The study of persistence of microorganisms and parasites in food products

Yu O Lyashchuk¹, A I Novak², Yu B Kostrova¹, O Yu Shibarshina¹, O V Evdokimova² and I V Kanina²

¹ Department of Business and Management, Ryazan Branch of Moscow Witte University, 62, Pervomaisky ave., Ryazan, 390013, Russia
² Department of Microbiology, Ryazan Acad. I.P. Pavlov State Medical University, 9, Vysokovolntaya str., Ryazan, 390026, Russia

E-mail: ularzn@mail.ru

Abstract. Safety of food products is assessed by hygiene standards, which include biological, chemical and physical risk factors. Biological risk factors include viruses, bacteria, mold and yeast fungi, protozoa, helminths and their toxins. Their presence in food products is either completely unacceptable, or should not exceed the acceptable ranges of concentrations in a certain volume of the test products. The original scoring technique was used for a quantitative assessment of biological risks. The persistence of microorganisms and helminthes was evaluated in meat, dairy and vegetable products, culinary products, eggs, canned food, pickles and marinades. Among the studied biological risk factors, the following have very low persistence in food products: adolescari of Fasciola spp.; eggs of Trichocephalus trichiuris, Enterobius vermicularis, Hymenolepis nana, Echinococcus spp., Ascaris lumbricoides, Strongyloides stercoralis larvae, cysts of Lamblia intestinalis, Entamoeba histolytica. Low persistence was demonstrated by Rotavirus, hepatitis A virus, the genus Norovirus, bacteria of the Leptospira spp. and Vibrio spp., Escherichia coli, Toxoplasma gondii and Cryptosporidium parvum. Medium persistence was demonstrated by plerocercoids of Diphyllobothrium spp, cysticercuses of Taeniaechnynchus saginatus and Taenia solium, bacteria Shigella spp. and Francisella tularenensis. High persistence was shown by larvae of the genus Trichinella, metacercaria Opisthorchidae, bacteria Mycobacterium spp., Proteus spp., Campylobacter spp., Yersinia spp., Brucella spp., Bacillus cereus, Clostridium perfringens, Staphylococcus aureus and Clostridium botulinum. Aphthovirus, Salmonella spp. and Listeria monocytogenes have very high persistence.

1. Introduction
An important component of the issue concerning food safety is the assessment of biological risks in the production and storage of food [1].

The issue of biological safety of food products is a complex problem, which takes many efforts from biochemical scientists, microbiologists, toxicologists and others, as well as from manufacturers, sanitary and epidemiological services, government bodies and, finally, consumers [2].

The urgency of the problem of food safety is increasing every year, since ensuring the safety of food raw materials and food products is one of the main factors, which determines people's health and preservation of the gene pool [3].
Food safety is assessed by hygiene standards, which include biological, chemical and physical risk factors. Their presence in food products is either completely unacceptable, or should not exceed acceptable levels in a certain volume of the test products [4].

In the HACCP system, “risk” is defined as a biological, chemical or physical contaminant or condition that can make a product hazardous to consumption. Potentially hazardous risk factors (biological, chemical and physical) that threaten product safety are determined by risk analysis. Biological risk factors include bacteria, viruses, protozoa, helminths, as well as their toxins, which pose a danger to public health and can lead to illness or death of people [5].

A particular problem is food contamination during storage. This is mainly due to the fact that along with traditional materials, such as wood and paper, polymers have increasing application being used in pure form and in combination with other materials, e.g. paper, cardboard, aluminum foil, tin, etc. With the advent of new risk factors, consumers are becoming increasingly demanding in terms of food safety for their health. Ensuring food safety is a pressing issue facing scientists.

2. Materials and methods
For the quantitative assessment of the level of biological risks, we used analytical and statistical methods, a method of expert estimation and a method of mathematical expression of the risk level with the help of a scoring system.

To analyze the persistence of biological risk factors, the main groups of food products were selected: meat and meat products; milk and dairy products; plant products; fish and seafood; eggs and their processed products; confectionery and bakery products; canned food, pickles and marinades.

