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PREVALENCE OF LISTERIA MONOCYTOGENES IN MEAT PRODUCTS DURING 2017–2019 DEPENDING ON TECHNOLOGICAL FACTORS AND SEASONS

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Abstract

Microbiological examination of contamination of imported and domestic meat products with pathogenic bacteria Listeria monocytogenes depending on a meat type, technology and season was carried out during 2017–2019. In total, 2777 product samples were analyzed; the presence of this pathogen was revealed in 8.8% of products (244 positive samples). It was found that the prevalence of L. monocytogenes in meat products increased over three years of observation (2017–2019). The highest occurrence of this pathogen was found in poultry meat (on average 18.7%) followed by products from beef (13.2%). Meat products from mixed raw materials (beef and pork) accounted for 5.3% of tested samples, while in pork semi-finished products L. monocytogenes was found only in 3.2% of cases. It was noted that the technology of semi-finished products significantly affected the level of contamination of meat products with L. monocytogenes. Various technological approaches are used in the production process increasing the risk of contamination of the finished product since there is no timely data on Listeria contamination of raw materials used for production of a particular product. It has been established that a significant role in microbiological studies is played by various approaches to sample preparation of analyzed samples of meat cuts, semi-finished products in large and small pieces, as well as minced semi-finished products. Not knowing the real level of surface contamination with L. monocytogenes of carcasses, half-carcasses, semi-finished products in large pieces, manufacturers use such raw materials for the subsequent production of other types of semi-finished meat products, increasing the risk of manufacturing unsafe products with following contamination of equipment, work surfaces and other objects of the production environment. The highest occurrence of L. monocytogenes in meat products during three years of observation was found in the summer period (14.2%). The proportions of positive samples in the winter, spring and autumn months varied on average within 6.7–7.1%.

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Introduction

Listeria monocytogenes (L. monocytogenes) is a facultative Gram-positive intracellular pathogen, which causes an infectious illness called listeriosis. In terms of the lethality and severity of clinical course, listeriosis exceeds salmonellosis and campylobacteriosis turning into one of the most significant foodborne infections in the world [1]. This pathogen is widely distributed in the environment, where it is frequently found in foods, and poses a serious problem in the food chain, especially for ready-to-eat (RTE) food products [2,3].

Over the last decades, the majority of large epidemic outbreaks of listeriosis with the high percent of fatal cases have been associated with food consumption, first of all, cheese (especially soft), milk and other dairy products, as well as meat semi-finished products and salads [1]. With that, a leading role is played by ready-to-eat (RTE) foods supporting the growth of *L. monocytogenes* that are stored

in the refrigerated conditions for a long time and subjected to cross-contamination during storage. At low positive temperatures, the pathogen can slowly multiply in foods, including meat products [4]. According to the data of the European Food Safety Authority (EFSA), 2,480 cases of listeriosis were reported in the EU countries in 2017 [5]. The number of reported confirmed human cases of listeriosis in the EU countries was 2,545 in 2018 and 2,621 in 2019 [6]. These data show the stable high number of recorded cases of listeriosis among the EU population.

At the beginning of the 21st century, in the Russian Federation, the corresponding changes were made in SanPiN2.3.2.1078–01[1] by introducing the norm for controlling *L. monocytogenes* in foods and SanPiN3.1.7.2817–10[2] "Prevention of listeriosis in humans" by introducing the periodicity of the control of *Listeria* in food industry enterprises. These documents allowed organizing the effective control of pathogenic *Listeria*. If measures on the control of this microorganism in the food production environment are ineffective, it can persist, which leads to cross-contamination of foods [7]. McCarthy Z. et al. [8] assessed a risk of changes in the level of contamination with pathogens at different technological links in the places of poultry slaughter and meat processing, and found that the complexity and continuity of a technological process can easily lead to cross-contamination. Different *L. monocytogenes* strains can survive and proliferate in food processing enterprises due to the corresponding phenotypic properties such as the attachment to surfaces, biofilm-forming ability and increased resistance to environmental stress [9,10]. Bacteria organized in a biofilm develop resistance to harsh environmental conditions: desiccation, nutrient deprivation or sanitary treatment [11,12,13,14]. In the study carried out by Bonsaglia et al. [15], almost all *L. monocytogenes* strains isolated from the food production environment were able to form biofilm on stainless steel and glass surfaces.

Since 2011, the safety of food products regarding pathogenic *Listeria* has been ensured by the Technical Regulation of the Customs Union (TR TU 021/2011[3]). Methods for controlling foods for the presence of pathogenic *Listeria* according to GOST 32031–2012[4] "Food products. Methods for detection of *Listeria monocytogenes*" were developed and introduced into practice in Russia. The modern methodological base allows fast and effective detection of pathogenic *Listeria* in foods along with other pathogens and opportunistic pathogens.

