

Ministry of Education and Science of Ukraine

ODESA NATIONAL UNIVERSITY OF TECHNOLOGY

International Competition of
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BLACK SEA SCIENCE 2023

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STANDARTIZATION OF RADIATION-TREATED POULTRY MEAT**Author:** Gulzhan Kurtibayeva¹**Advisor:** Danko Igor², Uazhanova Raushangul¹¹Almaty Technological University (Kazakhstan)²Institute of Nuclear Physics (Kazakhstan)

Annotation. *Ionizing radiation is recommended for use in the storage of meat, semi-finished products and culinary products from them, fish and other sea products, edible potatoes, onions and other root crops in the spring and summer months, perishable berries and fruits for the duration of their transportation from the manufacturer to the consumer, fruit juice concentrates, etc*

. Further study of the possibility of using ionizing radiation sterilization to extend the shelf life of food products, as well as to ensure quality control and safety of meat and meat products is very relevant for science and practice.

The practical use of ionizing radiation exposure to increase the shelf life of food products is based on their ability to slow down or accelerate the processes of germination or ripening of fruits and vegetables, to fully or partially suppress the vital activity of food spoilage pathogens.

Food processing by ionizing radiation belongs to the so-called high technologies and has been used in Europe and America on an industrial scale for several decades. For these purposes, electron accelerators or special gamma-ray installations with various sources of ionizing radiation are used.

Only certain radiation sources are used for food irradiation: cobalt-60 or caesium-137 isotopes, X-ray installations, electronic accelerators with a maximum energy of no more than 10 MeV. The energy of these radiations is relatively small and does not cause induced radioactivity in any material, including food. None of the chemical changes in the irradiated products is dangerous to health. Irradiation does not affect the nutritional qualities of food. Consumption of irradiated foods does not lead to the formation of abnormal chromosomes, i.e. genetically safe.

Irradiation at internationally recommended dose levels up to 10 kGy eliminates the risk of botulism compared to other "substerilized" technological processes of food processing, such as pasteurization. According to the main indicators, the irradiated products have no signs of poor quality and meet the medical and biological requirements.

Keywords: *standardization, radiation treatment, irradiated material, dose rate, food products, microorganisms, poultry meat.*

I. INTRODUCTION

World industrial experience has proved that the economic efficiency of most organizations is not possible without continuous improvement of their activities to improve the quality of products. At the same time, an important role is played by improving methods for increasing the shelf life of raw materials and food products, taking into account the desire of consumers for biologically safe products. The

presence of a competitive environment in a market economy confirms the importance of quality control problems. Serious competition in countries with developed market economies has led to the development of quality improvement programs. There was a need to develop, among other things, methods of veterinary and sanitary assessment of the quality and safety of raw materials for food production. The role and importance of quality for the formation of the economy of our country are now becoming decisive.

Ionizing radiation is recommended for use in the storage of meat, semi-finished products and culinary products from them, fish and other sea products, edible potatoes, onions and other root crops in the spring and summer months, perishable berries and fruits for the duration of their transportation from the manufacturer to the consumer, fruit juice concentrates, etc.

II. ANALYTICAL REVIEW OF THE LITERATURE

In different countries of the world, the maximum permissible dose of food irradiation varies. In the USA it is 30 kGy, in Belgium and the Netherlands - 10 kGy, in France - 11 kGy. In Russia, this value is not regulated, since radiation treatment of food products has not become widespread in our country due to the lack of regulatory documents.

Further study of the possibility of using ionizing radiation sterilization to extend the shelf life of food products, as well as to ensure quality control and safety of meat and meat products is very relevant for science and practice.

The practical use of ionizing radiation exposure to increase the shelf life of food products is based on their ability to slow down or accelerate the processes of germination or ripening of fruits and vegetables, to fully or partially suppress the vital activity of food spoilage pathogens.

The technological effect of irradiation depends on the conditions of irradiation and the dose of absorbed energy, so: low doses (up to 1 kGy) - inhibit the germination of vegetables and fruits during storage, destroy insects, barn pests;

- medium (1-10 kGy) - harmful to many types of vegetative forms of microbes provide "cold sterilization" of products;
- high (10-50 kGy) - inhibit the vital activity of microbes and spores.

