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Analysis of safety indicators for poultry products produced in subsidiary farms in penitentiary facilities

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Abstract. The production of poultry, eggs and their processed products is growing rapidly worldwide. Poultry products are in great demand; however, they are a source of a number of risks: physical, chemical, as well as microbiological. Ensuring food safety is currently the main aspect for the global food industry, including for the production of poultry products. The article discusses the safety and quality of poultry products produced in subsidiary farms of correctional facilities of the penal system. Attention is drawn to the risks and threats of sanitary and epidemiological well-being that arise in connection with the intensification of the impact of negative environmental factors. In the subsidiary farms of correctional facilities, the cage-type bird keeping system and the frequency of feeding are regulated depending on the age of the bird. The results of the analysis have shown that poultry and chicken eggs comply with established sanitary standards. Thus, the average heavy metal content in poultry meat was: Hg - 0.0061 mg kg^{-1}, Cd - 0.0233 mg kg^{-1}, As - 0.0501 mg kg^{-1}, Pb - 0.1765 mg kg^{-1}; in the egg: Hg - 0.0072 mg kg^{-1}, Cd - 0.0198 mg kg^{-1}, As - 0.0485 mg kg^{-1}, Pb - 0.1812 mg kg^{-1}. Antibiotics, radionuclides and dioxins were not found in poultry meat. The pesticide content in poultry meat was below the permissible level: by 2.2 times of DTM and its metabolites, and hexachlorocyclohexane (a, b, g - isomers) - by 5 times. Coliforms, Staphylococcus aureus, Proteus, as well as pathogenic salmonella, listeria were not found in poultry meat and eggs. NMAFAnM in meat amounted to 0.5×10^4, in the egg - 1×10^3 CFU g^{-1} incl. In general, poultry products produced in correctional facilities are of high enough quality and can be used to prepare various dishes not only for adults but also for baby food. These estimates allow us to conclude about a fairly high level of quality and safety of this product.

Key words: safety, poultry products, quality, ecotoxicants, penal system.

INTRODUCTION

Food provision is of great importance for the normal functioning of all facilities and bodies of the penal correction system (Moshnenko, 2017). An important role in the implementation of the food self-sufficiency program is played by subsidiary farms in correctional facilities.

The problem of food safety does not lose its relevance at all stages of the development of the state and society, since it is one of the main factors determining the life and health of people. Food safety means not only the absence of danger to human health when consumed, but also the absence of danger of long-term consequences (carcinogenic, mutagenic and teratogenic effects) (Gul et al., 2016).

The physical health of the population, its labor activity and, ultimately, the pace of economic development of the country directly depend on the quality of food products.

Food products must satisfy the physiological needs of a person in necessary substances and energy, meet the requirements for organoleptic and physicochemical quality indicators, meet the requirements established by regulatory documents for the content of chemical, radioactive, biological substances and their compounds, microorganisms that pose a danger to the health of the present and future generations (Goldfein et al., 2015).

At the present stage of development, the quality and safety of food products are the main factors determining their competitiveness in the market. These indicators are becoming increasingly significant, leaving criteria such as the price of the product and the range of its traditional consumption far behind (Dabakhov et al., 2005).

Over the past decade, there has been a steady increase in poultry meat consumption (Glamoclija et al., 2013). In the implementation of the state policy in the field of healthy nutrition, it is important not only to increase the volume of production of this product, but also to ensure its safety. Poultry farming is the most science-intensive and dynamic industry, which makes a significant contribution to the provision of food security in the penal system. In addition, the expansion of this product area can serve as an impetus for the development of production activities in correctional facilities.

One of the modern directions of intensification of the productivity of poultry meat and egg is the use of modern methods of feeding and keeping poultry (Petracci & Berri, 2017).

The composition of the feed should include all the necessary components and meet the needs of the body of the bird, the effectiveness of meat poultry farming depends on this to a greater extent. However, in connection with the permanently arising environmental problems, fodder used for feeding poultry and, as a result, poultry products are contaminated (Gulieva et al., 2018).

