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Safe Technologies of Prophylactic Disinfection in the Presence of Animals

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Abstract: Prophylactic disinfection in the presence of animals reduces the concentration of microorganisms in the air and thereby prevents various infectious diseases. The study aims to develop a technological mode of prophylactic disinfection in the presence of animals. As part of the disinfection measures, aerosol disinfection, wet disinfection, and foam disinfection were performed. Sanitation procedures used the preparations of Dezinfekt, Penodez, Yodizol, Glutex, and bleach. The study demonstrated that after wet disinfection in the research object with the use of Penodez by the added foam method (combined method), the obtained quantitative indicators when compared to those of the control objects, indicate a 9.7% increase in disinfection effectiveness. With the use of Yodizol in aerosol disinfection in the presence of piglets, the survival rate of microorganisms in the air dropped by 96.3% and on the floor and surfaces by 95.2 and 93.0%, respectively. In the monitoring of the toxic effects of the preparation on the body, no allergic reactions are observed and the level of hemoglobin in the blood was 8.1% higher than in the control group. The experiment demonstrated the highest effectiveness of the combined disinfection method (wet + foam). The use of safe prophylactic disinfection (aerosol) in the presence of animals was found to be expedient. An eco-friendly composition disinfectant based on iodine compounds (Yodizol) was developed for disinfection in the presence of animals. The timing of prophylactic disinfection (considering the accumulation of microorganisms on various surfaces and in the air in facilities) is established.

Keywords: Prophylactic Disinfection, Combined Method, Yodizol Preparation, Piglets, Infrared Spectrum

Introduction

A component of veterinary and sanitary work on livestock farms, especially in pig farming, is the need for preventive disinfection (during periods of transportation of animals). This is a critical procedure that reduces the number of infectious microbes that cause diseases in productive animals (Casal *et al*., 2007; Liu *et al*., 2021; Zhanabayev *et al*., 2022).

At present, disinfection measures in pig farming facilities are conducted mainly using traditional technology (singular wet disinfection during prophylactic periods) with traditional preparations (chlorinated, formaldehyde, etc.,) or those of foreign production (Spain, China, Russia, Germany, etc.,) such as Glutex, Muvan, Disefect, etc., (Kuzmin *et al*., 2020a).

Regular disinfectants are commonly used because of their affordable prices, yet it is important to mention that they are highly toxic and corrosive. These preparations pose a threat to the environment and human health, which is why prophylactic disinfection in the presence of animals cannot be conducted with these substances. In the meantime, today's foreign preparations are made based on complex bactericidal compounds (iodine, surfactants, quaternary ammonium compounds, hydrogen peroxide, etc.,) and are widely applied in production facilities. Many small farms in Kazakhstan (and even some large farms) are unable to constantly use modern preparations for prophylactic disinfection. This owes to the combination of such factors as high prices for these products, specifics of their use in disinfection, deficiency of components,

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inability to assemble them, as well as a decline in the bactericidal and other properties of most of these preparations during their shipment to Kazakhstan (Myrzabekov *et al*., 2020; Shao *et al*., 2020).

For these reasons, it is a topical task for Kazakhstan to develop complex disinfectants that are suitable for preventive disinfection methods (wet, foam, and aerosol), economically efficient and affordable, and not inferior to modern analogs in all properties (bactericidal, corrosive, toxic, etc.).

Prophylactic disinfections are not always performed in the presence of animals in pig farms and complexes. In the meantime, as animals are housed in facilities, the microclimate parameters in them become worse and accumulation of conditionally pathogenic microflora occurs, which can adversely affect the housing conditions, productivity, growth, and development of animals (Noordergraaf *et al*., 2018; Salkhozhayeva *et al*., 2022). In such conditions, animals and especially piglets, show reduced resistance to diseases with increased incidence (Pritchard *et al*., 2005).

Therefore, to improve animals' health, form natural resistance, and raise their productivity, it becomes necessary to optimize the antibacterial regime in facilities (Zhang, 2020). Naturally, reducing the concentration of microbes in a facility requires improvement of the quality and regularity of prophylactic disinfection in pig houses accompanies by periodical disinfection in the presence of animals (Kuzmin *et al.*, 2020b). However, veterinary workers do not have at their disposal the respective effective means of disinfection, which would be effective against conditionally pathogenic microflora and simultaneously have no negative effects on animals' health (Holley *et al*., 2004; Mohakud *et al*., 2020).

It has been established that with timely monitoring and preventive measures, it is possible to improve the resistance and productivity of farm animals and to prevent various infectious and invasive diseases (Narbayeva *et al*., 2016; Tanbayeva *et al*., 2016; Aitpayeva *et al*., 2022).