With that, the number of recorded listeriosis cases in the Russian Federation is not high, although its registration as a distinct nosological form of human illness was introduced in the RF in 1992. In Russia, only sporadic listeriosis cases were detected. In 2005–2017, 644 listeriosis cases were recorded in Russia with the highest number (75) of cases in 2006–2007. During this period, 229 listeriosis cases were recorded in Moscow accounting for 35.6% of all cases reported in Russia [16]. In 2019, the clinical diagnosis of listeriosis was laboratory confirmed in the RF in 86 cases (19 fatal cases) [17]. It can be stated that there is a certain imbalance between the confirmed level of *Listeria* contamination of foods and the revealed level of listeriosis incidence.

In our view, Russia has significant reserves to increase the effectiveness of the epidemiological surveillance of the *Listeria* infection based on the improvement of the laboratory diagnostics of the main clinical forms of listeriosis (meningitis, meningoencephalitis, sepsis; abortion and stillbirth in pregnant women), introduction of the obligatory epidemiological investigation of listeriosis cases with an emphasis on the foodborne transmission, and analysis of the level of *Listeria* contamination of foods in the conditions of the technological chain of modern food production. Only few studies on detection of *Listeria* in the conditions of modern meat processing plants were carried out in Russia [18,19]. In this study, quite extensive investigations of *L. monocytogenes* contamination of imported and domestic meat products depending on a meat type, technology and seasons were carried out.

The aim of the study was to analyze the prevalence of *L. monocytogenes* in meat products and semi-finished products depending on a meat type, production technology and season during a period from 2017 to 2019.

Objects and methods

The following samples were investigated: raw poultry semi-finished products (natural, minced and with spices), pork and beef semi-finished products (in large pieces, in small pieces and minced), semi-finished products (minced and in dough) made from mixed meat types (beef and pork), as well as ready-to-eat (RTE) meat products.

Sample preparation for microbiological analysis included thawing (when necessary), opening packages under aseptic conditions (when analyzing packed meat products), flaming of the sample surface or sampling without flaming of the surface, and comminution of samples.

Sampling from pork and beef semi-finished products in large pieces as well as from poultry carcasses was carried out according to GOST R ISO 6887–2–2013[5] and

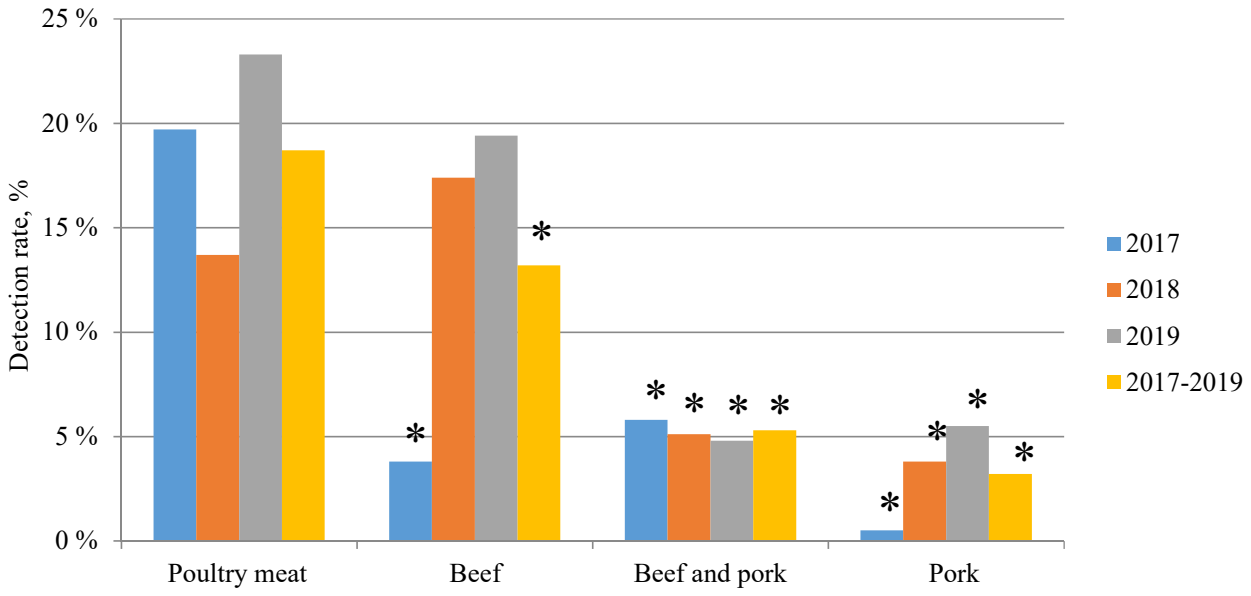
[1] Additions and changes No 22 to SanPiN 2.3.2.1078–01. Sanitary and epidemiological rules and regulations SanERR 2.3.2. 2804–10 "Hygienic requirements for the safety and nutritional value of food products". Retrieved from https://base.garant.ru/12183206/53f89421bbdaf741eb2d1ecc4ddb4c33/ Accessed August 25, 2022. (In Russian)