Irradiation is carried out: γ - quanta, accelerated electrons, x-ray bremsstrahlung. The main advantage of this method of processing food products is the possibility of a sharp reduction in the amount of various preservatives used in the storage and preparation of food.

The problem of preserving the nutritional properties of the product, as well as the likelihood of the formation of various toxins and mutagens as a result of exposure to ionizing EM radiation at various doses, has been studied in detail for many decades and considered at the level of official international organizations regulating the use of nuclear energy, health and food quality.

When analyzing the technical side of the issue, the problem arises of optimizing the value of the absorbed dose and the treatment regime in terms of preserving the beneficial properties of the product and neutralizing strains of microorganisms. The purpose of processing can be both to extend the shelf life of the product and to prevent the appearance of possible pathogenic viruses. Depending on the type of product and

the purpose of treatment, one or another value of the absorbed dose can be selected. Of course, during the processing there is a partial destruction of some useful components (trace elements, vitamins). And the sale of such products may be associated with the rejection by consumers of the very fact that it came into contact with ionizing radiation. Nevertheless, it should be understood that the varieties of preservatives currently used can definitely provoke the occurrence of serious health disorders. While the radiation treatment method has undergone many years of laboratory research, extensive experience has been accumulated confirming the safety of its industrial application.

The process of radiation sterilization of food consists in the fact that food products, packaged or unpacked, are exposed to carefully controlled levels of ionizing radiation for a specific time to achieve certain desired goals.

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Irradiation at internationally recommended dose levels up to 10 kGy eliminates the risk of botulism compared to other "substerilized" technological processes of food processing, such as pasteurization. According to the main indicators, the irradiated products have no signs of poor quality and meet the medical and biological requirements.

The radiation method allows you to use any packaging, significantly prolongs the shelf life, destroys pathogenic microflora. Currently, permission has been obtained from the Ministry of Health of the Republic of Belarus for the practical application of a radiation method for processing a number of food products: egg powder, lactose, various spices, gelatin, poultry meat.

Taking into account the importance of providing the population with high-quality food and the possibilities of the radiation base of the Institute, the Ministry of Health of the Republic of Belarus is developing new standards for microbiological indicators for spices, and is also considering giving the IRFCP the role of a coordinating center for radiation treatment of medical devices and food.

The safety and benefits of food treated with ionizing radiation have been documented. In order to provide accurate scientific information, the International Advisory Group on Food Irradiation decided to publish a series of brochures on this topic in 1991. After these publications, many developments were made in the field of the development of food irradiation technologies. Along with traditional methods of food storage, these technologies are gaining great popularity all over the world. Already in 1905, the first patents for the use of ionizing radiation to kill bacteria in food were issued in the United States and Great Britain. It is known that pork must be

thoroughly cooked or fried, as it may contain a dangerous parasite trichinella. However, this parasite can be destroyed with a minimum dose of radiation. Frog legs can be infected with salmonella, and irradiation in this case is an effective method of disinfection. With the help of irradiation, it is also possible to neutralize salmonella found in chicken eggs without compromising the quality of the product. These diseases threaten human health even in countries with modern food processing systems. According to approximate estimates, the number of cases is several million.

To control these diseases, relatively low doses of radiation are needed, which will neutralize certain food bacteria. For this purpose, in Belgium, France and the Netherlands, significant quantities of frozen seafood are treated with irradiation. The volume of irradiated seasonings and spices worldwide has increased significantly in recent years.

Not all countries currently allow the import of chemically treated fruits. The main importing countries, which include the United States and Japan, have banned the use and import of products treated with certain fumigants that pose a health risk. This is a serious problem for countries whose economies are mainly based on food and agricultural production and receive income from exports. Irradiation treatment is an alternative to chemical treatment for such countries. In addition, the "cold process" of processing (i.e. irradiation) is ideal for preserving the taste and aroma of fruits, herbs and spices, which are often lost during heat treatment. Studies have shown that carbohydrates, proteins and fats undergo little change under irradiation, as well as minerals, vitamins, trace elements. The shelf life of fruits, vegetables, meat, fish and seafood can be significantly increased by a combination of freezing and low doses of radiation, since many rotting bacteria are sensitive to radiation. Irradiation also prevents fruit from overripe.