Given the high importance of the outlined problems for pig farms, the goal of the present study is to develop a technological mode of prophylactic disinfection in the presence of animals.

To attain this goal, the following research objectives are established:

- To optimize the technology of prophylactic disinfection and improve the antimicrobial regime in pig houses
- To develop and implement a disinfectant for prophylactic disinfection in the presence of animals
- To study the effect of the technological mode of prophylactic disinfection on some physiological indicators of the piglet organism

Materials and Methods

The conducted experiments and method of research on laboratory animals comply with biosafety and ethical principles of animal experimentation stipulated by the European convention for the protection of vertebrate animals used for experiments and other scientific purposes (opinion of the bioethics commission of the Kazakh National Agrarian Research University of October 07, 2021).

Experimental work to study the effectiveness of preventive disinfection (safe) measures was carried out in the pig farm complex of the Karaoi LLP, Ili district, Almaty Region, in 2021-2022.

To implement the set objectives, we selected three objects: Two control facilities (objects No. 1-2) and one experimental facility (object No. 3), all of them being identical in terms of area, capacity, design, and other parameters. In object No. 1 (control), preventive disinfection was performed by the method adopted on the farm (by the wet method): Mechanical cleaning, washing, and disinfection with a 4% solution of bleach (Russia). This preparation was constantly used in production, although the market offers a wide variety of more effective and environmentally friendly disinfectants. Here it was important to bear in mind that this preparation was highly toxic and corrosive, which was why it must not be used in the presence of animals. In object No. 2 (control) preventive disinfection was performed by the wet method (with a 3% Glutex solution (Spain)). Finally, in object No. 3 (experimental) preventive disinfection was performed by a combined method: disinfection by the wet (2% Dezinfekt solution Kazakhstan), foam (2% Penodez solution Kazakhstan), and aerosol (1.5% Yodizol solution in the presence of piglets Kazakhstan) methods.

In the course of the experiment, the control groups included 259 (object No. 1) and 254 (object No. 2) piglets, and the experimental group (object No. 3) 251 piglets.

The time of accumulation of microorganisms on the surfaces (feeders, drinkers, and walls) of the studied objects and in the air was tested in all three farrowing facilities (No. 1-3) after disinfection by taking swabs from the studied points during the experiment (the 1st, 15th, 30th and 45th days), seeding them on a nutrient medium, cultivating and calculating the total amount of microorganisms.

By the regime adopted in the farm, prophylactic disinfections are typically performed each time animals are taken out of the facility and include the steps of sanitary repairs and mechanical cleaning and washing of surfaces.

The long-standing practice of prophylactic measures in farm facilities housing sows during their farrowing period consists of mechanical cleaning, washing the surfaces, wet disinfection with a bleach solution, and drying (the technology adopted in production). After the cleaning and disinfection, sows are placed in the facility for farrowing in individual farrowing crates, which are filled with animals 1-2 days before farrowing. Sows stay in these individual crates until the weaning of piglets (35 days) and piglets stay in the crate up to 45 days of age. Further, after the transfer of sows, no special sanitary measures (washing or disinfection) are carried out in this facility during the specified period except for cleaning. For this reason, the longer animals stay in the farrowing sector room, the worse becomes the microclimate in this facility. This is evidenced by data obtained in a preliminary study of individual components (ammonia, microbial contamination, etc.,) of microclimate in a farrowing house. In particular, in the farrowing house No. 1, the content of ammonia in the air during the period of study rose from 10.1±0.4 to 23.3±2.1 mg/m^3 by the end of housing piglets with sows, while the number of microorganisms in the air increased by 2-3 times (58.1±0.7 ths/m^3) from the initial level during that time. Under such conditions, animals and especially piglets have an increased incidence of diseases.

Works to improve the technological prophylactic disinfection mode on the farm were carried out at three sites (two facilities control and one facility experimental) using conventional bleach (wet method) and modern preparations such as Glutex (wet method), Dezinfekt (wet method), Penodez (foam method) and Yodizol (aerosol method).

The degree of microbial contamination of indoor air was determined using a 50 mL microorganism trap (UM-1 AZVI passive method) made of chemically pure glass.

In the course of experimental work, wet disinfection was carried out with a high-pressure sprayer on a HONDA fuel engine (China), foam disinfection with a Karcher foam generator (Germany), and aerosol disinfection with a LOMA Cyclone-4 aerosol generator (Russia).

