EFFECT OF HYDROXY POLYMERS ISOLATED FROM SUNFLOWER OIL ON THE STATE OF THE GASTROINTESTINAL TRACT IN EXPERIMENTAL ANIMALS

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Food fats, especially liquid vegetable oils, are readily oxidized by the oxygen of the air with the formation of various oxidation products. In the first place, as a rule, unstable hydroperoxides and peroxides are formed in the fats, followed by more stable products—epoxides, hydroxy acids, hydroxy polymers, cyclic monomers, aldehydes, ketones, etc. [1, 2, 3, 6, 7, 9, 14].

The character, rate of formation, and accumulation of the various oxidation products of fats depend on the temperature, degree of aeration, and the action of light, microorganisms, or other factors.

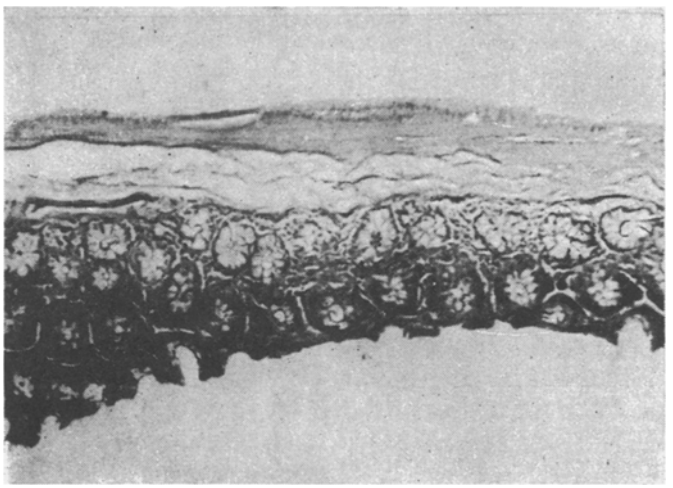

Fig. 1. Regenerative changes in the gastric mucosa at the site of deep sloughing. Stained with hematoxylin-eosin. Ocular: Hamal 4, objective 3.7.

Investigations have shown [4, 5, 8, 10, 11, 12, 13, 15, 16] that the oxidation products of fats are to some extent toxic to animals. Bearing in mind that the chemical structure and properties of oxidation products of fats may vary widely, it is to be expected that their action on the organism will differ.

The object of this investigation was to examine the character of the action of a polymer fraction isolated from spontaneously oxidized sunflower oil on the organs of the gastro-intestinal tract of experimental animals.

The polymer fraction was specially isolated in the lipid investigation division of the All-Union Lipid Research Institute by Z. K. Lebedeva from sunflower oil which had been kept for a long time in the presence of air at room temperature.

The principal characteristics of the polymer fraction were as follows: acid number 143.5, iodine number 45.9, hydroxyl number 45.7, refractive index at 20° 1.4, specific gravity at 20° 1.070, elementary composition (in %): carbon 67.47, hydrogen 10.28, oxygen 22.25 (from the difference). According to the report from the lipid investigation division, chemical analysis and spectrophotometry revealed that the fraction isolated consisted mainly of dimers.

EXPERIMENTAL METHOD

Male albino rats weighing about 50 g were used in the experiments. The experimental animals (24) received a standard laboratory diet. The polymer fraction was added to the diet as a 5% solution in refined sunflower oil, so that on the average the animals received 1 g/kg body weight of polymer daily. The control group (24 rats) received the same diet and refined sunflower oil without polymers.

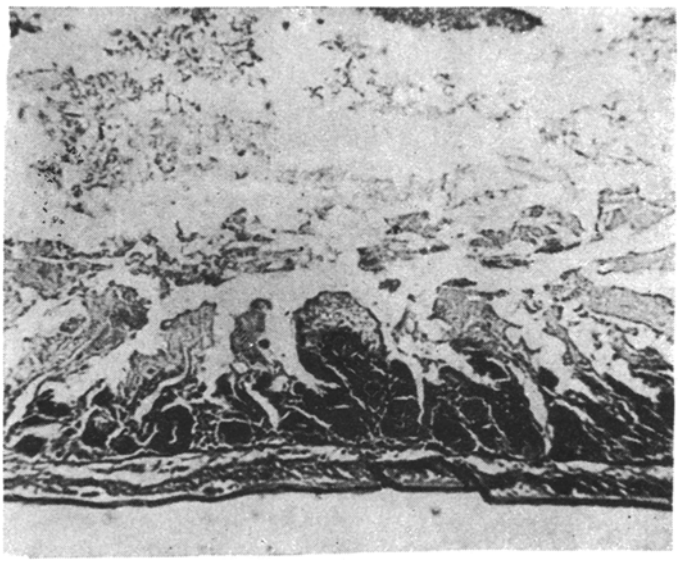

Fig. 2. Hypersecretion and desquamation of duodenal mucosa. Hematoxylin-eosin. Ocular: Hamal 4, objective 3.7.