Products treated with irradiation are specially treated with certain types of radiation energy to destroy pathogenic bacteria and better preservation. In addition to food products, many other materials are treated by irradiation in the production process, for example, cosmetics, bottle caps, medical equipment. Irradiated products cannot become toxic.

Several hundred toxicological experiments were conducted on animals to assess the safety of consumption of irradiated products. These experiments did not show toxic effects, as well as genetic defects as a result of consumption of irradiated products. Can the consumption of irradiated foods cause the appearance of extra chromosomes? No. In the early 1980s, several studies were conducted in China involving 400 volunteers who consumed irradiated food for a period of 7 to 15 weeks. One of the areas of research was the possibility of changes in chromosomes.

In the event of an accident, radiation leakage is impossible, since the source of radiation energy does not produce neutrons that make materials radioactive, so a nuclear "chain reaction" cannot occur on the irradiating equipment. The walls of the irradiation cells through which the products pass, the equipment inside the cell and the processed products cannot be radioactive, radioactivity does not enter the environment. The products themselves never come into direct contact with the source of radiation. The irradiation process is the passage of products through the radiation field at a set speed to control the amount of energy and dose absorbed by the products. Food

products that are exposed to radiation become no more radioactive than luggage undergoing a scan at the airport, or our teeth after an X-ray.

Despite the fact that in 1929 a patent was issued for the use of radiation as a means of preserving or protecting food, it was only shortly after World War II that this method of protecting food received serious consideration. At the same time, the use of radiation is limited, and the full application of this method raises some doubts among microbiologists and other food scientists.

Radiation can be defined as the emission and propagation of energy through a vacuum or through a medium. The main type of radiation that is of interest when preserving food is electromagnetic. Different radiations are separated based on their wavelength, the radiations with the shortest wavelengths are the most destructive for microorganisms. The electromagnetic spectrum can be further divided with respect to the significance of radiation in food preservation as follows: microwave, ultraviolet rays, X-rays (X-rays) and gamma rays. The most interesting radiations used for food preservation are ionizing radiation, radiation with a wavelength of 2000 Å or less, for example alpha particles, beta rays, gamma and X rays. Their quanta contain enough energy to ionize molecules in their path. Since they destroy microorganisms without raising the temperature, the process is called cold sterilization.

Types of radiation used to preserve agricultural raw materials and food products. Ultraviolet light (UV) is a strong bactericidal agent with the most effective wavelength equal to approximately 2600 Å. It is non-ionizing and is absorbed by proteins and nucleic acids, photochemical changes of which can lead to cell death. The mechanism of bacterial cell death as a result of UV exposure is the occurrence of lethal mutations as a result of action on the nucleic acids of the cell. The poor penetrating abilities of UV light allow it to be used only for surface treatment of the product, where it can catalyze oxidative changes that lead to rancidity, discoloration and other reactions. When using UV light, small amounts of ozone can also be produced on the surface of certain products. UV light is sometimes used to treat the surface of baked cupcakes with candied fruits and nuts and similar products before packaging.

Beta rays can be defined as streams of electrons emitted by radioactive substances. Cathode rays are the same, except that they are emitted by the cathode of the vacuum tube. These rays have poor penetrating power. Among the industrial sources of cathode rays are Van de Graf generators and linear accelerators. The latter are more suitable for food protection. There is some concern about the upper limit of the energy level of cathode rays that can be used without the risk of inducing radioactivity in some food components.

Gamma rays

These are electromagnetic radiation emitted by excited nuclei of elements such as ^{60}Co and ^{137}Cs . This is the cheapest form of radiation for food preservation, because the initial elements are by-products of atomic decay or products of radioactive waste. Gamma rays have excellent penetrating power, unlike beta rays. ^{60}Co has a half-life of approximately 5 years; the half-life of ^{137}Cs is approximately 30 years.

X-rays

These rays occur when heavy metal nuclei are bombarded by accelerated

electrons (cathode rays) in a vacuum tube. Otherwise, they are essentially the same as gamma rays.