[2] SanPiN 3.1.7.2817–10. Sanitary and epidemiological rules and regulations "Prevention of listeriosis in humans". Retrieved from https://36.rospotrebnadzor.ru/documents/san_nor/6082 Accessed August 25, 2022. (In Russian)

[3] Technical regulation of the Customs Union TR CU 021/2011"On food safety". (Adopted by The decision of the Council of the Eurasian economic Commission of December 9, 2011 No. 880). Moscow, 2011. Retrieved from https://docs.cntd.ru/document/902320560. Accessed August 24, 2022. (In Russian)

[4] GOST 32031–2012 "Food products. Methods for detection of *Listeria monocytogenes*" Retrieved from https://docs.cntd.ru/document/1200105310 Accessed August 24, 2022. (In Russian)

[5] GOST R ISO 6887–2–2013 «Microbiology of food and animal feeding stuffs. Preparation of test samples, initial suspension and decimal dilutions for microbiological examination. Part 2. Specific rules for the preparation of meat and meat products» Retrieved from https://docs.cntd.ru/document/1200104686 Accessed August 24, 2022 (In Russian)



* p < 0.05 when compared to poultry meat during the same period.

Figure 1. Detection rate of contaminated meat product samples by meat types in 2017–2019

GOST R 54354–2011[6] as follows. A package was removed with the adherence to the aseptic rules and use of sterile instruments. After that, a layer 2 mm thick was cut out from a product surface area of 50 × 50 mm. The surface of this site was flamed up to carbonization, and then the carbonized layer with an area of 40 × 40 mm and thickness of 10 mm was removed with other sterile instruments. Analytical units of 25 g each were taken with sterile forceps and scalpel, and placed into sterile bags for homogenization.

Analytical units of 25 g each were taken from semi-finished products in small pieces, minced semi-finished products and semi-finished products in dough without treating sample surfaces.

All analytical units were tested on the presence of *Listeria monocytogenes* according to GOST 32031–2012.

Statistical analysis was performed using software MS Excel 2019 (Microsoft, USA) and Statistica 12.0 (Statsoft, USA). To assess statistical significance of differences in data, Pearson's chi-squared test and Fisher's exact test were used. Differences were considered significant at $p < 0.05$.

Results and discussion

During the period from January 2017 to December 2019 (inclusively), 2777 samples of meat semi-finished products were analyzed. Among them, 244 samples (8.8%) were positive for *L. monocytogenes* (Table 1).

Analysis of the obtained data allows us to note that the frequency of detection of *L. monocytogenes* rose steadily from 2017 to 2019. The percent of samples positive for *L. monocytogenes* grew year after year and increased practically twofold during the studied period despite the fact that the smallest number of samples was analyzed in 2019.

[6] GOST 54354–2011 «Meat and meat products. General requirements and methods of microbiological testing» Retrieved from https://docs.cntd.ru/document/1200087716 Accessed August 24, 2022 (In Russian)

Table 1. Results of the investigation of different meat types and the number of samples positive for *L. monocytogenes* in 2017–2019

Meat type	2017 r. (analyzed/ positive)	2018 r. (analyzed/ positive)	2019 r. (analyzed/ positive)
Poultry meat	122/24 (19.7%)	226/31 (13.7%)	223/52 (23.3%)#
Beef	156/6 (3.8%)#	132/23 (17.4%)*	144/28 (19.4%)*
Beef and pork	411/24 (5.8%)	394/20 (5.1%)	336/16 (4.8%)
Pork	213/1 (0.5%)#	239/9 (3.8%)*	181/10 (5.5)*
Total	902/55 (6.1%)	991/83 (8.4%)	884/106 (12.0%)#

