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Characteristics of microbial contamination of animal raw materials and products in the Russian Federation from 2015 to 2018

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SUMMARY

To date, there is a whole system of legal documents, regulating food security issues in the Russian Federation. Monitoring of food quality and safety is performed on the federal level, on the level of the Russian Federation Subjects and on the municipal level based on the developed and adopted regulatory and methodical documents. The paper presents the analysis of ASSOL information system data related to microbial contamination of animal raw materials and products, collected within the following official activities: "Laboratory Testing within Official Monitoring of Food Safety and Quality" and "Laboratory Testing of Animal Raw Materials and Products, Feed and Biological Materials for the Purposes of Food Safety and Quality Assurance". Microbiological test data were obtained from 37 Russian laboratories, subordinate to the Rosselkhoznadzor, within 2015–2018. The analysis performed showed that the maximum number of tests was performed for the following pathogenic microorganisms: *Salmonella* bacteria (29.5% within official monitoring and 26.8% within official programme). The highest number of non-compliances within monitoring was revealed when testing for total viable count (total mesophilic anaerobic and facultative anaerobic microorganisms) – 14.8% and Coliforms – 8.98%; within the official programme most violations were related to yeast (18.8%), yeasts and molds (18.5%) and TVC (12.4%). The parameters, showing less than 1% of positives within official programme testing, were identified. They include *Vibrio parahaemolyticus*, *Proteus* bacteria and sulphite-reducing clostridia. The necessity in further tests for safety and quality of animal raw materials and products in the Russian Federation was justified.

Key words: animal raw materials and products, microbiological parameters of safety, official monitoring, risk-oriented approach.

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Характеристика микробной контаминации сырья и продукции животного происхождения в Российской Федерации за период с 2015 по 2018 год

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РЕЗЮМЕ

На сегодняшний день в Российской Федерации сложилась целая система нормативно-правовых документов, регулирующих вопросы обеспечения продовольственной безопасности. Мониторинг качества и безопасности пищевых продуктов осуществляется на федеральном уровне, уровне субъектов Российской Федерации, уровне муниципальных образований на основе разработанных и утвержденных в установленном порядке нормативных и методических документов. В статье представлен анализ данных информационной системы «Ассоль» по микробной контаминации сырья и продукции животного происхождения, полученных при выполнении государственных работ «Проведение лабораторных исследований в рамках плана государственного мониторинга качества и безопасности пищевых продуктов» и «Проведение лабораторных исследований сырья, продукции животного происхождения, кормов и биологического материала в целях обеспечения качества и безопасности пищевых продуктов». Данные по микробиологическим показателям были получены в 37 подведомственных Россельхознадзору лабораториях Российской Федерации за период с 2015 по 2018 г. На основании выполненного анализа установлено, что максимальное количество исследований приходилось на обнаружение патогенных микроорганизмов: бактерий рода *Salmonella* (29,5% при проведении государственного мониторинга и 26,8% при выполнении государственного задания) и *Listeria monocytogenes* (22 и 21% соответственно). Наибольшее количество несоответствий при проведении мониторинга установлено по показателям КМАФАнМ (количество мезофильных анаэробных и факультативно анаэробных микроорганизмов – 14,8%) и БГКП (бактерии группы кишечной палочки – 8,98%); при выполнении государственного задания – по показателям дрожжи (18,8%), дрожжи и плесневые грибы (18,5%) и КМАФАнМ (12,4%). Определены показатели, процент выявления которых при выполнении государственных работ составил менее 1. Это парагемолитический вибрион, бактерии рода *Proteus* и сульфитредуцирующие клостридии. Обоснована необходимость дальнейших исследований по оценке безопасности и качества сырья и продукции животного происхождения на территории Российской Федерации.

Ключевые слова: сырье и продукция животного происхождения, микробиологические показатели безопасности, государственный мониторинг, риск-ориентированный подход.

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INTRODUCTION

To date, there is a legal and regulatory system, regulating safety of animal raw materials and products in the Russian Federation. To ensure animal and public health safety several legal acts have been developed, including RF Veterinary Law No. 4979-1, Federal Laws on food safety and quality No. 29-FZ and technical regulation No. 184-FZ [1, 2].

