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REGULARITIES OF INHIBITION OF CONDITIONALLY PATHOGENIC MICROFLORA UNDER THE INFLUENCE OF ACCELERATED ELECTRON BEAMS

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Abstract

Article is devoted to the study of the irradiation efficiency of model systems containing conditionally pathogenic microorganism by electron beams with energy of 7 and 10 MeV. The research on the effectiveness of inhibition of the initial degree of inoculation of the microorganisms E. coli and Salmonella were carried out. Irradiation doses up to 10 kGy performed at radiation-technological installations the A.N. Frumkin Institute of Physical Chemistry and Electrochemistry RAS and State Research Center Burnasyan Federal Medical Biophysical Center. The results of the effective inhibition of initial contamination degree for the two samples, which model liquid and solid nutrient media, were obtained. It is shown that it is necessary to take into account not only the effectiveness of microorganism inhibition on specific products, but also the installation efficiency for a particular sample.

INTRODUCTION

According to the international Commission of FAO (Food and Agriculture Organization) UN world food losses at all stages of production reach 30%. Especially significant losses of fruits and vegetables. Recently, Russia has revived its interest in radiation technologies as a basis for the development of an innovative economy. Radiation treatment of food products leads to delayed germination, disinsection (destruction of insects), slowing down the maturation process, lengthening the shelf life and suppression of pathogenic microorganisms.

The use of radiation technologies in agriculture and food industry is a global trend [1]. According to IAEA statistics, there are more than 1,500 electron accelerators in the world, mainly used for food processing, medical device sterilization and radiation chemistry. The largest number of accelerators installed in the United States (more than 500 units) and Japan (more than 300). Also, accelerators are numerically predominant in the BRICS countries [2].

The advantages of radiation technologies are food processing, with a high degree of efficiency and productivity, accuracy of radiation dosing, the possibility of irradiation of packaged products, the lack of high heating of the product, low operating costs and compliance with accepted environmental standards [3, 4]. The low sterilization temperature allows the sterilization of thermolabile objects.

The intensity of irradiation of food products can vary from a number of characteristics:

- product contamination before and after irradiation. (Knowing the value of the initial contamination of the product, you can calculate the dose, after irradiation of which the number of living cells will reach the normalized level.)
- spectrum of microorganisms [5]. (Resistance to ionizing radiation varies among microorganisms. The most sensitive to irradiation among bacteria are gram-negative, especially *Ps. aeruginosa*, *E. coli*. Somewhat more resistant gram-positive bacteria. Weak resistance to radiation differ psychrophilic bacteria. Very resistant to ionizing radiation were some micrococci and spores of the genera *Bacillus* and *Clostridium*.
- physical and chemical properties of the product (aggregate state). [6,7].

Thus, the study of the effect of ionizing radiation on food products and agricultural raw materials should be approached by a comprehensive solution of problems based on the characteristics of the studied products.

Despite numerous studies in this area, existing teaching methods need to be optimized to allow exposure to all types of fruit and vegetable products. The main problem is the possibility of minimizing the impact of ionizing radiation. The solution to this problem is possible in two ways: by reducing the intensity of irradiation or by using installations with different electron beam characteristics.

In this paper, a comparative analysis of the irradiation efficiency of the same object on two radiation installations with different beam characteristics was carried out. The used electronic accelerators have differences in beam energy, beam power, scattered beam formation system and transportation of the processed object. Various parameters of the units should be taken into account when irradiating food products with electron beams, especially at low doses from 1 to 5 kGy. Studies were carried out using model systems that allow to standardize irradiation conditions to obtain reproducible results. The efficiency of inhibition of the microorganism coli and Salmonella

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located in two model systems using accelerators with beam energy of the order of 7 MeV and 10 MeV, other things being equal, was studied. Researches on studying and revealing of dependences of inhibition of pathogenic microflora, at irradiation with various intensity, on structure (density) of the studied samples are carried out.

METHODS AND RESULTS OF RESEARCH

Inoculation of model systems was carried out as follows: suspension *E Coli* or *Salmonella*, containing a certain number of microorganisms from one of the studied cultures, was introduced into tubes containing 5 ml of liquid and solid uncured medium. Inoculate was 2% by weight of the medium.