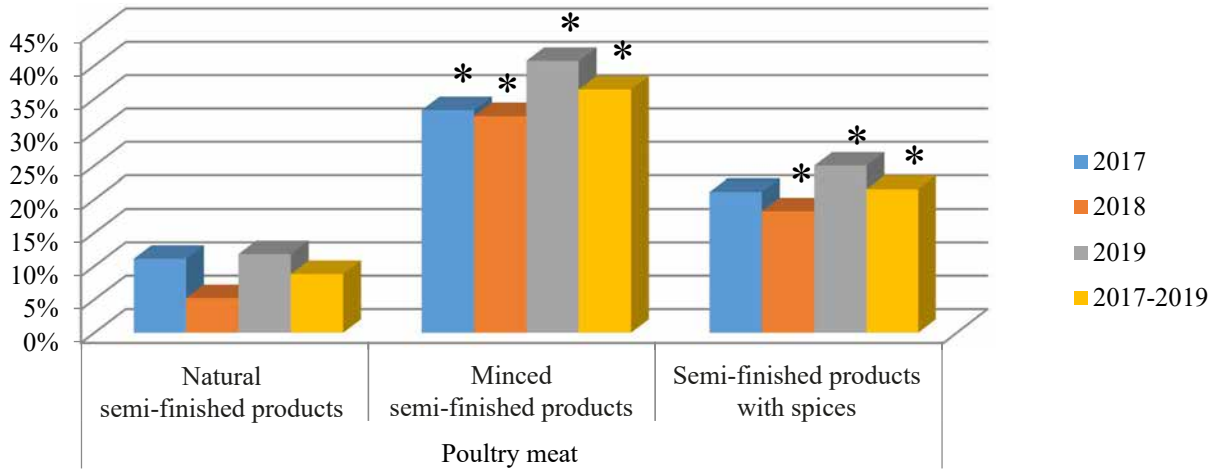
* p < 0.05 when compared with 2017,
# p < 0.05 when compared with 2018.

Data obtained for 2019 agree with the results of the researchers from Brazil [20], who studied the prevalence of *L. monocytogenes* in different meat types in Brazil using a systematic review and meta-analysis of scientific studies published during the period from 2009 to 2019. The total prevalence of *L. monocytogenes* in meat products in Brazil was 13% [20].

It was interesting to assess an impact of different conditions and factors on detection of *L. monocytogenes* during 2017–2019. The results of the investigation were ranked by meat types, technologies of product manufacture, years and seasons.

When analyzing the raw material composition of the tested meat products (Figure 1), it is possible to state with reasonable confidence that the most vulnerable in terms of *L. monocytogenes* contamination were poultry meat and beef. The data on the frequency of detection of *L. monocytogenes* in different meat types during the period of 2017–2019 are presented in the histogram below.

In 2017, the detection rate of *L. monocytogenes* in poultry meat (19.7%) significantly differed from that in other meat types, showing the maximum number of positive samples among all meat types. The proportions of positive



* p < 0.05 when compared with natural semi-finished products from poultry meat.

Figure 2. Detection rate of *L. monocytogenes* in different types of poultry semi-finished products in 2017–2019

samples from mixed raw materials (beef and pork) and from beef were at a level of 5.8 and 3.8%, respectively, while pork was the least contaminated (only 0.5%).

In 2018, products from beef accounted for the maximum proportion of positive samples (17.4%), followed by poultry meat (13.7%), products from mixed raw materials (beef and pork) and pork (5.1 and 3.8%, respectively).

In 2019, it was established with certainty that during the studied period the highest proportion of all positive samples was in poultry meat (23.3%), the second place in terms of the contamination degree was occupied by beef products (19.4%), which also showed the maximum number of positive samples over the period of 2017–2019. The proportion of meat products from mixed raw materials (beef and pork) reduced to 4.8% of tested products showing the insignificant trend towards a decrease in the prevalence over the studied period. At the same time, the prevalence of *L. monocytogenes* in pork increased to 5.5%.

Our data indicate with certainty that *L. monocytogenes* most often occur in poultry meat and beef, which is in complete agreement with the results of other researchers on the RF territory [21]. However, studies carried out abroad, on the contrary, indicate the maximum contamination of pork [20].

The obtained statistical data show an insignificant reduction (from 5.8 to 4.8%) in the detection rate in meat products from mixed raw materials (beef and pork) and a clear increase in the detection rate in pork (from 0.5 to 5.5%).

It was interesting to analyze detection of the pathogen in products depending on the methods for sample preparation in microbiological examination, technological processes applied to meat raw materials during production and different seasons of the investigations.

Products from poultry meat were divided into three types of semi-finished products depending on the technology of their production according to GOST 31936–2012[7]: a) natural semi-finished products, which included carcasses and parts of carcasses, semi-finished products in pieces (boneless and bone-in), b) minced semi-finished products, and c) semi-finished products with the use of spices.

Figure 2 presents the results of the investigation as a diagram, which clearly demonstrates that among the tested poultry semi-finished products, natural semi-finished products were the least contaminated with the pathogen under study. We established by statistical data processing that natural semi-finished products differed significantly from other types in all cases (23 positives out of 262 tested samples) except semi-finished products with spices in 2017.