The basic documents regulating processes of production (manufacturing), storage, transportation (movement), marketing and rendering of food products are Customs Union Regulations Nos. 021/2011, 033/2013, 034/2013 and Eurasian Economic Union Regulation No. 040/2016 [1, 2].

Pursuant to CU TR 021/2011 on food safety, the food business operator shall develop, introduce and maintain procedures, based on HACCP principles [2].

The major provisions of HACCP concept are given in the Directives of the European Council. HACCP principles are recommended for practical use by Codex Alimentarius Commission and are obligatory for the European Union (EU) countries [3, 4].

The importance of HACCP system is acknowledged by all countries in the world, but the degrees of this system implementation vary a lot in different countries. If maintenance of HACCP principles is mandatory for the EU, the adherence to these principles in the Russian Federation is far from being strict [3, 4, 5, 6].

Pursuant to Council Directive 96/23/EC of 29 April 1996 on measures to monitor certain substances and residues thereof in live animals and animal products laboratory tests shall be performed for two major groups of substances: group A – substances having anabolic effect and unauthorized substances and group B – veterinary drugs and contaminants. Microbiological criteria are not included into animal product monitoring scope due to a well developed HACCP system in the EU countries and a great share of food business operators' responsibility for the food safety [6].

As stated above the level of HACCP system implementation in the Russian Federation is not adequate yet [3, 4, 5]. In this context to ensure the compliance with the requirements of the WTO Agreement on Application of Sanitary and Phytosanitary Measures the microbiological criteria were included into the Official Food Quality and Safety Monitoring Plan by the Order of the Federal Service for Veterinary and Phytosanitary Surveillance (Rosselkhoznadzor).

Starting from 2007 the Food Monitoring Plan in the Russian Federation has been implemented by the Rosselkhoznadzor.

The target of this study is to analyze the data of ASSOL Information System on microbial contamination of animal raw materials and products, collected within the following public works: "Laboratory Testing within Official

Monitoring of Food Safety and Quality" (hereinafter "Food Quality and Safety Monitoring") and "Laboratory Testing of Animal Raw Materials and Products, Feed and Biological Materials for the Purposes of Food Safety and Quality Assurance" (hereinafter "Food Safety") during 2015–2018.

MATERIALS AND METHODS

Pursuant to Regulation on Monitoring of Food Quality and Safety and Public Health, approved by Ordinance of the RF Government No. 883 on November 22, 2000, food safety and quality monitoring shall be performed on the federal level, on the level of the Russian Federation Subjects and on the municipal level in accordance with developed and adopted regulatory and methodical documents [2].

ASSOL Information System data for 2015–2018 related to the public works implementation ("Food Safety and Quality Monitoring" and "Food Safety") from 37 laboratories subordinate to the Rosselkhoznadzor were analyzed. Microbiological criteria of safety and quality were focused on.

Microsoft Excel program was used for diagram constructions.

RESULTS AND DISCUSSION

Public works "Food Safety and Quality Monitoring" and Official Epidemiological Monitoring with respect to microbiological tests in 2015–2018.

Pursuant to Orders of the Rosselkhoznadzor No. 831 of 31.12.2014, No. 993 of 31.12.2015, No. 995 of 30.12.2016, No. 1304 of 28.12.2017 on laboratory tests within the implementation of the Rosselkhoznadzor activities aimed at fulfillment of WTO SPS Agreement commitments, taken under accession of the Russian Federation to the WTO the Official Food Quality and Safety Monitoring Plan was approved.

131,545 microbiological tests were conducted in 2015–2018. Data are shown in Table 1.

As shown in Table 1 the highest number of tests was performed for pathogenic *Salmonella* (29.5 % out of total number) and *L. monocytogenes* (22%). Further, in descending order of quantity, tests for total viable count (20.1%) and coliforms (15.6%) are listed. Tests for *Staphylococcus aureus* account for 4% out of total number of tests. Insignificant numbers of tests were performed for *Clostridium* sulphite-reducing bacteria (0.6%), *Proteus* bacteria (0.5%) and *Vibrio parahaemolyticus* (0.4%).