The sunflower oil and solution of the polymer fraction were kept in a glass vessel in a refrigerator under a layer of inert gas to prevent accumulation of spontaneous oxidation products. The diet for the experimental animals was prepared daily in the form of a fine mince of all the components of the daily ration. Each animal received a daily food intake equivalent to 60 cal/100 g body weight. Water was given ad lib. The experiments lasted for 12-14 weeks. Throughout this period biological observations were made on the growth and development of the animals and on their general condition.

EXPERIMENTAL RESULTS

During the first 2-3 weeks the animals receiving polymer fraction in addition to their diet were almost indistinguishable from the controls. From the third week the experimental animals began to fall behind the controls in body weight. Between the third and fifth weeks of the experiments the animals did not eat their food and hardly gained in weight. After the end of the fifth week, they again began to eat a large part of their food and to gain in weight, although they still lagged behind the controls. At the end of the fourteenth week the mean weight of the experimental rats was only 176 g, compared with 214 g in the control group.

At the end of the fourteenth week of the experiment, all the animals were sacrificed by an overdose of ether. The organs of the gastro-intestinal tract were immediately fixed in 15% formalin solution. Histological examinations were made of the esophagus, the stomach, and the intestines. The sections were stained with hematoxylin-eosin, by Van Gieson's method, and with Sudan III.

No significant changes were found in the esophagus; the desquamation of the surface layers of epithelium was merely more marked than normally. No changes were found in the subjacent tissues.

In the stomach wall catarrhal and desquamative changes were present. Necrosis and sloughing of the superficial layers of the mucous membrane were observed. The deep layers of the mucous membrane and the submucosa showed edema of the stroma and infiltration with small round cells. In the pyloric part of the stomach and in the region of the fundus the processes of desquamation were much more marked than in other parts. In some sections deep defects of the mucous membrane of the stomach were observed, covered in many places by glandular epithelium growing out from the residual superficial glands, indicating that the sloughing of the mucous membrane was an antemortem process and that it was accompanied by regeneration (Fig. 1).

In the duodenum superficial and, in some places, deep sloughing of the mucous membrane were found. The spithelial cells were enlarged and distended with secretion, and their nuclei showed signs of necrosis and necrobiosis (Fig. 2). In some fields of vision deep defects of the mucous membrane were present in the form of ulcers, the base of which was formed by the submucosa, infiltrated with small connective-tissue cells.

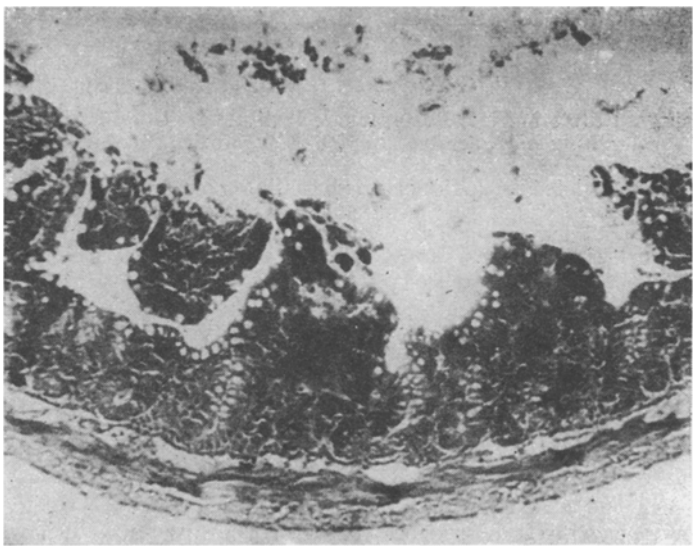

Fig. 3. Deep defects in mucous membrane of the small intestine; round-cell infiltration of the stroma. Hematoxylin-eosin. Ocular: Hamal 4, objective 3.7.