Minced semi-finished products were the most contaminated (43 positives out of 118 tested samples), which is probably linked with the technology of their production (the maximum product area comes into contact with production objects during mincing). Over the studied period, semi-finished products with spices occupied the intermediate position (41 out of 191), which can be linked with the inhibitory action of preserving agents being constituents of the final composition of these products.

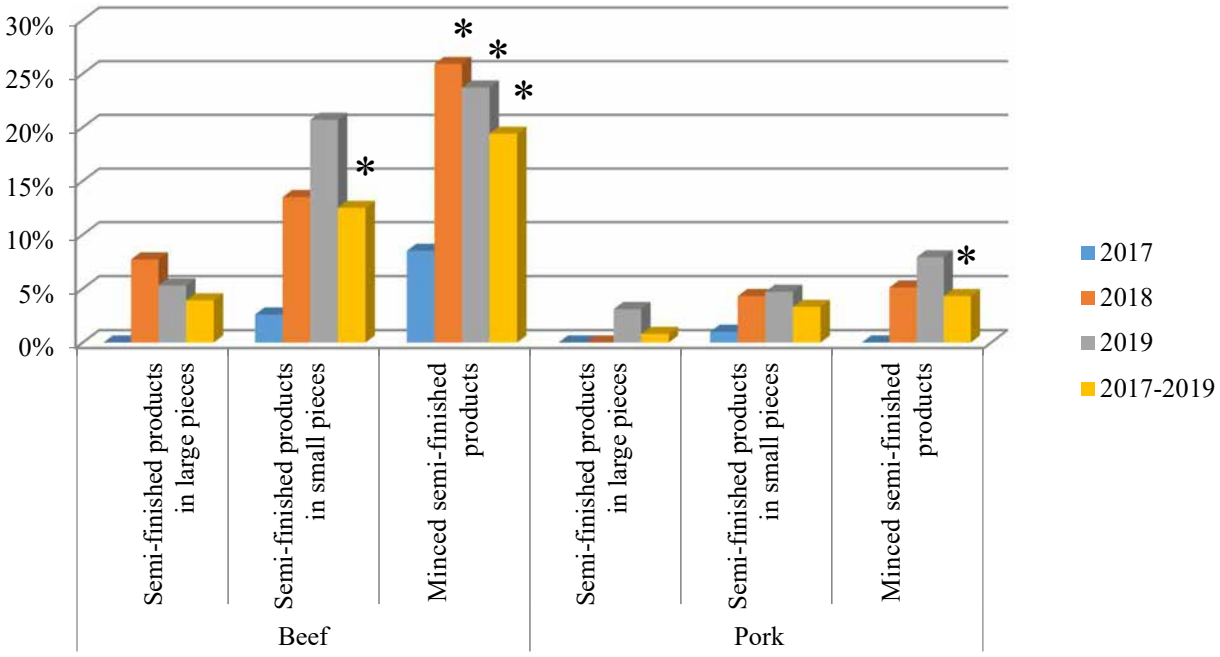
Fifty two poultry carcasses were tested during the indicated period; with that, contaminated samples were not found.

Results of investigations depend to a greater degree on sampling methods. A choice of these methods is directly linked with the aim of the research. According to the documents on sampling (GOST 7702.2.0–2016[8] and GOST R ISO 6887–2–2013[9]), two sampling methods are used for products from poultry meat to assess microbiological safety: the destructive method (tissue dissection) with surface treatment used for taking samples from deep layers of the pectoral muscle of poultry carcasses and the

[7] GOST 31936–2012 «Semi-prepared poultry meat and poultry offal. General specifications». Retrieved from https://docs.cntd.ru/document/1200103353 Accessed August 24, 2022 (In Russian)

[8] GOST 7702.2.0–2016 «Poultry slaughtering products, poultry meat ready-to-cook products and the objects of production environment. Sampling methods and the preparation to microbiological analyses» Retrieved from https://docs.cntd.ru/document/1200139190 Accessed August 24, 2022 (In Russian)

[9] GOST R ISO 6887–2–2013 «Microbiology of food and animal feeding stuffs. Preparation of test samples, initial suspension and decimal dilutions for microbiological examination. Part 2. Specific rules for the preparation of meat and meat products» Retrieved from https://docs.cntd.ru/document/1200104686 Accessed August 24, 2022 (In Russian)



* $p < 0.05$ when compared with semi-finished products in large pieces from beef and pork.