It should be noted that food spoilage indicators (yeasts and molds) were not included into the Official Food Quality and Safety Monitoring Plan.

Table 1 also shows the number of positive results for the above-mentioned microorganisms. The biggest number of positives accounts for TVC (14.8%), somatic cells (9.2%) and coliforms (9.0%), which suggests the unsatisfactory conditions at animal raw material and product manufacturing plants in the Russian Federation.

L. monocytogenes were detected in 4.2% of samples tested, *Salmonella* bacteria in 1.8%.

The detection rate for *Staphylococcus aureus* was 0.9%, for *Clostridium* sulphite-reducing bacteria – 0.6%,

Table 1
Characteristics of microbial contamination of animal raw materials and products, detected within official monitoring of food quality and safety in 2015–2018

Таблица 1
Характеристика микробной контаминации сырья и продукции животного происхождения, выявленной при реализации государственного мониторинга качества и безопасности пищевых продуктов в 2015–2018 гг.

Criteria	Number of tests according to Monitoring Plan	Share in microbiological tests, %	Number of positive tests	Detection rate, %
Total viable count	26,411	20.1	3,901	14.8
Somatic cells	4,146	3.2	383	9.2
Coliforms	20,520	15.6	1,843	9.0
Enteropathogenic *Escherichia coli*	3,351	2.5	191	5.7
Listeria monocytogenes	28,958	22.0	1,229	4.2
Total bacterial count	2,129	1.6	87	4.1
Salmonella	38,762	29.5	712	1.8
Staphylococcus aureus	5,234	4.0	45	0.9
Clostridium sulphite-reducing bacteria	798	0.6	5	0.6
Proteus bacteria	731	0.5	4	0.6
Vibrio parahaemolyticus	505	0.4	0	0
Total	**131,545**	**100**	**8,400**	**6.4**

