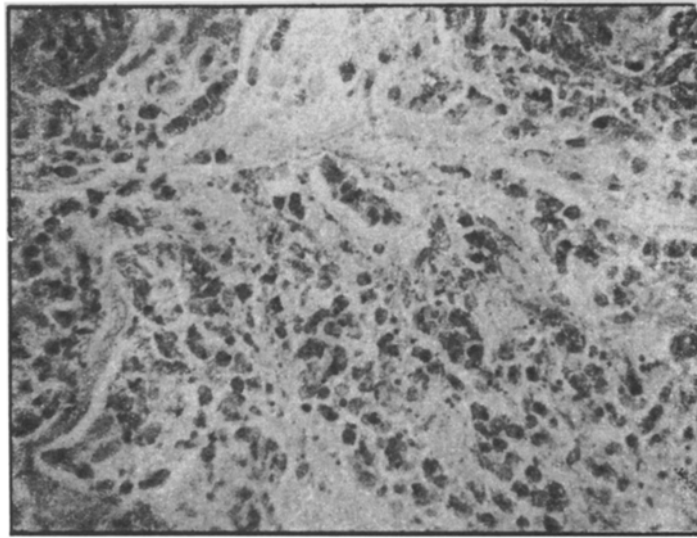


Fig. 2. Secretion of the caecum.
Stained with hematoxylin-eosin. Magnification 3×40 . Cytoplasm well preserved. Cells arranged on a homogeneous fibrous background.

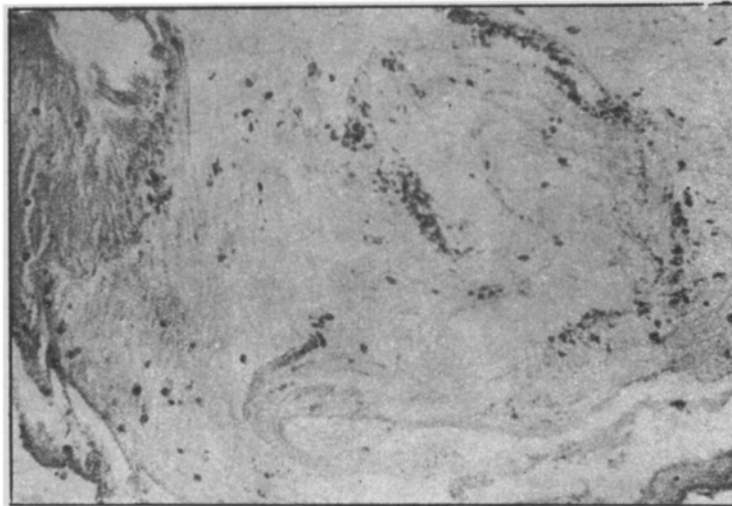


Fig. 3. Secretion of the middle part of the large intestine.
Stained with hematoxylin-eosin. Magnification 3×20 . Occasional scattered cells are seen against a homogeneous background.

On the fixed preparations the greater part of the secretion has the appearance of an aggregation of granular protein masses, staining intensively with eosin and consisting of products of disintegration of the protoplasmic part of the cells. Amidst the granular protein framework nuclei are arranged, sometimes evenly, sometimes densely. The majority of nuclei are reduced in size, often shrunken, and staining intensively and continuously with basic dyes. In addition, in the mass formed by disintegration of the protoplasm of the cells granules are distributed, sometimes having the appearance of droplets. All these formations are products of rupture of the cell nuclei. They stain intensively with hematoxylin and give a clearly positive reaction for desoxyribonucleic acid (DNA). On treatment of the films by Feulgen's method, in some portions of the secretion the individual stages of destruction of the nuclei can be traced. In place of the nucleus several granules of nuclear material appear in the cell, distributed in the cytoplasmic part of the cell. The number of these granules may vary. In far advanced processes of autofermentation of the cells, the nuclei are shattered into tiny granules having the appearance of droplets. The nuclear membrane ceases to be distinguishable and the droplets lie quite evenly throughout the cell. When the margins of the cells are destroyed, they are distributed throughout the whole mass of the juice, including the liquid portion, where they can be found by staining with hematoxylin and by the Feulgen reaction for DNA. M. I. Razumov [5] reported similar findings. Sometimes the nuclear granules and droplets merge with each other, forming clumps of nuclear material in the form of large spheres. These clumps give a positive reaction for DNA. Their formation may possibly be associated with processes of autofermentation caused by delay in secretion of the solid portion of the juice.

The investigations show that the solid portion of the juice from the caecum, like the solid portion of the juice from the small intestine, is an accumulation of desquamated, disintegrating cells from the epithelial lining, together with a few lymphoid cells. In this juice many of the nuclei also are apparently disintegrating into separate fragments of various sizes or into fine droplet-like granules. Individual stages in the splitting up of the nuclei may also be observed. Sometimes the DNA of the nuclei of the solid portion of the juice in this division of the intestine also forms small clumps in the form of spheres 2-3 times larger than the nucleus, or rod-like formations. However, in the solid portion of the caecal juice secreted periodically, it is never possible to see nuclei with a normal distribution of chromatin and with the characteristic intensity of staining. The majority of the nuclei are pyknotic and are shaped like angular clumps.

The cytoplasm of the cells in the juice from the caecum is better preserved than in the juice from the small intestine. It always stains intensively and has sharply outlined contours. Sometimes the contours of the protoplasm of the cells are well outlined even when their nuclei are completely absent. The cells themselves in the caecal secretion lie separately, and sometimes are unevenly distributed among the homogeneous fibrous mass that forms a background (Fig. 2). After treatment of this secretion with thionine a comparatively large amount of mucus is revealed in the form of quite large bands and threads. This is hardly observed at all in the juice of the small intestine.

The juice from the middle part of the large intestine is distinguished morphologically from the caecal juice by the fact that in the solid portion of the juice of this division of the intestine, areas are often observed in which few cells are found. The cells lie at great distances from each other, distributed among a large volume of mucus which has a homogeneous fibrous structure or appears in the form of thick bands and threads (Fig. 3).

In many samples of juice obtained from isolated segments of various divisions of the intestine, small collections of polymorphonuclear leucocytes are observed. These cells may possibly find their way into the juice from the outer margin of the orifice of the fistula.

The structure of the liquid portion of the intestinal juice is the same in the histological preparations from all divisions of the intestine. It has the appearance of a collection of protein material in the form of fine granules, among which may sometimes be seen isolated cells and droplets of nuclear substance.

SUMMARY

Ferments — phosphatase, lipase and peptidase are contained in the compact part of the large intestinal secretion. The compact portion of secretion from the isolated section of duodenum, ileum, caecum and the medial portion of the large intestine consists of detached epithelial cells (at various stages of disintegration), mucus and lymphoid elements. However, the compact part of secretion is characterized by its own morphological peculiarities in each portion of intestine. Much more cellular elements are contained in the compact part of duodenal and small intestinal secretion than in the compact portion of secretion of the caecum and the medial portion of the large intestine. The latter contains much mucus and the cytoplasm is better preserved. However, there are no nuclei with the normal structure revealed.

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