III. OBJECT, SUBJECT AND METHODS OF RESEARCH

Initially, the destruction of microorganisms in products by ionizing radiation was described by terminology relating to the destruction of microorganisms by high temperature and chemicals. Although microorganisms can really be destroyed

chemicals, high temperature and radiation, the use of this terminology for products treated with radiation is not entirely correct. Therefore, in 1964, an international group of microbiologists proposed the following terminology for radiation treatment of products [61]. Radappertization is the equivalent of radiation sterilization or "industrial sterility" in the canning industry. Typical exposure levels are 30-40 kGy. The term comes from the surname of the inventor of the method of thermal sterilization of food in sealed containers (canned food) Frenchman Nicolas Francois Appert. In the French transcription, the proper name Appert is at the end. the mute "t", which in the word "appertification" manifests itself and begins to sound.

Radisidation is the equivalent of pasteurization, for example, of milk. Leads to selective suppression of viable non-spore-forming pathogens of most types, except viruses, so that none is detected by any standard methods. Typical radiation doses of this process are 2.5-10 kGy.

Radurization can be considered the equivalent of pasteurization. It contributes to the increased preservation of food quality by significantly reducing the number of viable certain non-spore-forming pathogens by radiation. The usual radiation doses for fresh meat, poultry, seafood, fruits, vegetables and grains of cereals are 0.75-2.5 kg.

Radappertization of any products can be achieved by applying the appropriate dose of radiation under appropriate conditions. Of obvious interest is the effect of this treatment on the endospores and exotoxins of *C. botulinum*. For type E spores, it has been reported that doses of radiation D of the order of 1.2- 1.7 kGy are required. For spores of type A and B, as Ketre established, the values of D were 2.79 and 2.38 kGr, respectively. Type E spores are the most sensitive to radiation among these three types.

To achieve Y1D processing of meat products at ~30 °C, the following values of kGr are required: for beef and chicken — 41.2-42.7; ham and cod pie — 31.4-31.7; pork — 43.7; beef corned beef and pork sausage — 25.5-26.9. Irradiation treatment of this type does not make products radioactive.

The radiation resistance of *C. botulinum* spores in liquid nutrient media was studied by Roberts and Ingram, the radiation dose values were significantly lower than for meat products. For three strains of type A, the value of D ranged from 1.0 to 1.4; for two strains of type B— 1.0-1.1; for two strains of type E, 0.8—1.6 and for one strain of type F studied by these authors, the value of D was 2.5 kGy. All strains were irradiated at 18-23 °C, and an exponential mortality rate was used to calculate the D values. Regarding the effect of radiation on each of the five different strains (types A, B, C, E and F) of *C. perfringens*, it turned out that the values of D in the liquid medium were from 1.5 to 2 kGy. The values of 12D for 8 strains of this organism ranged between 30.4 and 41.4 kGy, depending on the strain and the method of calculating doses of 12D.

The DJO radiation dose values for the Scott A *Listeria monocytogenes* strain in Mozzarella cheese and ice cream irradiated at 78 °C were 1.4 and 2.0 kGy, respectively. The corresponding calculated values of Y1D were 16.8 and 24.4 kGy. To carry out the radappertization of ice cream and frozen yogurt, 40 kg was enough, but not in the case of Mozzarella or Cheddar cheeses. The dose of radappertization for *Bacillus cereus* in cheese and ice cream was 40-50 kGr.

Viruses are significantly more resistant to radiation than bacteria. Sullivan et al. found that the radiation dose values of D30 viruses are between 3.9 and 5.3 kGy in a minimal Iglu medium with the addition of 2% serum. These 30 viruses included Coxsackie virus, ESNO virus and poliovirus. For five selected viruses exposed to the rays of the radioactive isotope cobalt ⁶⁰Co in distilled water, the D values ranged from 1.0 to 1.4 kGy. Use of radiation 12D treatment with botulinum in meat products would lead to the survival of viral particles if they had not previously been destroyed by other methods, such as heating.

The enzymes are also very resistant to radiation, and a dose of 20-60 kGy was found to inactivate only 75% of the proteolytic activity of beef. Blanching at 64 or 70 °C was combined with radiation doses of 45-52 kGy, however, in this case only 95% of the proteolytic activity of beef was inactivated. The main disadvantages of using radiation to process some products are color changes or the formation of flavors. At the same time, those food products that undergo relatively minor changes in color and flavor have received the most attention for industrial radappertization. Bacon is the only product that undergoes slight changes in color and flavor after radappertization. The average scores of the organoleptic bacon after radappertization and the control bacon were close, but the value of the control bacon was slightly higher. Suitable products for irradiation are represented by a wide variety.