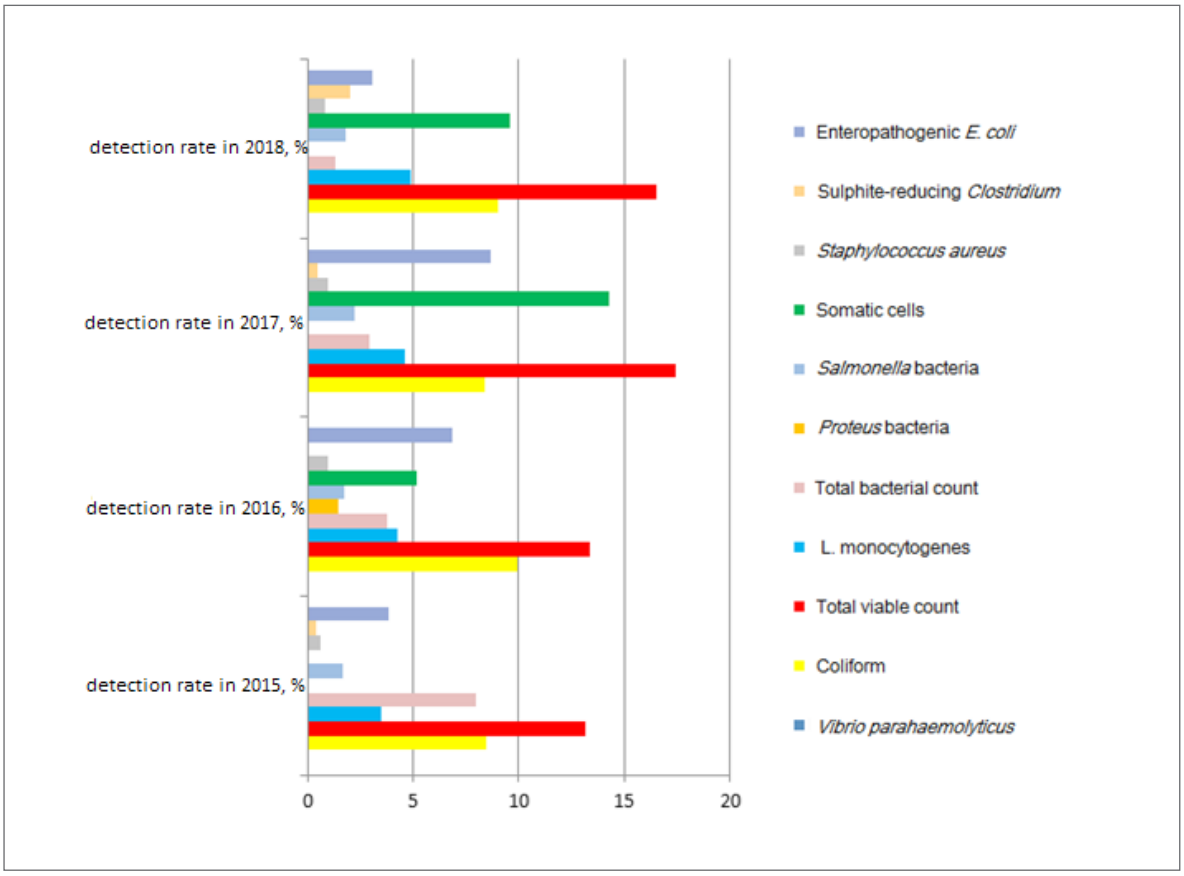

Fig. 1. Microbiological contaminant detection dynamics within official monitoring of food quality and safety in 2015–2018

Рис. 1. Динамика выявления микробиологических контаминантов при выполнении государственного мониторинга качества и безопасности пищевых продуктов за период с 2015 по 2018 г.

Proteus bacteria – 0.6%. *Vibrio parahaemolyticus* was not detected.

Percentage of non-compliances related to enteropathogenic *Escherichia coli* and total bacterial count in animal feeding stuffs were 5.7 и 4.1% respectively, which is indicative of technological violations in the production and storage processes.

Figure 1 presents detection rates for different microorganisms by years.

The detection rate for *Staphylococcus aureus* is within 0.6–1.0%, for *Salmonella* bacteria is 1.7–2.3% and for coliforms is 8.5–9.1%. Sulphite-reducing *Clostridium* were detected in 2015, 2017 and 2018, exceeded levels of somatic cells in raw milk products were reported in 2016, 2017 and 2018; *Proteus* bacteria were isolated only in 2016. Positive trend towards decreasing proportion of non-compliances related to total bacterial count in feeding stuffs of animal origin from 8% in 2015 to 1.3% in 2018 should be noted. The percentage of non-compliances, associated with total viable count in animal products was within 13.2–13.3 in 2015–2016, but it grew up to 17.4 in 2017. In 2018 the number of TVC violations decreased by 0.9% and was equal to 16.5%.

The analysis of monitoring data showed an upward trend in the number of detections of pathogenic *L. monocytogenes* from 3.5% in 2015 to 4.9% in 2018. We believe that this case can be explained by the biofilm-forming capability of *L. monocytogenes*, thus increasing the risk of animal product secondary contamination.

In 2015–2018 pursuant to the Orders of the Rosselkhoznadzor laboratory tests within the Official Epidemiological Monitoring were performed.

Data on detections of animal salmonellosis, listeriosis and campylobacteriosis agents are given in Table 2.

According to the data, presented in Table 2, 36,160 tests were performed for *Salmonella*. The detection rate was 1.5%.

Within the period under review *L. monocytogenes* were isolated from animal pathological material only in two cases (0.03%). It should be noted that the detection rate for this microorganism is 4.2% (see Table 1). We believe, that this difference can be explained by several reasons.

First of all, due to the differences in methodical approaches to listeria testing. To date *L. monocytogenes* isolation from food products is performed pursuant to GOST 32031-2012 "Food Products. Methods of *Listeria monocytogenes* detection", which envisages two-step enrichment of the sample. Pathological material shall be tested pursuant to "Methodical recommendations on laboratory diagnostics of human and animal listeriosis" (approved by USSR Ministry of Health on September 4, 1986 and USSR State Agriculture Committee on February 13, 1987). According to the methodical recommendations for the bacteriological test saline solution should be added to the suspension of brain and parenchymal organs (ratio 5:1); then this mixture should be inoculated into meat-peptone or Hottinger broth following by re-inoculation into liver or blood agar or potassium tellurite agar.