The other divisions of the small intestine showed more marked changes in every case than the duodenum. In sections of the wall of the small intestine taken from different points the signs of catarrhal desquamation were more marked than elsewhere in the alimentary tract. Here the whole mucosa and submucosa were grossly swollen and edematous. The superficial layers of the mucous membrane showed necrobiotic and necrotic changes almost throughout their length, and sloughing was present in many places. Transverse sections revealed flakes of desquamated mucous membrane in the lumen of the bowel. In the remaining layers of the mucous membrane signs of necrobiosis and necrosis were found. In some places the sloughing of the mucous membrane was so deep that only the submucosa was left. Where deep lesions of the mucous membrane were present the blood vessels were engorged and the stroma edematous in the submucosa, and a few groups of round connective-tissue cells were seen (Fig. 3). Processes of proliferation were found in the glandular epithelium at these places. In some fields of vision the defects in the mucous membrane were covered with one layer of glandular epithelium in the form of a uniform line, and in others in the form of a zigzag line, composed of incompletely formed regenerating glands of the mucosa.

In the large intestine necrosis and sloughing of the mucous membrane also were present, but were less marked and more superficial in character than in the small intestine. Deep sloughing was rare in this situation. Staining for lipids revealed tiny droplets of orange particles in nearly all the epithelial cells of the mucous membrane of the large and small intestine and stomach showing necrotic and necrobiotic changes. The highest degree of saturation of the epithelial cells with lipids was found in the small intestine, a lower degree in the large intestine, and a much lower degree in the stomach. Few lipid droplets were present in the residual glands of the deep layers of the small and large intestine, and these had the appearance of a fine dust in the cytoplasm of the cells. No such changes were found in the corresponding organs from the control animals.

Necrobiotic and necrotic changes were observed inconstantly in the epithelium of the gastric and intestinal mucous membrane of the control group of animals. Superficial desquamation of the mucous membrane of these organs was also noted. However, comparison of the sections from the control group with those from the animals receiving hydroxy polymers revealed a significant difference in the degree of desquamation of the gastric and intestinal mucosa. Whereas in normal conditions only individual epithelial cells were desquamated or only the superficial layers of the mucous membrane were sloughed, in the experimental animals the sloughing of the mucous membrane was deep, sometimes extending down to the submucosa, which was never found in the control animals.

SUMMARY

Oxipolymers, isolated from the oxidized sunflower oil and administered with food in the amount of about 1 gm per kg of body weight for 12-14 weeks proved too toxic for animals, and led to the delay in weight gain. Introduction of the mentioned oxipolymers into the diet of rats caused catarrhal changes in the stomach and intestine.

LITERATURE CITED

1. A. A. Zinov'ev, Chemistry of Fats [in Russian], p. 412, Moscow (1952).
2. I. A. Smorodintsev, Biochemistry of Oil [in Russian], p. 269, Moscow (1952).
3. V. P. Rzhekhin, N. I. Pogonkina, and É. K. Voronova, Transactions of the All-Union Research Institute of Lipids [in Russian], No. 19, p. 276, Leningrad (1959).
4. V. Benes and B. A. J. Sedlacek, Zh. gig. épidemiol. (Prague), 3, 343 (1959).
5. A. Dangouman, Boussagol, and H. Debruyne, Rev. franc. corps gras., 5, p. 613 (1958).
6. J. Fugger, J. A. Cannon, K. T. Zilch, et al., J. Am. Oil Chemists' Soc., 28, p. 285 (1951).
7. O. C. Johnson and F. A. Kummerow, J. Am. Oil Chemists' Soc., 34, p. 407 (1957).
8. T. Kaneda, H. Sakai, and S. Ishii, J. Biochem. (Tokyo), 42, p. 561 (1955).
9. H. P. Kaufmann, J. G. Jhieme, and J. G. Thieme, Fette und Seifen, Bd. 57, S. 1040 (1955).
10. H. Kaunitz, C. A. Slanetz, R. E. Johnson, et al., J. Am. Oil Chemists' Soc., 33, p. 630 (1956).
11. K. W. Keane, G. Jacobson, and C. Krieger, J. Nutr., 68, p. 57 (1959).
12. N. Matsuo, J. Japan Soc. Food and Nutr., No. 2, p. 118 (1959).
13. Idem, J. Chem. Soc. Japan. Pure Chem. Sec., 81, p. 469 (1960).
14. R. F. Paschke and D. H. Wheeler, J. Am. Oil Chemists' Soc., 32, p. 473 (1955).
15. B. Y. Rao, J. Scient. and Industr. Res., 19, A, p. 430 (1960).
16. M. C. Reporter and R. S. Harris, J. Am. Oil Chemists' Soc., 38, p. 47 (1961).

All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. *Some or all of this periodical literature may well be available in English translation.* A complete list of the cover-to-cover English translations appears at the back of this issue.