To assess the stability of biological risk factors in food products we took three criteria into account and used the following formula:

\[ L_{pf} = \sum (D_{pf} \times T_p) + A_{rf}, \]  

where \( L_{pf} \) – the level of persistence of the causative agent of the disease in food products; \( D_{pf} \) – the duration of persistence of the causative agent of the disease in food products; \( T_p \) – the type of product and the method of contamination of the product by the pathogen; \( A_{rf} \) – the ability to reproduce in food products.

3. Evaluation of biological hazards by their persistence in food
Biological risk factors include bacteria, viruses, fungi, protozoa and helminths, as well as their toxins and metabolic products, which are dangerous to human life and health and can lead to illness or death of people.

Unlike physical and chemical factors, biological risk factors are potentially dangerous on the scale of the entire agro-industrial production (including production and processing of products), since they have a number of features due to the specifics of living organisms, as a result of which they are the most unpredictable and difficult to manage. When ingested with food, pathogens can not only survive and multiply, but also spread from infected to healthy people.

The study of biological risk factors in terms of persistence in food was carried out in meat and meat products, milk and dairy products, vegetable products, confectionery and bakery products, eggs, canned food, pickles and marinades. The “+” in the tables indicates the possibility of contamination of products via surface contamination, including that during transportation and storage.

About 60 % of known biological risk factors can enter the human body with meat and meat products. Of these, the most important ones are bacteria of the genera Brucella, Leptospira, Campylobacter, Salmonella, Yersinia, as well as Mycobacterium tuberculosis, M. bovis, M. avium, Listeria monocytogenes, Francisella tularensis, foot and mouth disease virus, Toxoplasma gondii, Taeniarynchus saginatus and Taenia solium (cysticercuses) since they are transmitted directly from the meat of infected animals. Living objects that enter the product through superficial contamination are of secondary importance and indicate non-compliance with sanitary standards during transportation, storage and processing of products.
### Table 1. Characterization of biological risk factors by their persistence in meat and meat products

| Risk factor | Meat and meat products |
|-------------|------------------------|
| Mycobacterium tuberculosis, M. bovis, M. avium | In frozen meat – up to 1 year |
| Brucella spp. | In frozen meat – up to 1 year |
| Leptospira spp. | In fresh meat – up to 2 days |
| Salmonella spp. | In frozen meat – more than 1 year |
| Francisella tularensis | In frozen meat – up to 93 days |
| Staphylococcus aureus | + In frozen meat – more than 1 year (including poultry meat) |
| Proteus spp. | + In frozen meat at -13 °C – for 6 months |
| Clostridium botulinum | + (smoked sausages, ham and poultry) |
| Clostridium perfringens | + (meat dishes, minced meat, including poultry meat) |
| Bacillus cereus | + It multiplies in meat and meat products, produces a toxin at 17 °C, in sausages – at 20 °C |
| Campylobacter spp. | In frozen meat - up to 60 days (most often broiler chickens, pork and their processed products) |
| Shigella spp. | + (jellied meat, pastes) |
| Diarrheagenic Escherichia coli, coliform bacteria | + (most often cooked meat dishes) |
| Yersinia spp. | From 35 days at 4 °C to 75 days at -18 °C |
| Listeria monocytogenes | In frozen meat (from -10 to -28 °C): lamb – up to 20 days, pork – up to 14 months, beef – up to 9 months |
| Vibrio spp. | + On boiled meat and meat dishes up to 5 days |
| Aphthovirus | In frozen meat – more than 1 year |
| Entamoeba histolytica | Vectors (in the intestines of flies and cockroaches up to 72 hours) → cooked meals (often cold snacks, sliced, sausage, etc.) – up to 5 days (chilled) |
| Toxoplasma gondii (cysts) | In meat and meat products at 2-5 °C – up to 1 month |
| Cryptosporidium parvum | + cooked meat dishes |
| Ascaris lumbricoides (eggs) | Mechanical vectors (flies, cockroaches) → cooked meals |
| Taeniarhynchus saginatus (cysticercuses) | Beef, less often venison, which has not undergone sufficient heat treatment – up to 7 weeks |
| Hymenolepis nana (eggs) | Mechanical vectors (flies, cockroaches) → cooked meals |
| Taenia solium (cysticercuses) | In pork cysticerci persist up to 6-7 weeks |
| Echinococcciae (eggs) | Mechanical vectors (flies) → cooked meals |
| Helminths of the genus Trichinella (larvae) | Most often, pork that has not undergone sufficient heat treatment – for more than 2 months |
| Enterobius vermicularis (eggs) | Mechanical vectors (flies) → cooked meals |

