7. D. S. Sarkisov and B.V. Vtyurin, Electron-Microscopic Analysis of Increased Tolerance of the Heart, Moscow (1969).
8. A. N. Shchegol'kov, in: Medical Problems in Physical Culture [in Russian], No. 4, Kiev (1974), p. 83.

PATHOMORPHOLOGICAL CHANGES IN THE TESTES OF RATS FED ON PRODUCTS IRRADIATED WITH γ RAYS

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Information on the harmful effects of prolonged consumption of products preserved by exposure to γ rays has accumulated in the Soviet and western literature. In particular, it has been shown that prolonged feeding with irradiated meat and fish causes disturbances of protein and lipid metabolism, a decrease in the rate of gain of body weight, and a decrease in the number of offspring in experimental animals [2]. Previously [1] the writers described significant morphological changes of the membranous glomerulonephritis type in the kidneys of rats fed for 20 months with irradiated products.

This paper describes the results of a morphological study of the testes of the same animals.

EXPERIMENTAL METHOD

Experiments were carried out on 120 mature male rats aged 1 month kept in all experiments together with the same number of females. The animals of group 1 received the standard animal house diet [1], irradiated in a dose 10 times higher than the optimal dose used in practice for food preservation (0.25-5.6 megarads). The animals of group 2 received food products irradiated in the optimal dose of 25-500 kilorads, and the food given to animals of group 3 was irradiated in a dose one-tenth as high as in group 2 (2.5-56 kilorads). The rats of group 4 (control) received identical food products, but not exposed to γ rays. The food products were irradiated on the K-300 (All-Union Food Conservation Research Institute) γ-ray apparatus with cobalt-60.

All the animals were decapitated 20 months later. The testes were weighed on analytical scales, fixed in neutral 10% formalin, and sections were cut and stained with hematoxylin–eosin, by Masson's method, with Scharlach red, methyl green–pyronine, and by the PAS reaction. To study the dynamics of spermatogenesis, the frequency of discovery of stages of the cycle in the spermatogenic epithelium (CSE) was determined in sections. The numerical data were subjected to statistical analysis.

EXPERIMENTAL RESULTS

The coefficient of variation of the absolute weight of the testes in animals receiving food irradiated in doses of 0.25-5.6 megarads (group 1) and 25-500 kilorads (group 2) was significantly higher than normally. A marked difference was observed in the size and weight of the right and left testes, which could be either increased (up to 2.7 g) or reduced (down to 0.5 g). However, the difference between the ratio of the weight of the larger testis to the weight of the smaller testis was significant only for the males of group 1 ($P < 0.05$), fed with products irradiated in a dose 10 times higher than optimal. Meanwhile, edema of the stroma was observed microscopically in animals of all three experimental groups to a varied degree, accompanied by a high content of PAS-positive substances, enlargement and coarsening of the collagen fibers and, in a few cases, accumulation of labrocytes. Collections of lym-

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phoid cells with pyroninophilic cytoplasm were found in the interstitial tissue and tunica albuginea of nearly all testes. The walls of the blood vessels appeared edematous, with separation of the fibers of the basement membranes and with a high concentration of PAS-positive substances in the subendothelial layer. The basement membranes of the seminiferous tubules also were loosened in structure and thickened because of permeation by PAS-positive substances. Most cells of the spermatogenic epithelium had pycnotic nuclei and contained droplets of fat in their cytoplasm (Fig. 1). Spermatogonia, multinuclear spermatids, and Sertoli cells were preserved in some tubules. Spermatogenic cells were absent from individual tubules. The walls of these tubules were sclerotic and thickened, their diameter was reduced by half to two-thirds, and their lumen was packed with proliferating Sertoli cells with a high content of fat in their cytoplasm. The changes described above were found in 88.2 ± 5.16% of tubules in the animals of group 1, in 41.1 ± 2.44% in group 2, and in 54.4 ± 3.1% in group 3, whereas in the control they were observed in only 11.6 ± 0.48% of tubules.

Regions 0.5-0.8 cm in diameter, yellowish in color with dark red patches, could be distinguished macroscopically in the enlarged testes (1.9-2.7 g). Microscopically it could be seen that these regions consisted of an extensive accumulation of glandulocytes (Leydig cells) (Fig. 2), containing large droplets of fat, among which atrophic tubules, packed with PAS-positive material, and also hemorrhages with clumps of hemosiderin could be distinguished. In the reduced testes, on the other hand, the most conspicuous features were absence of spermatogenesis in the tubules and coarse, sclerotic changes in the interstitial tissue. In addition, small groups of proliferating Leydig cells and foci of coagulation necrosis of the tubular epithelium were found in all testes.

Extensive areas of proliferation of Leydig cells, signs of aspermatogenesis, and coagulation necrosis were observed most frequently in the animals of groups 1 and 2 — in 27.5 ± 6.0 and 13.9 ± 2.1%, respectively, much less often in the rats of group 3 (8.4 ± 1.98%), and not at all in the control.

There was also a significant difference ($P < 0.05$) from the control in the frequency of discovery of the stages of CSE in the sections and, consequently, in their duration. Shortening of the X stage and lengthening of all other stages except the first were noted in the rats of group 1, shortening of stages VIII, X, and XI and lengthening of stages II, V, VII, and XII in group 2, and shortening of stages V, VI, X, and XIII and lengthening of stages II, IV, IX, and XII of CSE in group 3.