Secondly, the secondary contamination, caused by violation of production and processing technologies could be the reason of the product contamination.

The third possible reason, impeding bacteriological diagnostics of listeriosis in pathological material, can be concomitant microflora, able to inhibit vital functions of listerias.

The detection rate for *Campylobacter* in tests performed in 2015–2018 was 1.1%.

According to the World Health Organization *Campylobacter* bacteria are one of the most common reasons of acute diarrheal diseases [7, 8, 9, 10]. Nevertheless, tests for *Campylobacter* in animal products are currently not included into the public works plan in the Russian Federation.

Characteristics of microbial contamination of animal products detected in the course of the "Food Safety" official programme implementation in 2016–2018.

The official programme on food safety testing in 2015–2018 was implemented based on the following Orders of the Rosselkhoznadzor: No. 790 of 26.12.2014, No. 915 of 17.12.2015, No. 081-00037-16-00 of 29.12.2015, No. 081-00032-17-00 of 30.12.2016, No. 081-00015-18-00 of 29.12.2017. Data on microbiological testing results have been introduced into the ASSOL system since 2016.

The results of the official programme on microbiological testing for food safety in 2016–2018 are given in Table 3.

Table 2
Number of tests for pathogenic microorganisms, performed in 2015–2018 within epidemic monitoring

Таблица 2
Количество исследований на патогенные микроорганизмы при проведении эпизоотологического мониторинга в 2015–2018 гг.

Bacteria	Number of tests	Number of positives	Detection rate, %
Salmonella	36,160	546	1.5
Campylobacter	1,269	14	1.1
L. monocytogenes	7,831	2	0.03

117,001 tests for microbiological parameters were performed during three years in total, 6,686 non-compliances were revealed with the detection rate equal to 5.7%.

Distribution of tests by criteria is the following: the biggest number comes from pathogenic microorganisms: *Salmonella* (26.8%) and *L. monocytogenes* bacteria (21.0%). They are followed by tests for TVC (19.7%) and coliforms (19.1%). The share of tests for *Staphylococcus aureus* is 7.0%, and this is almost twice higher than the monitoring test rate. The official programme envisages testing for food

Table 3
Microbial contamination of animal products, detected within the official programme in 2016–2018

Таблица 3
Микробная контаминация продукции животного происхождения, выявленная при реализации государственного задания за период с 2016 по 2018 г.

Criteria	Tests in total	Share in microbiological tests, %	Number of positive tests	Detection rate, %
Yeasts	968	0.8	182	18.8
Yeasts and molds	1,079	1.0	200	18.5
Lactic acid bacteria	306	0.3	39	12.8
Total viable count	23,016	19.7	2,842	12.4
Molds	594	0.5	51	8.6
Coliforms	22,391	19.1	1,911	8.5
Enteropathogenic *Escherichia coli*	2,124	1.8	137	6.5
L. monocytogenes	24,562	21.0	766	3.1
Pseudomonas aeruginosa	173	0.1	5	2.9
Total bacterial count	564	0.5	10	1.8
Staphylococcus aureus	8,170	7.0	130	1.6
Salmonella	31,392	26.8	404	1.3
Sulphite-reducing *Clostridium*	1,074	0.9	7	0.7
Proteus	588	0.5	2	0.3
Total	**117,001**	**100**	**6,686**	**5.7%**

spoilage indicators like yeasts and molds. Their combined share was 2.3%. Small number of tests accounts for tests for sulphite-reducing *Clostridium* (0.9%), *Proteus* (0.5%), *Pseudomonas aeruginosa* (0.1%). 2,688 tests (2.3%) were carried out to check feeding stuffs of animal origin (total bacterial count and enteropahogenic *E. coli*) .

The highest number of non-compliances was detected in tests for yeasts (18.8%), yeasts and molds (18.5%). They are followed by tests for lactic acid bacteria (12.8%) and TVC (12.4%), molds (8.6%), coliforms (8.5%), enteropathogenic *E. coli* (6.5%), *Pseudomonas aeruginosa* (2.9%), total bacterial count (1.8%) and *Staphylococcus aureus* (1.6%).

