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Radiation modification of glucose biological activity in *in vitro* experiments

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Radiation methods of modifying substances are a promising area in modern physics and biophysics, allowing for targeted changes in the properties of biologically active compounds. Ionizing radiation, interacting with molecules, can cause structural changes, initiate chemical reactions, and affect the biological activity of substances. One of the key mechanisms of this effect is the formation of radiolysis products that can change the reactivity of molecules and their interaction with biological systems.

Glucose is an essential biochemical object involved in metabolic processes and can be a target for targeted radiation modification. The effect of ionizing radiation on its molecular structure and biological activity is relevant in developing new antimicrobial agents.

This study evaluates glucose's antimicrobial activity change after exposure to different radiation treatment regimes. The test microorganisms used were Staphylococcus aureus (including methicillin-resistant strains, MRSA), one of the most common pathogens in medical practice, and Lactobacillus acidophilus, a representative of the normal human microflora that plays an essential role in maintaining the balance of the microbiota.

The work aims to study changes in the biological activity of glucose solutions after radiation treatment, in particular, using the M-30 microtron and a radiation stand with a Pu-α-Be source. The research includes the analysis of structural changes in molecules and their impact on the growth and viability of these bacterial cultures.

The idea of the work is based on the block principle of bioorganic molecules and the possibility of their structural rearrangement by radiation. Different modes of radiation treatment of glucose solutions were used with ionizing radiation sources (IRS) and the M-30 microtron. The M-30 microtron was used as a source of brake gamma radiation using a brake Ta plate (1 mm) and photon neutron radiation by a special assembly that, in addition to Ta, contained a 1 cm thick Pb plate. In the experiment, the fluence of the outgoing beam of accelerated electrons with an energy of 18.5 MeV was recorded, in particular, when the flux reached 5*1014 electrons/cm2 and 5*1015 electrons/cm2 when both γ- and photon neutron irradiation were generated. The samples were placed at a distance of 30 cm from M-30. A radiation stand was also used, realized in the form of a special block house made of neutron stop moderators, containing a Pu-α-Be source, type IBN-VIII; the dose rate γ, n-radiation was 5.0*108 Gy/s, the neutron flux was 2.7-106 neutrons/s. The neutron flux density was measured by a certified radiometer MKC-PM1401K and amounted to 2.05-103 neutrons/(cm2*sec) in the irradiation area at a distance of 10 cm from the IBN-VIII. The total dose/fluence for 566 days of irradiation was 2.63*1012 neutrons/cm2 [1].

Methods and results of microbiological studies. Irradiated and non-irradiated glucose samples in dry powder were provided for the work. Aqueous solutions of 5 % were prepared immediately before the microbiological studies. The daily culture prepared a suspension according to the standard of bacterial suspension turbidity of 0.5 McFarland density units (1.5×108 CFU), which was determined using a densitometer (Den-1). In the study, we used a clinical isolate of Candida albicans. We used a sterile titration plate (96 wells) to perform the analysis. The volume of one well is 250 microliters. Addition of test cultures of 20 microliters (plate) to 200 microliters (plate) of glucose solution and determination of the minimum inhibitory effect by serial dilutions. This was done up to the 8th dilution. The exposure time was 1 hour in a thermostat at 36.8-37°C. Sowing on a suitable selective nutrient medium for microscopic fungi –Sabouraud agar. Seeding was done in 10 microliters using a pipette. Negative and positive controls, solution samples, and m/o cultures were also inoculated. The positive control was 10 microliters of 1.5-108 CFU/ml, and the negative control was 10 microliters of the test solution sample. The experiment was carried out using the in vitro method in a time evolution, with 48 hours between stages.

According to the results of our studies, it was found that all glucose solutions selected for in-depth research showed different biological activity about the tested strain of Staphylococcus aureus and Lactobacillus acidophilus (Table 1).

Table 1. Results of radiation modification of the biological activity of glucose

№	The name of the solution	Initial concentration, CFU/mL	Concentration, CFU/mL
		Staphylococcus aureus	Lactobacillus acidophilus

(stage 1) (stage 2) (stage 1) (stage 2)
1 Glucose, control 1.5·108 >1010 >1010 2,1·105 NG
2 5·1014 –γ 1.5·108 5·1010 >1010 1·1010 NG
3 5·1015 –γ 1.5·108 >1010 >1010 1·108 2,1·105
4 5·1015 –n 1.5·108 >1010 >1010 3·108 1,7·105
5 5·1014 –n 1.5·108 2·1010 >1010 1·108 2·104
6 Pu-Be 1.5·108 1·1010 >1010 1·1010 NG

Note. NG –no growth.

Analyzing the data in Table 1, we can say that for the conditionally pathogenic culture Staphylococcus aureus, microbial growth is stimulated for all tested solutions, and this trend persists over time. For the probiotic non-spore culture Lactobacillus acidophilus, at the first stage, a stimulating effect on the growth of microorganisms was observed in solutions 2 and 6. Still, over time (stage 2), all solutions have an inhibitory effect.
The results of the study of the biological activity of solutions of radiation-activated glucose on the M-30 microtron proved the prospects of radiation technologies for targeted changes in properties and the possibility of creating a line of new biologically active agents on their basis.

1. C.A. Burmei at al. Determination of fungicidal activity of glucose solutions after radiation treatment by in vitro method. In: International Conference «Nuclear Physics in Transcarpathia» (dedicated to the 55th anniversary of the Department of Photo-Nuclear Processes of the IEP of the National Academy of Sciences of Ukraine). Uzhhorod, Ukraine, May 21 - 23, 2024 (Uzhhorod, 2024) p. 183.

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