About 70 % of biological factors dangerous to humans are transmitted via products of plant origin during their surface contamination. Pathogenic organisms get to plant products when they were fertilized with insufficiently neutralized animal manure or human feces containing infectious agents,
their spores, cysts or eggs, when they were irrigated with untreated sewage or from natural water bodies, as well as during fecal contamination of plant products in processing and sales companies.

**Table 2.** Characterization of biological risk factors by their persistence on products of plant origin

| Risk factor                  | Products of plant origin                                      |
|------------------------------|----------------------------------------------------------------|
| Leptospira spp.              | + vegetables, berries, greens                                |
| Listeria monocytogenes       | + on vegetables and greens – up to 600 days, on grain – up to 56 days |
| Francisella tularensis       | + on grain – up to 133 days                                  |
| Staphylococcus aureus        | +                                                              |
| Proteus spp.                 | +                                                              |
| Clostridium botulinum        | + fruit, vegetables, mushrooms, berries                      |
| Clostridium perfringens      | + beans                                                       |
| Bacillus cereus              | + (including spices – dry garlic, laurel, pepper, etc.)       |
| Campylobacter spp.           | + vegetables, berries, fruit                                 |
| Shigella spp.                | + vegetables, berries, fruit                                 |
| Diarrheagenic Escherichia coli, coliform bacteria | + vegetables, berries, fruit |
| Salmonella spp.              | + on vegetables, fruit, berries – up to 16 days              |
| Yersinia spp.                | + on fruit, vegetables, mushrooms, berries - more than 2 months |
| Vibrio spp.                  | + on fruit, vegetables, greens – up to 4 days                |
| Hepatitis A virus            | + vegetables, berries, greens                                |
| Rotavirus                    | + on vegetables at 4 °C – up to 30 days                      |
| Norovirus                    | + vegetables, fruits, greens                                 |
| Entamoeba histolytica        | + on fruits, vegetables, greens – up to 5 days               |
| Toxoplasma gondii (oocysts)  | + vegetables, berries, greens                                |
| Lamblia (Giardia) intestinalis| + on fruit, berries, vegetables, greens – from 6 hours to 2 days |
| Cryptosporidium parvum       | + fruit, vegetables, berries, greens                         |
| Ascaris lumbricoides (eggs)  | + vegetables, berries, greens                                |
| Hymenolepis nana (eggs)      | + vegetables, berries, greens                                |
| Taenia solium (eggs)         | + vegetables, berries, greens                                |
| Subfamily of Echinococcinae (eggs) | + vegetables, berries, mushrooms                            |
| Helminths of the genus Fasciola (adolescari) | + vegetables, berries, greens (watering), near-water plants (sorrel, watercress) |
| Trichocephalus trichiuris (eggs) | + vegetables, berries, greens                               |
| Strongyloides stercoralis (larvae) | + in cracks of vegetables, fruit, berries – up to 4 days      |
| Enterobius vermicularis (eggs) | + Mechanical vectors (flies, cockroaches) → ready meals      |