Figure 3. Detection rate of L. monocytogenes in different types of semi-finished products from beef and pork in 2017–2019

destructive method without treatment of the semi-finished product surface used in examination of all other poultry semi-finished products. The overall microbiological status of a product with consideration for its contamination during production is assessed by simultaneous examination of the surface and deep layers of semi-finished products [22]. At the same time, examination of poultry carcasses that are raw materials in the subsequent semi-finished product manufacture by the first method of sample preparation allows making a conclusion about the presence of *L. monocytogenes* only in the deep layers not reflecting possible contamination of the surface layers during primary processing. This statement was confirmed by our data obtained in 2017–2019 in examination of whole poultry carcasses using the destructive method of sampling from deep layers with surface treatment.

An important role in meat product contamination is played by the fact that various technological manipulations are used in the production process (for example, when mincing a semi-finished product) increasing a risk of microbial contamination of the finished product.

Moreover, *Listeria* occurs in the poultry intestine according to data of several scientists (the prevalence in poultry fecal samples was 33% for *Listeria* spp. and 33% for *L. monocytogenes*) [23]. Upon improper primary processing practice, they can contaminate poultry superficial skin layers as well as objects of production environment including floor drains that are considered to be the main point of *Listeria* location in poultry processing plants. This, in turn, leads to extremely high level of product contamination linked exactly with floor drains during the production process. A percent of *Listeria* detection in floor drains in poultry processing plants is almost three times higher than in meat processing plants [24]. Poor construction of the building can lead to accumulation of water in the drainage creating ideal conditions for *L. monocytogenes* survival and biofilm formation [25,26]. Finally, poor sanitary conditions, such as using high pressure hoses for washing floors, can generate aerosols potentially spreading *Listeria* from non-food contact surfaces (NFCS) to food contact surfaces (FCS), or new niches of NFCS [26].

According to GOST 32951–2014[10] and GOST 33102–2014[11], all tested meat semi-finished products were divided depending on the production technology and analyzed on the presence of *L. monocytogenes*.

As can be seen from Figure 3, it was calculated with confidence that among semi-finished products made both from beef and from pork, the lowest *L. monocytogenes* contamination was observed in semi-finished products in large pieces.

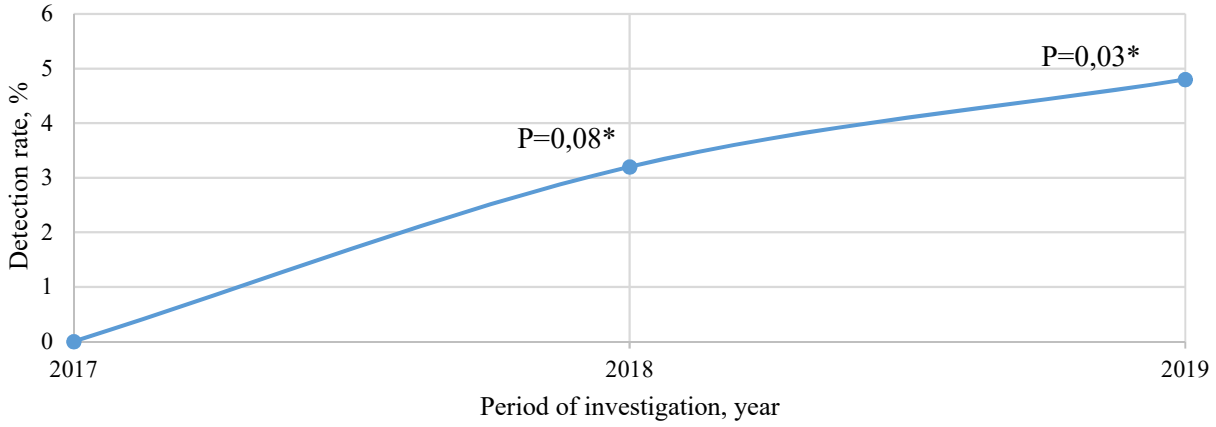
One of the reasons of obtaining such results is the fact that today different approaches to sample preparation for microbiological examination are used for meat cuts, semi-finished products in large pieces, semi-finished products in small pieces and minced semi-finished products.

Moreover, an important role is played by the technology of minced semi-finished product manufacture, where there is an increased risk of additional contamination of raw materials in meat grinders, mincemeat mixers, hamburger patty molders, from the surfaces of objects of the production environment in meat processing plants and so on.

Large scale investigations performed in Italy showed that the most frequently contaminated with *L. monocyto-*

[10] GOST 32951–2014 «Semi-prepared meat and meat-contained product. General specifications» Retrieved from https://docs.cntd.ru/document/1200113849 Accessed August 24, 2022 (In Russian)

[11] GOST 33102–2014 «Products of meat industry. Classification» Retrieved from https://docs.cntd.ru/document/1200114757 Accessed August 24, 2022 (In Russian)



* significance levels are given in comparison with 2017.

Figure 4. Detection rate of contaminated RTE meat product samples in 2017–2019

genes were the equipment (9%) and machinery (32.3%), as well as constructions, such as floor, walls, drains, (10%) and cleaning tools (26.7%) [27].