Among pathogenic microorganisms the highest detection rate was shown by *L. monocytogenes* (3.1%). The number of non-compliances in testing for *Salmonella* was 1.3%.

The detection rates for sulphite-reducing *Clostridium* and *Proteus* bacteria were 0.7 and 0.3% respectively.

The analysis of data, shown in Figure 2, proves a high number of non-compliances in tests for coliforms (the detection rate was within 8.2–8.9%) and total viable count (10.7–13.4%) and small number of detections in tests for sulphite-reducing clostridia (0.7% in average for the period under review).

Non-compliances in tests for different criteria were not revealed every year. *Pseudomonas aeruginosa* positives were reported in 2016 (3% detection rate) and 2017 (2.7%), *Proteus* bacteria were detected only 2016 (0.6%). Positives for molds were found in 2016 (9.6% detection rate) and in 2017 (7.3%). Exceeded levels of total bacterial counts were reported in 2017 (2.4%) and 2018 (0.5%).

Up to 2018 an increasing trend in the yeast detection rate was noted (from 14.6% in 2016 up to 23.6% in 2018). In 2016 no tests for lactic acid bacteria were performed. From 2017 to 2018 the detection rate in tests for this criterium increased from 4 to 15.6%.

The detection rate for *L. monocytogenes* was 2.8% in average in 2016 and 2017, but up to 2018 it reached 3.7%. The detection rate for *Salmonella* grew from 0.9% in 2016 to 1.5% in 2017 and 2018.

The presented data suggest the trend of decreasing in detection of *Staphylococcus aureus* in food products and enteropathogenic *E. coli* in feeding stuffs.

The analysis of microbiological test results, obtained during public works

Pursuant to Programme "Reform of Controlling and Supervising Activities", approved in December 2016, the Rosselkhoznadzor developed the institutional dossier of the project implementation in this area. The dossier envisages the implementation of several types of official veterinary surveillance and control at the border crossing points of the Russian Federation and (or) at the customs clearance facilities. It also ensures the application of a risk-oriented approach during control and surveillance activities within the established types of the control (surveillance).