The study of the interaction between the components that make up the disinfectant Yodizol (iodine crystal, potassium iodide, lactic acid, and sodium tripolyphosphate) was conducted by Infrared (IR) spectroscopy.

The IR spectrum of the developed preparation in the liquid phase was determined on a Nicolet 5700 FT-IR spectrometer with a resolution range of 200-4,000 cm^{-1} under 25°C 8 cm^{-1} (Japan).

Blood composition was tested on an MS4 automatic hematology analyzer (France).

For an overall assessment of the technological mode of prophylactic disinfection, we examined such indicators as piglets' live weight gain, vitality, and changes in physiological parameters.

Descriptive statistical analysis was performed with SPSS for Windows, 13.0 (SPSS Inc, Chicago, IL, USA), and the chi-squared test was used to analyze the prevalence of differences between the solutions.

Results

Optimization of prophylactic disinfection technology and improvement of the antimicrobial regime in pig yards results of the measures to improve the antimicrobial regime in pig yards are given in Tables 1-2.

Table 1 demonstrates that in a farrowing facility in regular conditions before disinfection, the most contaminated microorganisms are air in the rooms (up to 161.4±0.4). The lowest concentration of microorganisms was found on the surfaces of feeders (64.0±0.4) and drinkers (47.6±0.6). After disinfection (regardless of the type of preparation used) the number of microorganisms decreased significantly on all the studied surfaces. Moreover, the effectiveness of prophylactic disinfection was approximately the same regardless of the method of disinfection or the preparation used and amounts on average to 89.6 and 90.3% in the control objects No. 1-2, respectively, and 92.4% in the experimental objects (after treatment with Dezinfekt).

To increase the effectiveness of preventive disinfection, the experimental facility (after wet treatment with a 2% Dezinfekt solution) was additionally sanitized (48 h after the first disinfection) with a 2% solution of Penodez. The results of the additional treatment are shown in Table 2.

According to the data in Table 2, the efficiency of additional disinfection of the experimental room treated with 2% Penodez by the foam method averages 99.2%, meaning that compared with the results of treatment with Dezinfekt (92.4%), the effectiveness of additional disinfection increases by 6.8%. Comparing this result with the data of the control objects, after the additional treatment the efficiency increases, respectively, by 9.4 (object No. 1) and 8.9% (object No. 2).

Thus, the combined sanitation of object surfaces (wet + foam) enhances the effectiveness of prophylactic disinfection.

After prophylactic disinfection in the control (No. 1-2) and experimental (No. 3) farrowing houses where the disinfection optimization regime was studied, research was continued to determine the concentration of microorganisms in the air and on the surfaces of the facilities on the 15th, 30th and 45th days of animals staying there. The results show an increase in the level of microbial contamination in the air in all sites under study as the time of animals' stay on the premises grows longer. In particular, in the control objects the extent of increase in the number of microorganisms in the air is higher by more than 2 times compared to the experimental object. While the presence of microorganisms in the air (object No. 1) right after prophylactic disinfection amounts to $18.7 \cdot 10^3 \pm 0.3 \cdot 10^3$ CFU/m^3, on the 15th day, the number grows to $56.0 \cdot 10^3 \pm 0.8 \cdot 10^3$ CFU/m^3 and on the 30th day reaches the maximum permissible level.

Table 1: Results of the study on the effectiveness of disinfection (M ± m)

Place of swab taking	Object sanitation parameters					
	Object no. 1		Object no. 2		Object no. 3	
	Before disinfection	After disinfection	Before disinfection	After disinfection	Before disinfection	After disinfection
Wall (10^3 CFU/cm^2)	67.7±0.8	6.8±0.8	70.2±0.9	8.0±0.7	61.3±0.8	5.3±0.6
Feeder (10^3 CFU/cm^2)	64.0±0.4	5.7±0.4	77.9±0.7	5.4±0.4	69.8±0.8	4.4±0.2
Drinker (10^3 CFU/cm^2)	47.6±0.6	5.1±0.2	52.6±0.4	4.8±0.6	49.4±0.4	3.9±0.2
Air (10^3 CFU/m^3)	161.4±0.4	18.7±0.3	158.0±0.6	17.3±0.8	153.6±0.7	14.1±0.3
Mean disinfection effectiveness, %	89.6		90.3		92.4	

Note: Data are mean ± standard error mean

Table 2: Results of additional foam treatment of facilities with a 2% Penodez solution (M ± m)

Surfaces from which swabs were taken	Results of sanitation (10^3 CFU/cm^2)		
	Before treatment	After treatment	Disinfection effectiveness, %
Walls	5.3±0.6	0.10±0.40	98.9
Feeder	4.4±0.8	0.07±0.80	98.8
Drinker	3.9±0.2	0.02±0.50	99.5
Air, CFU/m^3	14.1±0.3	0.07±0.80	99.6