About 61% of biological risk factors dangerous to humans can be transmitted with milk and dairy products. Of these, Mycobacterium tuberculosis, Mycobacterium bovis, Mycobacterium avium, Listeria monocytogenes, Francisella tularensis, Staphylococcus aureus, bacteria of the Brucella spp., Leptospira spp., Campylobacter spp., Salmonella spp., Yersinia spp., Aphthovirus and protozoa Toxoplasma gondii are of paramount importance. The others are less important.
Table 3. Characterization of biological risk factors by their persistence in milk and dairy products

| Risk factor                                      | Milk and dairy products                                                                 |
|-------------------------------------------------|----------------------------------------------------------------------------------------|
| M. tuberculosis, M. bovis, M. avium             | In milk – up to 10 days, in butter – up to 10 months, in cheese – up to 260 days        |
| Brucella spp.                                    | In milk – from 6 to 45 days (chilled), in cheese and butter - more than 2 months         |
| Leptospira spp.                                  | In milk – from 10 minutes. (sour) up to 24 hours (fresh)                                 |
| Listeria monocytogenes                          | In milk, soft cheese and butter – more than 4 months                                    |
| Francisella tularensis                          | In milk – from 2 days (sour) to 90 days (fresh)                                         |
| Staphylococcus aureus                           | In milk of cows with mastitis – up to 4 months                                         |
| Proteus spp.                                    | +                                                                                       |
| Clostridium botulinum                           | + (infection of people is extremely rare)                                              |
| Clostridium perfringens                         | + (infection of people is extremely rare)                                              |
| Bacillus cereus                                  | + (infection of people is extremely rare)                                              |
| Campylobacter spp.                              | In milk (with mastitis, external contamination) - from 22 days (4 °C) to 8 months: (-20 °C) |
| Shigella spp.                                   | + In milk – up to 10 days, in butter – up to 8 months. (4-6 °C)                          |
| Diarrheagenic Escherichia coli, coliform bacteria| + (can multiply in milk)                                                                |
| Salmonella spp.                                 | In milk – up to 20 days, kefir – up to 1 month, in butter – up to 4 months, in cheese – up to 1 year |
| Yersinia spp.                                   | In milk – up to 18 days, in butter – up to 145 days, Cottage cheese, cheese – more than 20 days |
| Vibrio spp.                                     | + up to 5 days (except sour milk)                                                      |
| Aphthovirus                                     | In milk – from 12 hours (at 37 °C, fresh) to 47 days (chilled), in butter – up to 45 days (chilled) |
| Rotavirus                                       | + contamination during processing, storage or sale                                     |
| Norovirus                                       | + (ice cream)                                                                          |
| Entamoeba histolytica                           | Vectors→ finished products                                                              |
| Toxoplasma gondii                               | In raw milk at 4-5 °C – for 5 days                                                     |
| Cryptosporidium parvum                          | + Thermally unprocessed products                                                       |
| Ascaris lumbricoides (eggs)                      | Mechanical vectors → cooked meals                                                       |
| Hymenolepis nana (eggs)                         | Mechanical vectors → cooked meals                                                       |
| Subfamily of Echinococcinae (eggs)              |Mechanical vectors → cooked meals                                                       |
| Enterobius vermicularis (eggs)                  |Mechanical vectors → cooked meals                                                       |

About 36% of the considered biological risk factors are transmitted with fish and seafood. Of these, the plerocercoids of the cestodes of the genus Diphyllobothrium and metacercaria opisthorchids are of paramount importance. Other biological factors enter food products through contamination by infected people or mechanical vectors.
### Table 4. Characterization of biological risk factors by their persistence in fish and seafood