When reviewing 539 D values taken from 39 published papers, the most stable of the spore-forming ones were *Geobacillus stearothermophilus* and *Clostridium sporogenes*, while the most stable non-spore-forming ones were *Enterococcus faecium*, *Alcaligenes* spp. and the *Moraxella-Acinetobacter* group. In general, it follows from the published data that gram-negative bacteria were more sensitive than gram-positive ones.

Causes of the death of microorganisms during irradiation. The effect on microorganisms of various forms of radiant energy, which are electromagnetic vibrations with different wavelengths, manifests itself in different ways. The biological effect of radiation depends on the wavelength. The shorter it is, the more energy it contains, the stronger the effect on the body. The action is based on certain chemical and physical changes occurring in the cells of microorganisms and in the environment. The changes can only be caused by absorbed rays. Therefore, the penetrating power of the rays is of great importance for the effectiveness of irradiation.

Bearing in mind the different resistance of the components of the product to ionizing radiation, their effect is divided into direct and indirect. The first includes chemical changes in food substances or microorganisms under the direct influence of radiation energy, the second — changes as a result of exposure to active radicals formed by direct action on less resistant substances. In food products, the proportion of changes caused by indirect action is about 80%.

When irradiating food products containing in most cases a lot of moisture, the indirect effect of ionizing radiation prevails, due to the appearance of active particles as a result of changes (radiolysis) of water. Direct action is typical for dry foods and fats.

The depth of changes under the influence of ionizing radiation increases with increasing radiation energy and radiation dose.

Under the action of ionizing radiation on water, ionized molecules and active radicals are formed.

Thus, as a result of radiolysis of water, free active radicals H and OH appear, which have a high reactivity. These radicals can react with each other, forming active molecules, or interact with other components of the product, causing their undesirable changes. In the presence of oxygen, the formation of an active hydroperoxide radical is possible.

Radioactive radiation, α -rays, β -rays (high-speed electrons) and γ -rays (short-wave X-rays) have high energy, and therefore are chemically and biologically extremely active.

The peculiarity of radioactive radiation is their ability to cause ionization of atoms and molecules, which is accompanied by the destruction of molecular structures.

Microorganisms are significantly more resistant to radiation than higher organisms. The lethal dose for them is hundreds and thousands of times higher than for animals and plants.

The effectiveness of ionizing radiation on microorganisms depends on the absorbed radiation dose and many other factors. Very small doses activate some vital processes of microorganisms, affecting their enzyme systems. They cause hereditary changes in the properties of microbes, leading to the appearance of mutations. With an increase in the radiation dose, the metabolism is disrupted more significantly, various kinds of pathological changes in cells (radiation sickness) are observed, which can lead to their death. At a dose lower than lethal, normal vital activity of irradiated cells can be restored.

The radiation resistance of various types and even strains of microorganisms varies widely. The most radio-resistant microorganisms with increased carbohydrate and proteolytic activity, containing more magnesium and calcium in the cells, as well as having a high level of protective metabolic reactions. *E. coli*, *proteus*, and many bacteria of the genus *Pseudomonas* are sensitive to radiation — common pathogens of spoilage of meat and fish products. Micrococci are characterized by increased resistance. Bacterial and fungal spores are very radio-resistant. High radiation resistance of viruses; in some, it surpasses even the resistance of bacterial spores.

At the same absorbed dose, the radio frequency of microorganisms of the same species varies depending on the age of cells, the composition of the medium, temperature, and also the dose rate — the radiation dose per unit of time.

The radiation source for the radiation treatment of products is mainly the radioactive isotopes ^{60}Co and ^{137}Cs .

When processing food, the radiobiological effect depends on the composition of the microflora, its abundance, chemical composition and aggregate state of the product, absorbed dose and dose rate.

According to the decision of the Joint Committee of Experts, a number of International Organizations (FAO, IAEA, WHO²), irradiated food products should not contain pathogenic microorganisms and microbial toxins, as well as toxic substances that can be formed as a result of irradiation.