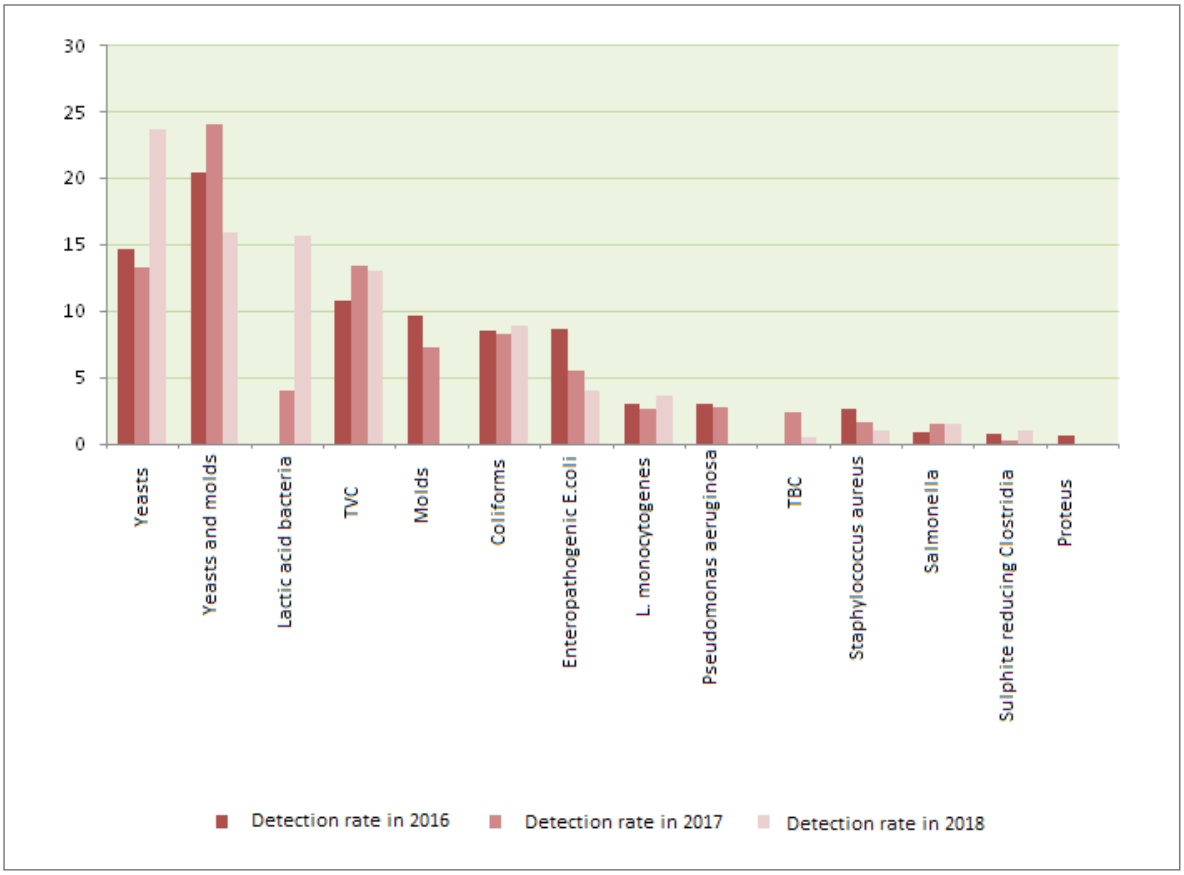

Fig. 2. Dynamics of non-compliances detection in microbiological tests within the official programme "Food Safety" in 2016–2018

Рис. 2. Динамика выявления несоответствий по микробиологическим показателям при выполнении государственного задания «Безопасность пищевой продукции» в 2016–2018 гг.

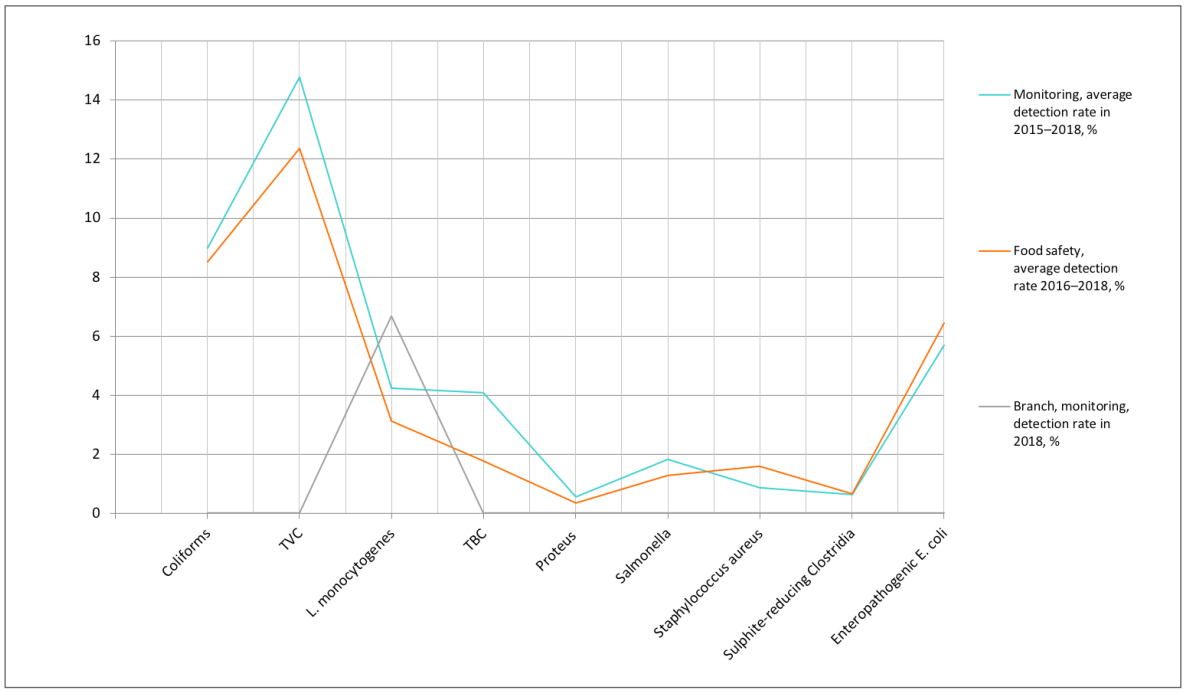

Fig. 3. Results of official microbiological testing

Рис. 3. Результаты выполнения государственных работ по микробиологическим показателям