| Risk factor                              | Fish and seafood                                      |
|------------------------------------------|-------------------------------------------------------|
| Leptospira spp.                          | + (extremely seldom fish)                             |
| Listeria monocytogenes                   | + (frozen shellfish and shrimp)                       |
| Staphylococcus aureus                    | +                                                    |
| Proteus spp.                             | +                                                    |
| Clostridium botulinum                    | + (salted and smoked fish)                            |
| Clostridium perfringens                  | + (shrimp, crab)                                      |
| Bacillus cereus                          | + (salted and smoked fish)                            |
| Salmonella spp.                          | + (fish and fish dishes)                              |
| Yersinia spp.                            | + (fish)                                              |
| Vibrio spp.                              | + (most often sushi, rolls, fish, crustaceans, shellfish) |
| Hepatitis A virus                        | + (shellfish, mussels)                                |
| Norovirus                                | + (most often shellfish, oysters)                     |
| Entamoeba histolytica                    | Vectors (flies, cockroaches) → cooked meals           |
| Cryptosporidium parvum                   | + (rarely, fish that has not undergone heat treatment) |
| Ascaris lumbricoides (eggs)              | Mechanical vectors → cooked meals                     |
| Hymenolepis nana (eggs)                  | Mechanical vectors → cooked meals                     |
| Genus Diphyllobothrium (plerocercoids)   | Freshwater fish (pike, burbot, etc.), that hasn’t undergone sufficient heat treatment, planer, stockfish, mildly salted caviar |
| Genus Opisthorchis (metacercaria)        | Fish of the cyprinid family, that hasn’t undergone sufficient heat treatment, sliced frozen raw meat, stockfish |
| Enterobius vermicularis (eggs)           | Mechanical vectors → cooked meals                     |

### Table 5. Characterization of biological risk factors by their persistence in confectionery and bakery products

| Risk factor                              | Confectionery and bakery products                    |
|------------------------------------------|-------------------------------------------------------|
| Listeria monocytogenes                   | + confectionery with meat and fish                   |
| Staphylococcus aureus                    | + confectionery with butter cream and whipped cream  |
| Proteus spp.                             | +                                                    |
| Bacillus cereus                          | + (including flour and dough)                        |
| Salmonella spp.                          | + on bread and confectionary – up to 15 days         |
| Yersinia spp.                            | + on bread and confectionary – up to 24 days         |
| Vibrio spp.                              | + on bread up to 4 days                              |
| Entamoeba histolytica                    | Vectors (flies, cockroaches) → cooked meals          |
| Lamblia (Giardia) intestinalis           | + up to 2 days                                       |
| Ascaris lumbricoides (eggs)              | Mechanical vectors → cooked meals                     |
| Hymenolepis nana (eggs)                  | Mechanical vectors → cooked meals                     |
| Helminths of the genus Opisthorchis (metacercaria) | Pies with fish (in depth, in case of insufficient heat treatment) |
| Helminths of the genus Trichinella (larvae) | Pork pies (in depth, in case of insufficient heat treatment) |
| Enterobius vermicularis (eggs)           | Mechanical vectors (flies) → cooked meals            |
The transfer of biological risk factors during the use of confectionery and bakery products is mainly associated with surface contamination of products by pathogens, in some cases with non-compliance with the heat treatment parameters when cooking culinary products with meat and fish (plerocercoids Diphyllobothrium spp. and metacercaria of the family Opisthorchidae).

**Table 6.** Characterization of biological risk factors by their persistence in eggs and their processed products

| Risk factor | Eggs and their processed products |
|-------------|----------------------------------|
| M. tuberculosis, M. bovis, M. avium | - upon detection, they are processed into bakery products or for domestic use |
| Listeria monocytogenes | - upon detection, they are only for domestic use |
| Staphylococcus aureus | + upon detection, they are processed into bakery products or for domestic use |
| Proteus spp. | + |
| Clostridium botulinum | - upon detection, they must be destroyed |
| Diarrheagenic Escherichia coli, coliform bacteria | + (infection of people is extremely rare) |
| Salmonella spp. | In egg powder – up to 9 months, on the shell – up to 24 days, in frozen yolk – up to 13 months |
| Yersinia spp. | + upon detection, they are processed into bakery products or for domestic use |
| Entamoeba histolytica | Vectors (flies, cockroaches) → cooked meals |
| Toxoplasma gondii | Raw eggs |
| Ascaris lumbricoides (eggs) | Mechanical vectors → cooked meals |
| Hymenolepis nana (eggs) | Mechanical vectors → cooked meals |
| Enterobius vermicularis (eggs) | Mechanical vectors → cooked meals |

When consuming eggs and their processed products, the bacteria of the Salmonella spp. (transmitted from infected birds) and the protozoa Toxoplasma gondii (cases of infection with raw eggs containing agent) are of paramount importance. Infection of people with bacteria of the genus Yersinia spp. and Staphylococcus aureus also periodically occurs, despite the strict veterinary and sanitary requirements for the processing of infected eggs for bakery products or for domestic use.