The studies were performed on the accelerator UELVv-10-10-S-70 in A.N. Frumkin Institute of Physical Chemistry and Electrochemistry RAS with the average energy of the electron beam of 7 MeV and on radiation-technological installation with an electron accelerator UELR-10-10-40 in State Research Center Burnasyan Federal Medical Biophysical Center with an average energy of 10 MeV. Modular systems were irradiated with doses in the range of 0 kGy to 10 kGy.

The irradiation process was controlled by film dosimeters SO PD(e)–1/10 manufactured according to Rassian technical condition TU 2379-006-1327176-00. Dosimeters were located near the tubes and inside the tubes with the analog of the carrier of opportunistic microorganisms. The doses of ionizing radiation from the accelerated electron beam absorbed by the dosimeter were determined on the spectrophotometer.

The efficiency of irradiation was determined by studying the residual microflora of samples subjected to different irradiation intensity in accordance with the current regulatory documentation to determine the number of mesophilic-aerobic and facultatively anaerobic microorganisms GOST 10444.15.

Figures 1 - 4 show the results of the study of radiation exposure to samples with microorganisms *E Coli* and *Salmonella.*

Studies have shown that the nature of *E Coli* inhibition has a stepped form, which can be explained by the presence of two subpopulations in the composition of the culture, more resistant and less resistant to radiation. Studies of the dependence of irradiation on solid and liquid model media have shown similar repeating graphs, allowing us to conclude that there are no differences in the irradiation of liquid and solid model media in this installation.

Studies conducted at the installation UELV-10-10-S-70 in A.N. Frumkin Institute of Physical Chemistry and Electrochemistry RAS the irradiation intensity of 3 kGy reduced the initial contamination at -10^6 -10^7 orders of magnitude, the irradiation of 5 kGy at -$10^{5,5}$ order. At dose 7 kGy the complete oppression of the initial degree of contamination was occurred. The study of the exposure dependence to different structure and location of the carrier showed slight difference in the experimental results.

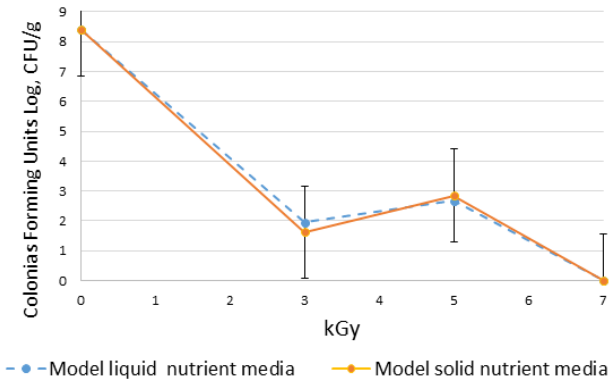

Figure 1: The dependence of the number of viable microorganisms *E Coli* on absorbed dose for irradiation of experimental samples at radiation-technological installations the A.N. Frumkin Institute of Physical Chemistry and Electrochemistry RAS.

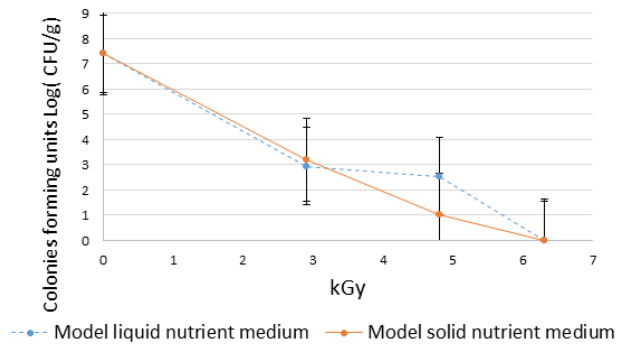

Figure 2: The dependence of the number of viable microorganisms E. coli on absorbed dose for irradiation of experimental samplesa at State Research Center Burnasyan Federal Medical Biophysical Center.

Studies conducted at the installation UELR-10-10-40 in State Research Center Burnasyan Federal Medical Biophysical Center show that the inhibition of the initial level of inoculation of samples at irradiation intensity of 3 kGy allows to reduce the initial contamination on the order of -10^4, when irradiated with 5 kGy at -$10^{6,4}$ order. At 7 kGy the complete oppression of the initial degree of contamination was occurred. The dependency of the impact of radiation from various structures and locations of the media showed the difference in the results of the study 1.5 the order when irradiated by 5 kGy intensity. This fact must be considered when calculating radiation dose.