International organizations have approved a list of food products that are allowed to be subjected to radiation treatment. In our country, in each individual case, a permit is issued by the health authorities.

In necessary cases, to increase the effect, irradiation can be combined with other exposure factors (cold, heating, chemical preservatives, etc.).

In our country, the current radiation treatment of products is hindered by the lack of a sufficient number of stationary and advanced installations, and there are no specialists with the necessary qualifications to manage this new technology of food storage. In addition, it is impossible not to take into account a certain consumer alertness to irradiated food.

Trends in the development of radiation treatment methods. In recent years, a new safe sterilization technology has appeared — electron beam. Unlike the methods of sterilization by gamma radiation and ethylene oxide, electron radiation does not use radioactive isotopes. Commercial application of the electron beam method was limited by two factors: the cost and lack of options for packaging materials, the adaptation of which would be scientifically confirmed. George Sadler, professor at the National Center for Food Safety Technology, Illinois, notes: "Electron beam radiation systems appeared back in the 50s, but until recently their operation was very expensive.

Note that electron beam (EL) radiation does not involve deep penetration into the thickness of the product, as does gamma radiation. EL penetrates into the product to a depth of 7.5 cm from the surface.

The effect of EL radiation is limited to a few seconds, unlike many hours of exposure to gamma radiation on the product. The short duration of exposure to accelerated electrons reduces the possible effects of oxidation of the product, minimizing disturbances in the structure of both the product and the packaging material. Most importantly, EL- (EVA). Most other packaging films were approved and tested in the 1960s only for gamma radiation. Over time and the in-depth development of technologies, the cost of electronic sterilization has decreased to a completely acceptable level, arousing interest from the food and packaging industry. Now it's time to expand the list of packaging options for E-sterilization."

Professor Sadler heads a working group consisting of representatives of 20 companies, mainly large suppliers and processors of plastics, such as KaKDuPont, Dow, Cryovac, American National Can, trying to get permission from the FDA to use an expanded range of packaging films and some structures based on semi-rigid and rigid plastics. The group tested and developed documentation for the use of materials such as ethylvinyl alcohol (EVON), nylons, all iogumers. "The interest in EL radiation is dictated primarily by the safety considerations of this sterilization method. We predict that fresh and processed meat, chicken will be the first objects of application of this technology.

Several issues remain unresolved, especially concerning composite multilayer packaging materials and how they will be affected by electron beam radiation. It is

assumed that about 80-90% of single-use medical plastic packages will be compatible with E—processing," says George Sadler.

Experts tend to believe that "if gamma radiation was the first step towards the application of this kind of technology, EL radiation is the second, then the time will soon come to use X-rays as a radiation source. The latest technology combines the speed of the electron beam method and the deep penetration of gamma radiation."

In 1981, the United Nations Food and Agriculture Organization (FAO), the International Atomic Energy Agency (IAEA) and the WHO Expert Committee on Food Irradiation found that foods irradiated with doses up to an average of 10.0 kGy were absolutely safe. At least 40 countries have approved the irradiation of one or more foods, and 29 countries are using food irradiation on an industrial scale. For the control of salmonella in animal feed, in 1995, irradiation with doses of 2-25 kGy was approved in the USA; in 1997, irradiation with a dose of 4.5 kGy was approved for chilled raw materials and a dose of 7.5 kGy for frozen raw beef.

In our country, the current radiation treatment of products is hindered by the lack of a sufficient number of stationary and mobile installations, as well as specialists with the necessary qualifications to manage this new technology of food storage. In addition, it is impossible not to take into account a certain consumer alertness to irradiated food.

Ionizing radiation has a strong bactericidal effect, providing, with sufficient dosage, complete sterilization in a very short time (tens of seconds). Among the radioactive radiations, gamma rays with high rigidity and, consequently, greater penetrating power (about 10 cm) are of practical importance. Radioactive isotopes of cobalt (cobalt-60), caesium (caesium-137) and other elements, as well as radioactive waste from nuclear reactors can be used as sources of gamma rays. The latter source is cheaper, but it is more difficult to use it, since you have to deal with a large number of radioactive isotopes having different radiation spectra.