In this regard, the purpose of this article was to study the safety indicators of poultry products produced in subsidiary farms of correctional facilities of the penal system.

MATERIALS AND METHODS

Poultry keeping conditions are an important link in obtaining quality products (Damaziak et al., 2017; Matt et al., 2019). Cage-type bird keeping system. It was established that the content of chickens in the cages is the most rational and effective, as applied to the subsidiary farms of correctional facilities. Its advantage is to increase the useful coefficient of the used area - it is possible to place 2–3 times more chickens on one square meter than with outdoor keeping.

With this type of keeping, it is easy to care for poultry, give food and water, remove litter. Nesting material is not necessary. In addition, the placement of birds in cages creates good veterinary and hygienic conditions, as there is no contact of the bird with the litter. Therefore, chickens are less likely to suffer from invasive and fungal diseases. A plus is the reduction in bird energy consumption for movement. Due to this, feed costs for a production of one unit of egg or meat products are reduced by 10–15%.

The feeding regime was strictly observed during growing poultry for meat and egg. Timely feeding was carried out with a certain frequency, with the aim of forming a strict rhythm of physiological processes and developing conditioned reflexes, which enhance the internal secretion of the digestive organs, that in turn leads to better digestibility of the feed and, as a result, increase the productivity of chickens.

The frequency of feeding was regulated depending on the age of the bird. So, in the first days of life, chickens were given food 5–6 times a day, at the age of one to four weeks - 3–4 times. Adult chickens were fed 2 times a day in the morning and in the evening. The amount of feed is determined taking into account the age and type of productivity of the bird.

An approximate diet for feeding poultry of meat and egg breeds is presented in Table 1.

Table 1. Sample rations for chicken of meat and egg breeds with the combined type of feeding, g per head per day

No.	Type of feed	Winter	Spring	Summer	Autumn
1	Whole grain (2 types)	50g	45g	40g	45g
2	Crushed grain (2–3 types)	50g	55g	60g	55g
3	Seed cake, oil cakes	12g	13g	12g	12g
4	Wheat bran	10g	10g	10g	10g
5	Boiled potatoes	50g	40g	20g	20g
6	Feeding yeast	3g	4g	3g	3g
7	Silage or carrot	40g	20g	-	20g
8	Herbal flour or fresh herbs	10g	10g	50g	30g
9	Meat-bone and fish meal	5g	7g	5g	5g
10	Fresh skimmilk	20g	30g	30g	20g
11	Shell, chalk	4g	5g	4,5g	4g
12	Bone flour	1g	1.5g	1.5g	1g
13	Common salt	0.5g	0.5g	0.5g	0.5g

The research material was samples of chicken meat and eggs, received for testing for microbiological safety indicators in accordance with TRCU 021/11 year, TPCU 034/13 year.

According to the requirements of normative and technical documentation, three carcasses were selected from each batch of birds by random sampling, as the weight of the carcasses was more than 900 g.

To test the safety indicators of chicken eggs from a batch of eggs, which amounted to 3,000 pcs., 300 pieces of eggs were selected, that was 10% of the total volume of the consignment. Packaging units were selected from different places of the batch (top, middle, bottom). Damaged packaging units were not included in the sample. Eggs in damaged packaging units were 100% sorted. To determine each safety indicator, samples of poultry muscle tissue were taken in the amount of 200 grams, and chicken eggs - 12 pieces.

The determination of heavy metals

The determination of lead and cadmium was carried out by atomic absorption spectrometry method, which is based on the mineralization of the product by dry or wet ashing and determination of the concentration of an element in a mineralized solution by flame atomic absorption.

The determination of arsenic was carried out by the inversion-voltammetric method. The method of inversion-voltammetric measurements is based on the ability of elements to electrochemically precipitate on the indicator electrode from the analyzed solution at a given potential of the limiting diffusion current, and then dissolve in the process of anode polarization at a specific potential characteristic of each element.