Table 4
Total tests and total positives in tests for major microbiological parameters within official activities in 2016–2018

Таблица 4
Общее количество исследований и общее количество положительных исследований по основным микробиологическим показателям при проведении государственных работ за период с 2016 по 2018 г.

Criteria	2016		2017		2018	
	Total tests (OP+MP)	Total positives (OP+MP)	Total tests (OP+MP)	Total positives (OP+MP)	Total tests (OP+MP)	Total positives (OP+MP)
Salmonella	22,338	297	18,013	333	18,497	300
L. monocytogenes	15,984	584	14,500	508	14,450	601
TVC	15,078	1,806	13,235	1,998	12,613	1,820
Coliforms	12,927	1,175	11,916	989	12,845	1,148
Staphylococcus aureus	4,263	89	3,470	38	4,248	39
Sulphite-reducing *Clostridium*	595	3	561	2	462	6
Vibrio parahaemolyticus	411	0	392	0	343	0

OP – Official Programme "Food Safety";
MP – "Food Safety and Quality Monitoring Programme".

The comparison of total results obtained in the course of the "Food Safety and Quality Monitoring" and "Food Safety" programmes for the period under review, given in Figure 3, reflects the risk-oriented approach to planning of the parameters and lists of microbiological criteria by different activities. It should be noted that the detection rates of major microbial contaminants in animal raw materials and products are similar with the

analogous ones, shown by the official programme implementation.

Starting from 2018 the FGBI "ARRIAH" Branch in the Republic of Crimea has been participating in the implementation of the State Monitoring Plan. The Food Safety Laboratory of the Laboratory and Diagnostic Centre performed tests, including those for *Salmonella* and *L. monocytogenes*, the detection rate of the latter was 6.7%, which is 1.5–2.0 times higher than the analogous rate for Russia. No *Salmonella* were detected.

Data on total number of tests performed and noncompliances detected within public works are presented in Table 4 by years.

These data suggest a successful application of a risk-oriented approach during public works planning, but it does not eliminate the need for further research in this area.

Previously we analyzed the microbial contamination of animal products in the EU countries using RASFF data. The major microbial contaminants of animal products reported were *Salmonella* bacteria (2,719 notifications out of 3,769), *E. coli* (548 notifications) and *L. monocytogenes* (440 notifications) [11].

L. monocytogenes detection rate, revealed during public works implementation in the Russian Federation, is 2.5 times higher than *Salmonella* bacteria, which is different from the European data, where *Salmonella* were detected 6 times oftener than *L. monocytogenes* [11].

It should be noted that EU Commission Regulation No. 1441/2007 of 05.12.2007 on microbiological criteria for foodstuffs, does not contain coliforms and TVC criteria. Unlike the EU countries presence of these hygiene product indicators is checked in the Russian Federation during the implementation of the public works on food safety. The detection rates for these criteria are the highest.

CONCLUSIONS

Total 205,750 tests for microbiological safety were performed within public works in 37 laboratories subordinate to the Rosselkhoznadzor in 2015–2018.

The highest number of tests were carried out for pathogenic *Salmonella* (29.5% under official monitoring and 26.8% under official programme) and *L. monocytogenes* (22 and 21% respectively). The detection rate for this microorganisms in animal raw materials and food products was equal to 1.8% for official monitoring and 1.3% for official programme; the rates for *L. monocytogenes* were 4.2 and 3.1% respectively.

The parameters, showing less than 1% of positives within public works testing, were identified. They include *Vibrio parahaemolyticus*, *Proteus* bacteria and sulphite-reducing clostridia. The lowest detection rate of these microorganisms during the whole period under review is the reason to reduce the number of such tests.

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