Note: Data are mean ± standard error mean

Subsequently, the accumulation of microorganisms in these facilities continues to increase and by the time of piglets' transfer to other production units (day 45) grows as high as $164.5 \cdot 10^4 \pm 4.2 \cdot 10^3$ CFU/m^3. In the experimental object, the general rise in the concentration of microorganisms is slower and their number reaches the maximum permissible level ($101.2 \cdot 10^4 \pm 3.2 \cdot 10^3$ CFU/m^3) by the end of the technological time of stay of sows, i.e., by the moment of the weaning of piglets. The obtained data indicate that additional treatment somewhat reduces the overall microbial contamination of the facility and makes the environment healthier for animals.

A similar pattern of growth of bacterial contamination during the time of animals' stay on the premises is observed on the surfaces of objects (floor, wall, etc.). The accumulation of microorganisms on the surfaces of the enclosing structures of the control objects (No. 1-2) is found to be significantly greater than in the experimental facility (No. 3). In particular, the total bacterial contamination of walls in the control objects during the initial period of animal housing (after 15 days) vary from 3.8·104±0.5·102 to 9.3*104±0.6*102 CFU/cm^2. In subsequent periods (30th days and beyond, i.e. after weaning), these values are significantly greater (from 64.6·104±3.0·103 to 121.2·104±4.5·104 CFU/cm^2). In turn, in the experimental facility, the considered parameters at the time of piglet weaning and sow retrieval are much lower on the floor and wall surfaces: up to 96.3·104±3.3·104 and 75.3·104±2.9·104 CFU/cm^2, respectively.

During regular mechanical cleaning of sow housing units, no significant exceedances of the permissible values of microbial contamination have been found on the surfaces of drinkers and feeders.

The conducted studies have shown that as the period of animal housing passes, microbial contamination gradually increases not only in the air but also on the floor and walls. A significant level of microbial contamination of the examined points is observed by the end of the technological period of joint housing of sows and piglets (after one month), which leads to the deterioration of their living environment.

Development and introduction of disinfectant for preventive disinfection in the presence of animals the results of spectroscopic studies are shown in Figs. 1-2 demonstrating the IR spectra of the preparation of Yodizol and its components.

Comparison of data on changes in the stretch vibrations of compound groups in different absorption ranges allows clarifying the nature of fluctuations in the parameters of the IR spectra of Yodizol components (Table 3).

The IR spectra of aqueous-alcohol solutions of I_2, KI, NaTPF, and α-oxypropanoic (lactic) acid in the range of 3,700-3,000 cm^{-1} are identical. In this region lie the absorption bands of the stretching (ν) vibrations of the-OH groups and the absorption bands (ν) of vibrations of the CH alcohol groups. The stretching vibrations of I_2 lie in the low-frequency part of the spectrum (ν 300-200 cm^{-1}) and are inaccessible to the device.

In the IR spectra of I_2, KI, and NaTPF in the range of ν 2,000-400 cm^{-1} there are absorption bands of the bending (δ) vibrations of C-H bonds (1,400-1,300 cm^{-1}) in -CH groups and of O-H bonds in -OH groups (1,640 cm^{-1}), as well as ν vibrations (1,091, 1,049 cm^{-1}) of C-OH bonds in C-OH groups.

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In the IR spectra of lactic acid ($CH_3CH(OH)COOH$) in the range of ν between 3,700-3,000 cm^{-1} there are absorption bands of the O-H bond in hydroxyl -OH groups of the solvent and acid (wide band in the interval 3,154-,2629 cm^{-1}). The absorption bands of stretching (ν) vibrations of C-H bonds in -CH groups are found in the range of 2,800 cm^{-1} and bending ones (δ) between 1,460 and 1,300 cm^{-1}. The stretching vibrations of the double bond in the carbonyl group C=O have a frequency of 1,730 cm^{-1}. The bending vibrations of C-H bonds in -CH groups have frequencies of 826 and 748 cm^{-1}, the absorption band at 644 cm^{-1} is attributed to the bending vibrations of the O-H bond in -OH acid groups.

In the IR spectrum of the product in the range of 4,000-3,000 cm^{-1}, there are absorption bands of stretching vibrations of free, bound, and acidic -OH groups, as well as the stretching and bending vibrations of -CH groups (Table 3). In addition, the spectrum has absorption bands of the stretching vibrations of the carbonyl group –C=O- with a frequency of 1,735 cm^{-1} and of the carboxylic group -O-C-O- with a frequency of 1,236 cm^{-1}. The low-frequency area has absorption bands at 1,086 and 1,044cm^{-1}, attributed to the stretching vibrations of bonds in -C-O H groups.