The determination of mercury is based on the ‘wet’ (acidic) mineralization of samples, the reduction of mercury ions contained in the solution to an elemental state under the influence of a chemical reducing agent, the conversion of mercury into the gas phase, and subsequent quantitative determination by flameless atomic- absorption spectrometry.

The determination of pesticides, Cs-137, dioxins

The pesticide content was determined by gas the chromatography method. The method is based on the extraction of pesticides with organic solvents, purification of the extract, followed by the analysis of the resulting solutions on an automatic gas chromatograph with an electron-capture detector to determine the composition and the mass fraction of pesticides.

Measurement of cesium Cs-137 activity was carried out on radiometric devices of scintillation and semiconductor gamma spectrometers.

The amount of dioxins was determined by high resolution chromatography-mass spectrometry. The method is based on the extraction of analytes with organic solvents, sequential purification of the extract using column chromatography on various sorbents and quantitative analysis by high-resolution chromatography-mass spectrometry using surrogate isotope-labeled standards - analogues of the determined compounds introduced into the sample at the sample preparation stage.

The determination of microbiological indicators

The research was carried out by the microbiological method. The following nutrient media were used for the research: Endo, BSA, XLD, RVS-broth, Kessler's medium, Palcam-agar, Frazier, ISM (Wilson-Blair), Vitelline salt agar physiological saline, meat-and-peptone agar, etc.

Statistical processing of the obtained results was carried out by generally accepted methods (assessment of significance by Fisher and Student criteria) using the Microsoft Excel software package.

RESULTS AND DISCUSSION

The facts of the use of growth stimulants and modern compound feed with directionally modified properties, which lead to the rapid accumulation of heavy metals in poultry carcasses, are known from literature sources (Gayeva et al., 2013). Changed environmental conditions for keeping poultry, new technological methods for the production and storage of feed, the intensive use of veterinary preparations and industrial pollution of the environment by various chemicals significantly increased the risk of contamination of poultry meat and poultry products by heavy metals.

The maximum level of concentration of a specific toxic element in animal feed and diets should be considered taking into account the duration of use of contaminated feed products, their processing and storage method. Long-term exposure of heavy carcinogenic elements in small amounts, especially with chronic lack of feed, unbalanced diets for essential nutrients, and keeping animals under poor conditions can also have a devastating effect on the body (Shah et al., 2010).

Of the food safety indicators, the parameters of the content of heavy metals, pesticides, and radionuclides in the muscle tissues of birds are of the greatest importance to human health. These substances, being in meat products, cause food toxicosis, have a carcinogenic and mutagenic effect, and also worsen the technological properties of animal raw materials, making it difficult or impossible to prepare high-quality food products (Oforka et al., 2014).

The most dangerous toxicants to human health are heavy metals. They are classified as thiol poisons that block sulfhydryl groups of proteins and disrupt metabolic processes in the body (at low doses), in large doses they can act as blockers and other functionally active groups of proteins - amine, carboxylic, etc. When the ecotoxicants enter the body, they are unevenly distributed in it. The main organs of excretion (kidneys, liver, lungs, etc.) take the first fall on themselves. If they enter the liver, they can undergo various changes, even with a favorable outcome for the body that contributes to their inactivation and excretion through the intestines and kidneys. If these mechanisms no longer work, the accumulation of heavy metals occurs in the animal's body (Bokoye et al., 2011).

Table 2. The results of laboratory analysis of the content of heavy metals and arsenic in the muscle tissue of poultry carcasses

Toxicant	Value	MAC, mg kg^{-1}	Actual content, mg kg^{-1}
Mercury	minimum	0.03	0.0004 ± 0.0001
	maximum		0.0189 ± 0.0053
	average		0.0061 ± 0.0014
Cadmium	minimum	0.05	0.0061 ± 0.0007
	maximum		0.0452 ± 0.0053
	average		0.0233 ± 0.0022
Arsenic	minimum	0.1	0.0118 ± 0.0003
	maximum		0.0857 ± 0.0017
	average		0.0501 ± 0.0069
Lead	minimum	0.5	0.0788 ± 0.0119
	maximum		0.3887 ± 0.0561
	average		0.1765 ± 0.0199
$LSD_{0.95}$			

The note: standard values of maximum allowable concentrations (MAC) are given in accordance with SanR&S 42-123-4089-86 'Maximum allowable concentrations of heavy metals and arsenic in food raw materials and food products'.