The nature of the effect of ionizing radiation on the product depends on the radiation energy and the radiation dose (the amount of radiation absorbed by the substance). To estimate the dose relative to this irradiated substance, it is customary to use units equivalent to X-rays. Currently, the radiation dose is more often expressed in non—relative units - rad (1 rad is equal to 100 erg / g).

The same radiation dose can be achieved with a high radiation energy and a short irradiation time, or with a low radiation energy and a long irradiation time. But the effect of the action will not be equivalent, since the nature of the changes in the substance depends on the radiation energy.

Compared with other methods of protecting products from spoilage, ionizing radiation has the following advantages:

- a) minor general chemical changes of the product;
- b) a slight rise in the temperature of the irradiated product (within a few degrees);
- c) processing of products in a short time to the desired depth (from surface exposure to a significant thickness of the irradiated layer);
- d) the possibility of organizing continuous-flow processing;
- e) the use of any kind of sealed packaging.

Along with this, there are also significant drawbacks: the occurrence of such chemical changes that can worsen the taste, smell, consistency, the danger of the

formation of harmful compounds during and after irradiation; the development of enzymatic processes during storage.

It has not yet been possible to prevent undesirable changes in full, so the widespread use of ionizing radiation on an industrial scale is delayed.

Ionizing radiation is recommended for use in the storage of meat, semi-finished products and culinary products from them, fish and other sea products, edible potatoes, onions and other root crops in the spring and summer months, perishable berries and fruits for the duration of their transportation from the manufacturer to the consumer, fruit juice concentrates, etc.

Radiation technology of processing and storage of products is based on the suppression of microbial contamination (radurization) or radiation sterilization (radappertization).

The conducted studies have confirmed the prospects of the method of their disinfection using gamma radiation and accelerated electrons. However, at the same time, there are some biochemical changes in products with partial loss of vitamins and changes in organoleptic properties.

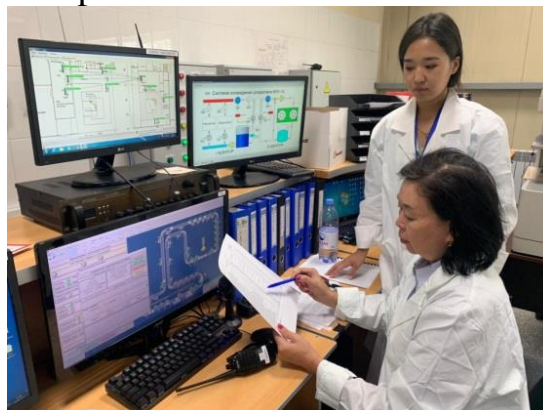
In different countries of the world, the maximum permissible dose of food irradiation varies. In the USA it is 30 kGr, in Belgium and the Netherlands - 10 kGr, in France - 11 kGr. In Russia, this value is not regulated, since radiation treatment of food products has not become widespread in our country due to the lack of regulatory documents.

The use of ionizing radiation opens up completely new possibilities for the preservation of food products, since there is no significant increase in temperature. This provision makes it possible to solve packaging issues in a new way, using polymer materials for meat products.

However, the problem with the use of ionizing radiation is the protection of the product itself from the influence of those doses of radiation that are needed to destroy microorganisms.

The scientific work was carried out at the department of "BiCPP" of JSC "ATU" in the period from 2021-2023 and in April 2022.

The meat of broiler chickens of the "Broiler 6" cross, taken immediately after slaughter at the poultry farm, served as the material for research. Processing of meat with gamma radiation was carried out in the RSE at the Institute of Nuclear Physics of the Ministry of Energy of the Republic of Kazakhstan at the ILU-10 accelerator.



Pic. 1. ARM of the operator ILU-10



Pic. 2. The resonator of the ILU-10 accelerator.

Meat samples before gamma radiation treatment were packed in plastic bags with a thickness of 20 to 45 microns. Irradiation of samples was carried out on a powerful gamma installation K - 120000 with a Co60 radiation source according to GOST R ISO/ASTM 51204:2004 "Guidelines for dosimetry in the processing of food with gamma radiation". The power of the absorbed radiation dose was: 2 kGy, 4 kGy, 6 kGy and 8 kGy.

The objects for laboratory research were samples of femoral and pectoral muscles of broiler chickens.