Research conducted on the installation of welv-10-10-C-70 (7 MeV) the results are presented in Fig.3, showed that the type of the curve of oppression of *Salmonella* culture has a step nature, which can be explained by the presence of two subpopulations in the composition of the culture, more stable and less resistant to radiation.

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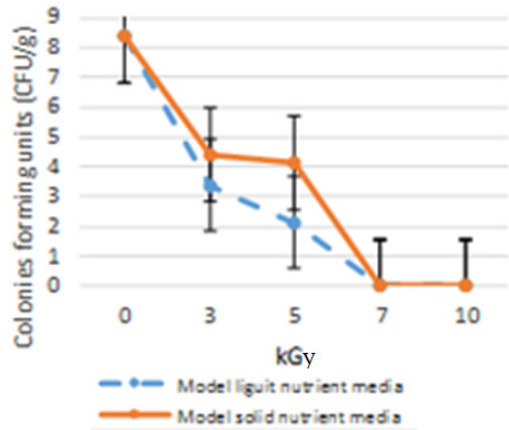

Figure 3: The dependence of the number of viable microorganisms *Samonella* on absorbed dose for irradiation of experimental samples at radiation-technological installations the A.N. Frumkin Institute of Physical Chemistry and Electrochemistry RAS.

The initial contamination is reduced by -10^4 when irradiated with an intensity of 3 kGy. The initial contamination is reduced on -10^4 for the liquid model medium and -10^5 for the solid model medium when irradiated with 5 kGy. There is a complete inhibition of the initial degree of contamination at dose 7 kGy. Studies on the difference, the structure of the carrier, showed a difference in the results of the study under irradiation in the range from 3 kGy to 7 kGy.

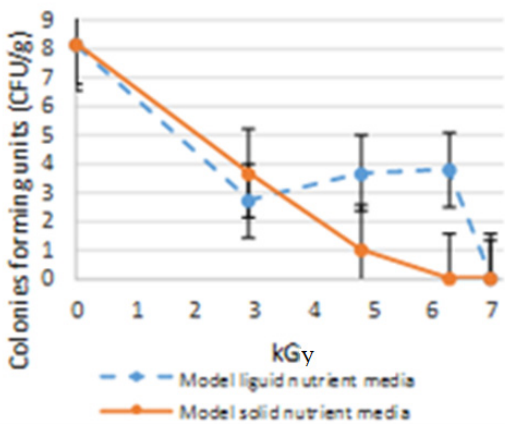

Figure 4: Dependence of the number of viable microorganisms *Salmonella* on absorbed dose for irradiation of experimental samplesa at State Research Center Burnasyan Federal Medical Biophysical Center.

The research was conducted on the installation UELR-10-10-40 (10 MeV). The results of these works are presented at Fig.4. The results show that the form of the curve of oppression of *Salmonella* culture also has a stepped character. Inhibition of the initial degree of inoculation of the studied samples under irradiation with dose of 2.9 kGy reduces the initial contamination by -10^4. When irradiated with a dose of 4.8 kGy for the solid medium, the decrease occurs at -10^4, and for the liquid medium this value is -10^7. Results at a dose of 6.0 kGy for the liquid model medium is reduced by -10^8, and for the solid medium -10^4. Complete inhibition of the initial microflora occurs at irradiated electrons dose of 10 kGy. Studies on the difference, the structure of the carrier, showed a difference in the results of the study under irradiation in the range of 3.4 kGy to 10 kGy.

CONCLUSION

The study of the effect of electron-beam radiation on the effectiveness of inhibition of pathogenic microorganisms, that causes food spoilage. The study is devoted to the comparative evaluation of two installations with different irradiation characteristics.

Studies have shown that inhibition of microorganisms has stepped character depending on the dose of electron radiation. It was found that irradiation of different model media (liquid and solid) changes the radiation intensity in the same order. Studies have shown that the results of the effectiveness of inhibition of *Salmonella* culture may vary depending on the type of accelerator and the average energy of the electron beam. Irradiation of 3 kGy to 7 kGy for installation UELV-10-10-C-70 10кГр to install UELR-10-10-40 you obtain different results of the effectiveness of the oppression of the culture of *E Coli* and *Salmonella* in environments with different structure.

In view of the circumstances, it is necessary not only to take into account the effectiveness of the inhibition of microorganism on specific products, but also to work out the effectiveness of the installation for this particular sample. It is from these characteristics determine the effectiveness of radiation treatment.

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