It is evident that the prevalence of this pathogen in beef semi-finished products was higher than in pork semi-finished products. The obtained data make it possible to conclude that pork is less susceptible to *L. monocytogenes* contamination, which corresponds to the scientific data of other researchers [21].

Our previous studies [4] allow stating that the surfaces of 20% of cattle carcasses after hide removal are contaminated with *L. monocytogenes* and 20–80% are contaminated with other *Listeria* species. At the same time, deep layers of beef and pork cuts, as a rule, are free from *L. monocytogenes*.

According to the existing normative documentation, sampling from meat cuts as well as from meat in carcasses, half-carcasses, quarters, semi-finished products in large pieces is performed from deep layers; that is, after surface sterilization by its flaming and removal of this area. Microbiological criteria indicated in TR CU 021/2011[12] are given for assessment of deep layers.

Therefore, when testing the above mentioned semi-finished products, only deep layers are assessed, while surface contamination with pathogenic microorganisms is not taken into account.

At the same time, when testing semi-finished products in small pieces and minced semi-finished products, another method for sample preparation is specified, namely, without flaming of the surface. Consequently, the surface and deep layers are assessed in total. This incompatibility in assessment distorts the true situation. Not knowing the real level of surface contamination of carcasses, half-carcasses and semi-finished products in large pieces with *L. monocytogenes*, producers use such raw materials to manufacture other types of semi-finished products increasing a risk of production of unsafe foods and contamination of the equipment, surfaces and other objects of the production environment. For example, scientific research demonstrated the features and routes of cross-contamination of meat products with pathogenic *Listeria*. Swabs (n = 240) from different production zones of a meat processing plant (slaughtering, deboning, cutting and packaging lines, shipping zones, refrigeration chambers) were investigated and *Listeria* was identified in 53 swabs [28]. At the same time, the use of GOST R ISO 17604–2011[13] for detection and enumeration of microorganisms on the carcass surface during processing of slaughter animals and poultry allows detecting a level of safety and establishing the risk-oriented approach to controlling the spread of pathogenic microorganisms including *L. monocytogenes*.

It was also interesting to establish the number of positive samples of ready-to-eat (RTE) meat products. Much attention is given to this particular group of products worldwide and today monitoring of the presence of *L. monocytogenes* is shifted from raw materials to RTE products. With that, quantification of this microorganism (not more than 100 CFU/g) is performed [29].

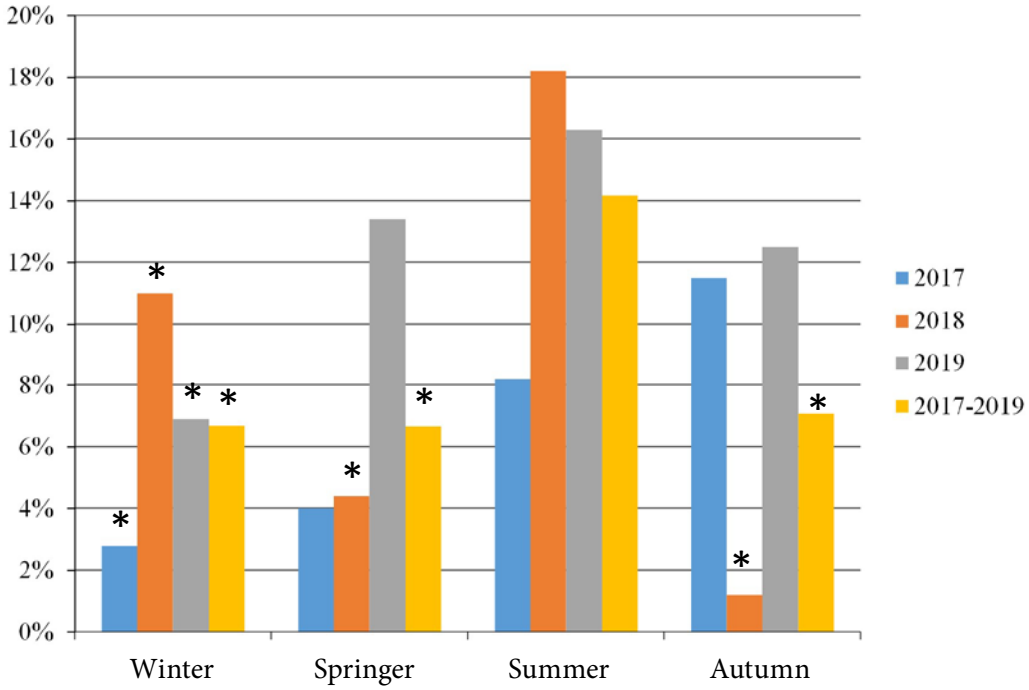
It can be seen from Figure 4 that positive samples were not revealed in all tested RTE meat products (n = 95) in 2017. In 2018, the prevalence of *L. monocytogenes* in the RTE meat products was 3.2% (4 positives out of 125 samples); in 2019, it was as high as 4.8% (7 positives out of 146 tested samples) taking into account the fact that the maximum number of samples was tested that year.