Method of processing broiler chicken meat by gamma radiation. Irradiation of samples was carried out on a powerful gamma installation K - 120000 with a Co60 radiation source according to GOST R ISO/ASTM 51204:2004 "Guidelines for dosimetry in the processing of food with gamma radiation". The power of the absorbed radiation dose was: 2 kGr, 4 kGr, 6 kGr and 8 kGr.

The main purpose of irradiation is to control (reduce the number of) pathogenic bacteria in fresh or frozen red meat and poultry meat in order to ensure the safety of these foods for consumption. Irradiation significantly reduces the number of vegetative pathogenic bacteria, such as *Campylobacter*, *Escherichia coli*, *Listeria*, *Salmonella*, *Staphylococcus aureus*, or *Yersinia enterocolitica*, and others if they are identified and determined in accordance with GOST 21237, GOST R 50396.7, GOST R 50454.

Irradiation also inactivates parasites such as *Trichinella spiralis* and *Toxoplasma gondii*.

Irradiation prolongs the shelf life of fresh red meat and poultry meat by reducing the number of viable, vegetative bacteria that cause spoilage, for example, various types of *Pseudomonas* (*Pseudomonas*).

Radiation exposure of fresh and frozen red meat and poultry products is a critical control point (CCT-SSR) in the risk analysis system of critical control points (HACCP) according to GOST R 51705.1. This system serves as an important means of controlling residual risks caused by pathogenic microorganisms before the product reaches the consumer.

Requirements for criteria for evaluating the effectiveness of irradiation

The requirement for the appointment of radiation for the control of pathogenic bacteria should be based on the criteria of an experimentally determined number of

pathogenic bacteria that can lead to contamination of products, their type and susceptibility to them of this consumer. The introduction of quantitative criteria determining the use of irradiation for not exceeding the permissible levels of contamination or the complete absence of possible pathogenic bacteria, which is established by sanitary standards for meat and poultry meat, is the most acceptable factor for the purpose of radiation treatment.

The requirement for the appointment of radiation for the inactivation of parasites should be based on the criteria for the suppression of parasites in raw, irradiated products, so that they are usually non-infectious and harmless. It is not necessary that the parasites were killed during irradiation.

The requirement for the purpose of irradiation to extend the shelf life should be based on the criteria for determining the number of microorganisms by sowing on Petri dishes under conditions corresponding to the storage conditions: at a certain time, temperature and environmental parameters. It should be taken into account that if the requirements of sanitary regulations, technical specifications for the product are known, for example, according to GOST 779, GOST 4814, GOST 12512, GOST R 52702, GOST R 52601, GOST R 52675 or both, then the reduction in the number of bacteria cannot be indicated as the only one or the final criterion. Thus, the requirement for the final product regarding the determination of the number of microorganisms by sowing on Petri dishes, as a criterion for the use of radiation, must be established by the client (customer).

If these criteria are not met, it is necessary to pay attention to the regulated process (see 8.1) and, if necessary, to restore the rules of production organization and product quality control (GMP). Risk analysis and critical control points (HACCP) according to GOST R 51705.1 or another similar process control system should be applied to the entire processing process and transport chain. Any point in the chain where a dangerous or critical situation occurs can be controlled and regulated using this system so that a dangerous and harmful product is prevented from reaching the consumer. See GOST R ISO 22000, provisions of the Codex Alimentarius.

The implementation of a process control system for evaluating the effectiveness of radiation treatment should include bacteriological examination of products before and immediately after irradiation, the use of time and temperature indicators of the entire process chain, and testing the integrity of packaging. Bacteriological testing should reveal a significant reduction in the number of certain bacteria compared to their number in non-irradiated products. Temperature control should warn the operators of any product about a violation that may lead to an increase in the number of bacteria after irradiation.

Methods for determining organoleptic and commodity indicators of meat quality of broiler chickens. Sampling and organoleptic examination of meat was carried out according to GOST 20235-74, 7702.0-74.

Organoleptic studies (color, smell, taste, consistency, cooking sample with broth evaluation) were carried out with the participation of volunteers in the number of 10 people. The organoleptic parameters of broth and boiled meat were evaluated according to a 9-point system (VNIIMP method), which includes determining the quality level of each indicator by its intensity in this product and according to GOST

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