About 42% of the presented biological risk factors can be transmitted with canned food, pickles, marinades, and smoked products. Of these, the bacteria Mycobacterium tuberculosis, Mycobacterium bovis, Mycobacterium avium, Listeria monocytogenes, the genera Brucella, Leptospira, the metacercaria of the trematodes of the genus Opisthorchis, the plerocercoids Diphyllobothrium latum, Taenia solium and Taeniarhynchus saginatus (cysticercuses) and larvae of the nematodes of the genus Trichinella are of paramount significance.

### 4. Scoring the significance of biological risk factors for infection in humans

The persistence parameters of biological risk factors are necessary for developing the score estimate of the significance of these factors for human infection with pathogens of certain diseases in consumption of various products.

The stability of biological risk factors in food products was evaluated according to three criteria: the duration of the pathogen persistence in food products; a type of a product and a method of its contamination with a pathogen; the possibility of reproduction in food.

A score system has been developed for each criterion. A low score characterizes the low stability of pathogens in food products. A high score shows the maximum persistence in foods processed by different methods before eating.
## Table 7. Characterization of biological risk factors by their persistence in canned, salted, smoked and pickled products

| Risk factor                                      | Type of product                                                                 |
|--------------------------------------------------|---------------------------------------------------------------------------------|
| M. tuberculosis, M. bovis, M. avium              | In salted meat – up to 60 days                                                  |
| Brucella spp.                                    | In salted meat – up to 30 days                                                  |
| Leptospira spp.                                  | In salted meat – up to 10 days (4.8 % NaCl)                                     |
| Listeria monocytogenes                           | In salted meat – up to 400 days (24 % NaCl)                                     |
| Staphylococcus aureus                            | + produce toxins at a concentration of NaCl up to 15 %                          |
| Proteus spp.                                     | + in salted meat at 17 % NaCl, in marinades at pH of 4.5-5.0 – death            |
| Clostridium botulinum                            | + 6-8 months, with NaCl up to 18 % (including canned food)                      |
| Clostridium perfringens                          | + (including canned food) – more than 8 months                                  |
| Bacillus cereus                                  | + multiply and produce a toxin at 20 °C (gray plaque), growth stops when NaCl ≥ 15 % |
| Salmonella spp.                                  | In salted products – up to 4 months                                            |
| Yersinia spp.                                    | + in salted vegetables - within 15 days (NaCl up to 10 %)                       |
| Aphthovirus                                      | In salted meat – up to 124 days (1 °C)                                          |
| Taeniarihynchus saginatus (cysticercoses)        | Salty and jerky meat                                                            |
| Taenia solium (cysticercuses)                    | Salty and jerky meat (salting in a strong brine leads to death only after 2-3 weeks) |
| Helminths of the genus Diphyllobothrium (plerocercoids) | In slightly salted fish and caviar, plerocercoids die after 1-2 weeks, in a 3% NaCl solution – after 2 days, in 5 % – after 30 minutes |
| Helminths of the genus Opisthorchis (metacercaria) | With hot smoking – death, cold does not affect viability. With warm salting (salt content in fish is 14 %) – up to 14 days, with cold one – 10-21 days in small fish and up to 40 days in large fish (more than 25 cm) |
| Helminths of the genus Trichinella (larvae)      | Salting and smoking do not have a detrimental effect                             |

The duration of persistence of the pathogen in food was estimated by the following number of points:

- 0.05 points – up to 24 hours;
- 0.1 points – up to 7 days (up to 1 week);
- 0.02 points – 8-14 days (up to 2 weeks);
- 0.03 points – 15-21 days (up to 3 weeks);
- 0.04 points – 22-30 days (up to 1 month);
- 0.08 points – up to 2 months (60 days);
- 0.12 points – up to 3 months (90 days);
- 0.16 points – up to 4 months (120 days);
- 0.20 points – up to 5 months (150 days);
- 0.24 points – up to 6 months (180 days);
- 0.48 points – up to 1 year (365 days);
- 0.50 points – more than 1 year.