Analysis of the revealed dynamics allows suggesting that the number of RTE products contaminated with *L. monocytogenes* is increasing year after year.

When comparing the average total prevalence of *L. monocytogenes* in RTE meat (11%) found in the studies carried out by the Brasilian researchers [20] with that in other countries, it is possible to note lower values of overall prevalence (0.5%, 2.1% and 3.2%, respectively) for the United States, European Union and China [30,31].

[12] Technical regulation of the Customs Union TR CU 021/2011"On food safety". (Adopted by The decision of the Council of the Eurasian economic Commission of December 9, 2011 No. 880). Moscow, 2011. Retrieved from https://docs.cntd.ru/document/902320560. Accessed August 24, 2022. (In Russian)

[13] GOST 17604–2011 « Microbiology of food and animal feeding stuffs. Carcass sampling for microbiological analysis» Retrieved from https://docs.cntd.ru/document/1200089425. Accessed August 24, 2022 (In Russian)



* $p < 0.05$ when compared with summer.

Figure 5. Detection rate of contaminated meat product samples depending on a season in 2017–2019

Prediction and prevention of epidemiologically unfavorable situations should also be based on determination of seasonal peculiarities in circulation of pathogenic bacteria. We studied the frequency of detection of *L. monocytogenes* in meat products depending on a season. The results obtained in the investigation are presented in Figure 5.

Over three years, the highest prevalence of *L. monocytogenes* was observed in summer (on average 14.2%). Several epidemiologists also note an increase in acute intestinal infections associated with pathogenic bacteria precisely in the warm period of the year [32]. Apparently, this peculiarity is linked with more favorable conditions for microbial growth and is determined by an increase in the ambient temperature, for example, as in a cold chain breach in food logistics. Another explanation for the high detection rates of the pathogen in summer can be found in the studies showing that wild birds living nearby agricultural objects can be vectors for *L. monocytogenes* transmission and facilitate the spread of the bacterium through feces in pastures, soil, water, and feed [33,34].

For example, seagulls that are feeding at sewage facilities and rooks (to a smaller degree) were earlier identified as carriers of *L. monocytogenes* in feces. With that, the bacterial load increased in the nesting season and coincided with the peak period for listeriosis in sheep [34,35].

In 2017–2019, the detection rate of *L. monocytogenes* in winter, spring and autumn was in a range of 6.7–7.1% without clear predominance in this indicator depending on a season contrary to summer.

Conclusion

The results of the study show that the prevalence of *L. monocytogenes* in meat products dynamically grew year after year during the period from 2017 to 2019 making up 6.1, 8.4 and 12%, respectively.

The obtained data allow making a conclusion that poultry meat was definitely the most susceptible to *L. monocytogenes* contamination (its proportion was on average 18.7% of all products in 2017–2019), followed by beef (the detection rate was 13.2%).

Among the tested poultry semi-finished products that were sampled without flaming of the surface, natural semi-finished products were the least contaminated with *L. monocytogenes*. When analyzing the whole poultry carcasses (with flaming), this pathogen was not found in the deep layers.

Furthermore, the lowest *L. monocytogenes* contamination was found in semi-finished products in large pieces made from different meat types compared to semi-finished products in small pieces and minced semi-finished products. This can be explained by the fact that today different approaches to sample preparation are used for cuts and semi-finished products in large and small pieces.

Analysis of the obtained data indicates that detection of *L. monocytogenes* depends on the product composition (a type of meat raw materials), production technology and method of sample preparation for microbiological analysis.

A higher prevalence of *L. monocytogenes* was observed in beef semi-finished products compared to semi-finished products made from pork. Pork is less susceptible to *L. monocytogenes* contamination.

The number of ready-to-eat (RTE) products contaminated with *L. monocytogenes* is increasing every year.

The highest prevalence (14.2%) of *L. monocytogenes* in meat products was observed in summer, which was probably conditioned by a stable increase in the ambient tem-

perature, possibly, with a cold chain breach in food logistics and so on.

The obtained results showing quite a high level of *Listeria* contamination at different stages and under different conditions of meat product manufacture can be used for the preparation of modern guidance on the control of *Listeria* in food processing plants as well as methodical recommendations for analysis of this pathogen in raw materials, ingredients and objects of the production environment.

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