The results of laboratory research have shown that the lead content in chicken meat does not exceed the maximum permissible values. The concentration of this element in the muscle tissue of birds ranges from 0.0788 to 0.3887 mg kg^{-1}, which is safe for humans. In poultry meat grown in poultry farms not related to the facilities of the penal correction system, an insignificant (2%), but an excess of the MAC content of arsenic is recorded. The arsenic concentration in the test samples did not exceed the maximum permissible concentrations (0.1 mg kg^{-1}), and amounted to 0.0118–0.0857 mg kg^{-1} (Table 2).

The research of the cadmium content in chicken meat has shown that this element varies from 0.0061 to 0.0452 mg kg^{-1} and does not exceed acceptable standards.

The mercury content was within allowable concentrations. The maximum mercury value was 0.0189 mg kg^{-1} with a MAC of 0.03 mg kg^{-1}.

A chicken egg, acting as an equally important poultry product, is a valuable food product and is included in the diet of suspects, accused and convicted persons. The digestibility of egg components is 96–98%.

The chemical composition of a chicken egg depends on the breed, age and feeding of the bird. Not only nutrients and elements that have nutritional value can come as part of this product in the human body, but also a variety of pollutants, the source of which is the bird. As a result, the degree of contamination of the chicken egg with heavy metals is directly related to their quantity in the body of chickens.

In our research, we evaluated chicken eggs by the content of heavy metals in it. The results of the content of heavy metals in the chicken egg are shown in Table 3.

Table 3. The results of laboratory analysis of the content of heavy metals and arsenic in chicken eggs

Toxicant	Value	MAC, mg kg^{-1}	Content, mg kg^{-1}
Mercury	minimum	0.02	0.0003 ± 0.0001
	maximum		0.0179 ± 0.0044
	average		0.0072 ± 0.0018
Cadmium	minimum	0.05	0.0053 ± 0.0006
	maximum		0.0332 ± 0.0054
	average		0.0198 ± 0.0029
Arsenic	minimum	0.1	0.0099 ± 0.0004
	maximum		0.0875 ± 0.0033
	average		0.0485 ± 0.0066
Lead	minimum	0.5	0.0778 ± 0.0119
	maximum		0.3988 ± 0.0569
	average		0.1812 ± 0.0269
$LSD_{0.95}$			

The lead content in the chicken egg did not exceed the maximum allowable concentrations. The maximum value of this element was 0.3988 mg kg^{-1}, its average content was 0.1812 mg kg^{-1}.

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The quantitative content of arsenic in the studied samples varies widely: from 0.0099 to 0.0875 mg kg^{-1}, which does not exceed the maximum allowable concentration and meets the established requirements.

In poultry farms not related to the facilities of the penitentiary system, there is an excess of the cadmium content in the chicken egg by 1.4–8.2 times over the MAC, and the supply of cadmium in the chicken egg above the maximum level is recorded in 30% of the total number of samples studied. In the samples studied by us, the quantitative content corresponds to the established standards, and its concentration is below the MAC by 1.2–9.4 times.

The research results have shown that the mercury content in the egg did not exceed the MAC of 0.02 mg kg^{-1}. In accordance with safety requirements, hormones and some antibiotics should not be detected in eggs and poultry meat. There are quite stringent rules in relation to these preparations in our country regarding their residual amount, both in raw materials and in finished products.