In the absence of the pathogen persistence period in the table, a score of 0.1 is used for canned food, pickles, marinades, smoked meats, etc., 0.05 points for products of animal origin (except eggs)
and 0.01 points for the rest of the products. For the products marked "extremely rare" we used 0.001 points.

Types of products and methods of product contamination by the pathogen are assigned specific points:

- 10 points – canned food, pickles, marinades, smoked meats, dried products (the pathogen is directly in the raw materials – zoonoses);
- 8 points – canned food, pickles, marinades, smoked meats, dried products (surface contamination);
- 6 points – products of animal origin (the pathogen is directly in the raw material – zoonoses);
- 4 points – products of animal origin (surface contamination);
- 3 points – products of plant origin (surface contamination);
- 2 points – confectionery and bakery products;
- 1 point – mechanical vectors → cooked meals.

For some of the criteria, additional points are assigned:

- 1.5 points – salting and smoking do not have a detrimental effect on spores, cysts, oocysts or larvae of human pathogens;
- 2 points – canning does not have a detrimental effect on spores, cysts, oocysts or larvae of the pathogen;
- 2 points – spices and dried seasonings;
- 1 point – meat, dairy products, fish products (including sliced frozen raw meat) and egg powder;
- 0.8 points – raw meat, sour milk and frozen yolk;
- 0.6 points – 24% or more salt solution and 14% salt are used per 1 kg of animal products (fish, caviar, meat);
- 0.5 points – 17-23% salt solution and 5% salt per 1 kg of animal products;
- 0.4 points – 14-16% salt solution and 3% salt per 1 kg of animal products;
- 0.2 points – salt solution up to 5%;
- 0.1 points – warm salting;
- 0.3 points – cold salting;
- 0.4 points – frozen meat, fish and seafood, fresh chilled milk, raw eggs.

If it is possible for pathogens to reproduce in food, the following points were assigned:

- 2 points – pathogens can reproduce in food;
- 3 points – pathogens produce toxins in canned and pickled products.

In cases where the terms or features are not indicated, the calculation is carried out according to the minimum indicator.

In general, the level of persistence in food is characterized by the following scale:

- up to 1 point – very low persistence;
- from 1 to 3 points – low persistence;
- from 3 to 6 points – medium persistence;
- from 6 to 10 points – high persistence;
- above 10 points – very high persistence.

The above studies show that among the presented biological risk factors, 47.22% have very low persistence in food (adolescaria Fasciola spp; eggs of Trichocephalus trichuris, Enterobius vermicularis, Hymenolepis nana, Echinococcus spp., Ascaris lumbricoides; larvae of Strongyloides stercoralis, cysts of Lamblia intestinalis). Low persistence is demonstrated by 11.11% (genus Rotavirus, hepatitis A virus, the genus Norovirus, bacteria of the Leptospira spp. and Vibrio spp., Escherichia coli, Toxoplasma gondii, Cryptosporidium parvum). 19.44% have medium persistence (plerocercoids Diphyllolothrium spp., cysticerci Taeniarhynchus saginatus and Taenia solium, bacteria of genus Shigella, Francisella tularensis). 16.67% have high persistence (larvae of the genus Trichinella, metacercaria of the Opisthorchidae family, bacteria of Proteus spp., Campylobacter spp., Yersinia spp., Brucella spp., Bacillus cereus, Clostridium perfringens, Staphylococcus aureus, Clostridium botulinum, Mycobacterium tuberculosis, Mycobacterium bovis, Mycobacterium avium).
Aphthovirus, bacteria of the Salmonella spp., Listeria monocytogenes (about 5.56 % of known biological risk factors) have very high persistence in the food products.