The experiments thus showed that three types of morphological changes arise in the testes as a result of prolonged feeding of rats with irradiated products: trophic disturbances, amounting in some cases to coagulation necrosis and aspermatogenesis; compensatory adaptive changes with the formation of large, nodular foci of proliferation of glandulocytes; disturbances of the dynamics of spermatogenesis.

Judging from these morphological observations, the structures first affected were those forming the blood–testes barrier, and later morphological changes were found in the spermatogenic epithelium. This corresponds to the pattern of autoimmune changes in the testes [4, 6]. At the same time, it is noteworthy that the structural changes observed were similar in many respects to those arising in the testes during prolonged exposure to radiation [5]. This similarity evidently is not fortuitous, but is due to the common nature of the initial biochemical factors producing responses of the animal, similar in their final effect, to prolonged feeding with irradiated products and after chronic irradiation. Radiotoxic substances capable of simulating the action of radiation on the body may be formed in irradiated cells and tissues of plant and animal origin [3]. It can therefore be suggested that prolonged entry of such substances into the body in the composition of irradiated food may give rise to morphological changes in the testes, as also in other organs [1], similar to the after-effects of chronic irradiation. This hypothesis is confirmed by the direct dose dependence established between the severity of the structural changes in the testes and the dose of irradiation of the foods consumed. As regards compensatory and adaptive changes, in the form of proliferation of glandulocytes, these may be connected with a reduction in production of the hormone "inhibin" as a result of trophic disturbances in cells of the tubular epithelium [7, 8].

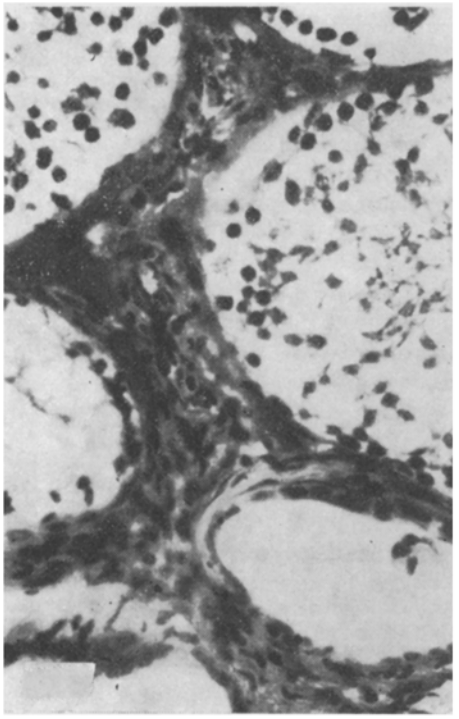

Fig. 1

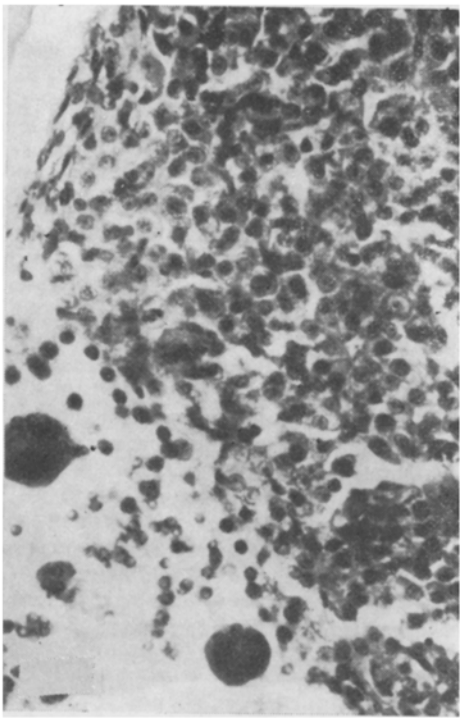

Fig. 2

Fig. 1. Infiltration of stroma, its permeation with PAS-positive material, and degenerative changes in the spermatogenic epithelium (rat of group 2). PAS reaction, 140 ×.

Fig. 2. Accumulation of Leydig cells, epithelium of neighboring tubule thickened, spermatogonia, Sertoli cells, and multinuclear spermatids visible (rat of group 2). Hematoxylin—eosin, magnification: objective 20, [ocular not specified].

LITERATURE CITED

1. A. I. Levina and A. E. Ivanov, Byull. Éksp. Biol. Med., No. 2, 230 (1978).
2. Z. M. Kamal'dinova, "A hygienic study of cooked products of animal origin exposed to γ-rays to lengthen their storage life," Author's Abstract of Candidate's Dissertation, Moscow (1970).
3. A. M. Kuzin, in: Radiotoxins, Their Nature and Role in the Biological Action of High-Energy Radiation [in Russian], Moscow (1966), pp. 5-17.
4. S. S. Raitsina, Trauma to the Testis and Autoimmunity [in Russian], Moscow (1970).
5. E. A. Savina, V. I. Yakovleva, G. I. Plakhuto-Plakutina, et al., Kosmich. Biol., No. 10, 57 (1976).
6. J. Freund, M. Lipton, and G. Tompson, J. Exp. Med., 97, 711 (1953).
7. R. Howard, R. Schiffen, F. Simmons, et al., J. Clin. Endocrinol., 10, 121 (1950).
8. M. Julesz and I. Hollo, Diagnostik der neuroendokrinen Krankheiten und ihre pathophysiologischen Grundlagen, Budapest (1961).