Currently, special additives are used in the feeding process to stimulate the production of eggs and poultry meat. Therefore, quite often the bird receives giant doses of growth stimulants, significantly exceeding its physiological needs. According to experts, the egg and meat of such a bird cannot be considered safe.

Dioxins are a by-product resulting from some production processes (bleaching of pulp using chlorine, production of some pesticides and herbicides, melting). They get into the environment during the operation of waste incineration plants. Moreover, despite the fact that the release, as a rule, takes place in a certain area, the distribution of dioxins has become widespread - they can be found in almost any environment around the world. Most of them are in the soil, sediment, and food (meat, fish, dairy products).

The test results of meat raw materials in accordance with the requirements of SanR&S 2.3.2.1078-01 show that the meat being tested corresponded to all regulatory requirements in terms of safety.

Cesium, as a radionuclide, was not found in poultry meat. In addition, such highly toxic chemically hazardous substances as antibiotics: bacitracin, chloramphenicol and the tetracycline group were not fixed (see Table 4).

Table 4. The results of laboratory analysis of safety indicators for poultry meat

Name of substance		mg kg^{-1} in poultry	
		Allowable level	Content
Antibiotics	Levomycetin (chloramphenicol)	Not allowed	-
	Tetracycline group	Not allowed	-
	Bacitracin	Not allowed	-
Pesticides	DTM and its metabolites	0.1	0.045
	Hexachlorocyclohexane (a, b, g - isomers)	0.1	0.02
Radionuclides	Cesium-137 Bq kg^{-1} (l)	200	-
Dioxins		Not allowed	-
$LSD_{0.95}$			

The pesticide content in poultry meat was by 2.2 times lower than the allowable level of DTM and its metabolites, and hexachlorocyclohexane (a, b, g - isomers) was by 5 times lower, and amounted to 0.045 mg kg^{-1} and 0.002 mg kg^{-1}, respectively.

An important indicator of product safety and quality is the presence and number of microorganisms (Schaffner & Smith-Simpson, 2014; Baltic et al., 2019). Microbiological indicators of meat and poultry eggs met regulatory requirements (Table 5).

Table 5. Microbiological (CFU g^{-1} incl.) and pathogenic indicators (g (cm^3) incl.) poultry meat and eggs

Test indicators	Standards		Content	
	meat	egg	meat	egg
	Microbiological indicators (CFU g^{-1} incl.)			
NMAFAnM	1×10^5	5×10^3	0.5×10^4	1×10^3
Coliforms	not allowed in 0.0001 g in 0.01^{-1} g		not found	not found
Staphylococcus aureus	not allowed		not found	
Proteus				
	Pathogenic (g (cm^3) incl.)			
Salmonella	in 25 g not allowed		not found	
Listeria				
$LSD_{0.95}$				

The determination of the number of mesophilic aerobic and facultative anaerobic microorganisms (NMAFAnM or total microbial number, TMN) refers to the estimation of the size of the group of sanitary-indicative microorganisms. NMAFAnM contains various taxonomic groups of microorganisms - bacteria, yeast, mold fungi. Their total number indicates the sanitary-hygienic condition of the product, the degree of its dissemination by microflora. For the consumer, the NMAFAnM (TMN) indicator characterizes the quality, freshness and safety of food products.

Based on the results obtained, it is clear that NMAFAnM did not exceed the permissible level. Their content in poultry meat was $5\times10^3\times$CFU g^{-1} incl., in the egg – 1×10^3 CFU g^{-1} incl. No pathogens, such as salmonella and listeria, were found.

CONCLUSIONS

Laboratory research has shown that poultry products produced in facilities of the penal system are environmentally friendly. Such meat and poultry egg can be used to prepare various dishes not only for adults, but also for baby food. All this, in turn, indicates that the poultry production technology adopted by farms with the appropriate set of feeds contributes to the production of high-quality, environmentally friendly products.

Thus, poultry meat and egg produced in the subsidiary farms of penitentiary facilities are safe, and therefore can be highly competitive in the consumer market.

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