5. Conclusion

The sensitivity of biological risk factors to physical and chemical influences is the basis for the formation of measures to reduce the incidence in the population. The sensitivity of biological risk factors to physical influences plays an important role in the disinfection of products that are either undesirable to be treated with chemicals (fresh fruit, milk, etc.), or they are treated with chemicals in low concentrations that do not affect all types of pathogens (for example, chlorination of water, salting or pickling meat, fish, vegetables), or biological risk factors have a very high resistance to chemicals and disinfection is carried out mainly by physical methods (for example, biological risk factors of helminthic etiology).

Sensitivity to drying can be both the main (spices, tea, dried fruit, jerky meat and fish), and additional (dry fruit concentrates for the production of juices and juice drinks, milk powder, egg powder, etc.) measure to reduce the risk when processing products of plant and animal origin in natural conditions (drying raisins in the sunlight) with the help of special equipment.

Sensitivity to temperature is the main criterion for preventing the spread of biological factors among people. The use of high temperatures is the basis of disinfection in technological processes of product processing. The most common types of pasteurization are long (at 63-65 °C for 30-40 min.), short (at 85-90 °C for 0.5-1 min.) and instant ones (at 98 °C for several seconds). Disinfection by boiling and treatment with hot steam at 100 °C are in wide use. Recently, methods of lamporization and plate pasteurization, that is, instantaneous pasteurization within a few seconds at a temperature of 102-105 °C [6], have also been used.

Low temperatures play an important role not only in the disinfection of products, but also during their storage, since some risk factors quite successfully survive and reproduce at temperatures close to zero.

The above information about the possible biological risk of using this or that product and regulatory requirements should be available not only to food industry specialists, but also to all consumers. In a market economy, the preference given to safe products can serve as a serious economic incentive for its production. Thus, ensuring the structure, safety and quality of food is the most important strategic task of the state at the current stage of development of the Russian Federation [3, 7, 8].

Making the system of biological safety based on the identification of critical control points, development of equipment for express diagnostics, processing and transmission of data on the epidemic and epizootic situation taking into account risks, efficient prevention, disinfection, disinsection and disactivation, as well as the creation of a biosafety monitoring system at all stages of the production chain will serve as the main criterion for obtaining biologically safe food.

References

[1] Kostrova Yu B and Martynushkin A B 2015 Food resources of the Ryazan region and risk management in food production Vestnik RSATU 198-104
[2] Lyashchuk Yu O 2012 Food quality management based on the HACCP system Innovative directions and methods for the implementation of scientific research in the agro-industrial complex (Materials of the scientific and practical conference of the Russian State Technical University) 163-168
[3] Shibarshina O Yu 2016 On the issue of sustainable development of socially significant markets in the Ryazan region Sustainable development of socio-economic systems: science and practice (Materials of the III international scientific and practical conference) (Moscow) 717-725.
[4] Briko N I, Pokrovsky V I and Malysheva N A 2015 Globalization and spread of infectious diseases Applied Microbiology 1(4) 20-28
[5] Lyashchuk Yu O and Sudnitsyn I A 2017 Features of the occurrence of risk situations in the activities of agricultural enterprises Problems of regional socio-economic development: trends and prospects (Materials of the student scientific and practical conference) ed N V Byshov (Ryazan publishing house of the Russian State Technical University) 526-532

[6] Zykin L F, Khaptsev Z Yu and Spiryakhina T V 2011 Modern methods in veterinary microbiology (Moscow KolosS)

[7] Zavyalov M A, Kuhto V A, Ilyuhina N V and Kolokolova A Yu 2018 Irradiation of biological objects using an ionization beam in order to inhibit conditionally pathogenic and pathogenic microflora of agricultural raw materials Proceedings of the Voronezh State University of Engineering Technologies 80(3) 278-282

[8] Semenova Z A, Levshenko M T, Kolokolova A Yu, Ilyuhina N V and Kurbanova M N 2019 Establishment of a test culture to study the effects of ionizing radiation on the opportunistic and pathogenic microflora of food Proceedings of the Voronezh State University of Engineering Technologies 81(2) 245-249