The presented data show that the absorption bands in the spectra of the Yodizol preparation are preserved and this, in turn, indicates the presence of certain structural correspondence between the components of the Yodizol preparation.

Table 3: Fluctuations in IR spectra in the drug component of Yodizol

	Compound and absorption frequency, cm^{-1}				
Group, type of stretch vibration	I_2	KI	$Na_5P_3O_{10}$ (NaTPF)	α-oxypropanoic (lactic) acid ($CH_3CH(OH)COOH$)	Yodizol preparation
ν -OH (free)	-	3,596	3,694	3,523	3,552, 3,428
ν -OH (bond)	3,378	3,388	3,430	3,357	3,343
ν -OH (acid)	-	-	-	3,154-2,629	3,150-2,620
δ -OH	1,652	1,647	-	1,647	1,630
ν -CH	2,957, 2,936	-	-	2,990, 2,936	2,990, 2,943
δ -CH	1,460, 1,325	-	-	1,455, 1,366	1,461, 1,376
ν -C-O-C-	-	-	-	1,231	1,236, 1,131
ν -C=O-	-	-	-	1,730	1,735
ν -C-OH	1,091, 1,049	1,195, 1,117	-	1,127, 1,044	1,086, 1,044
ν P-O-	-	-	1,230, 1,132	-	-

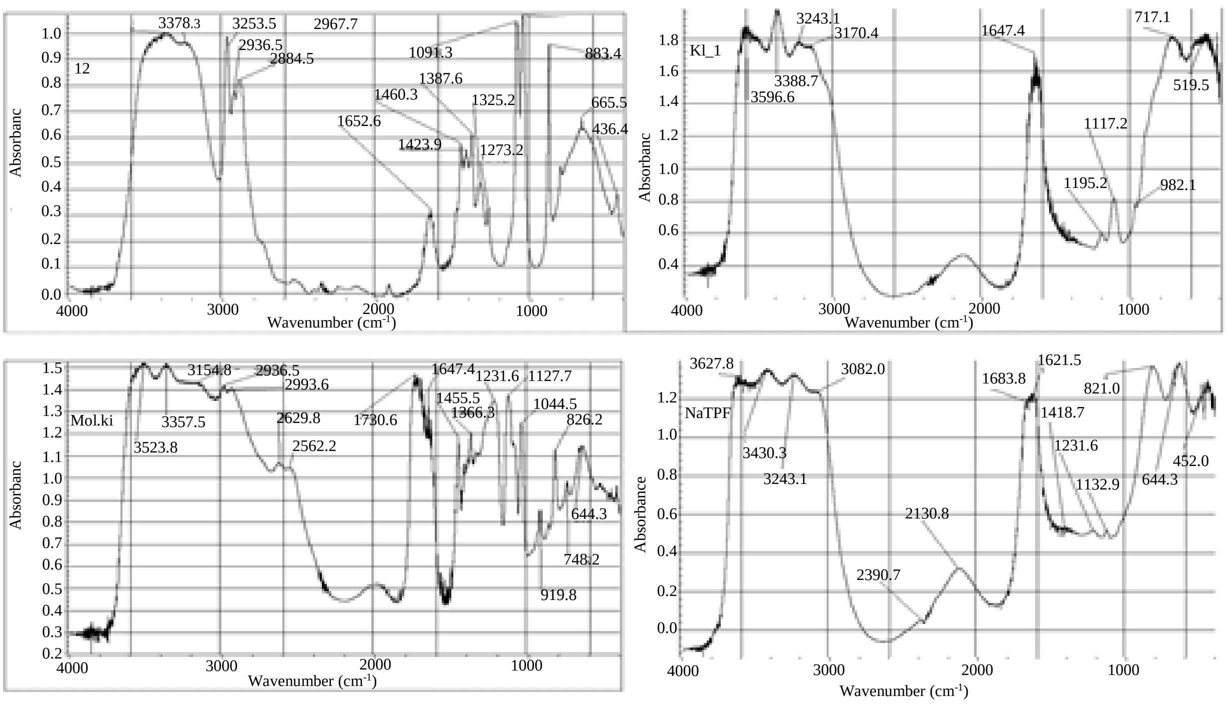

Fig. 1: IR spectrum of Yodizol ingredients: A-crystal iodine; B-potassium iodide; C-lactic acid; D-sodium tripolyphosphate

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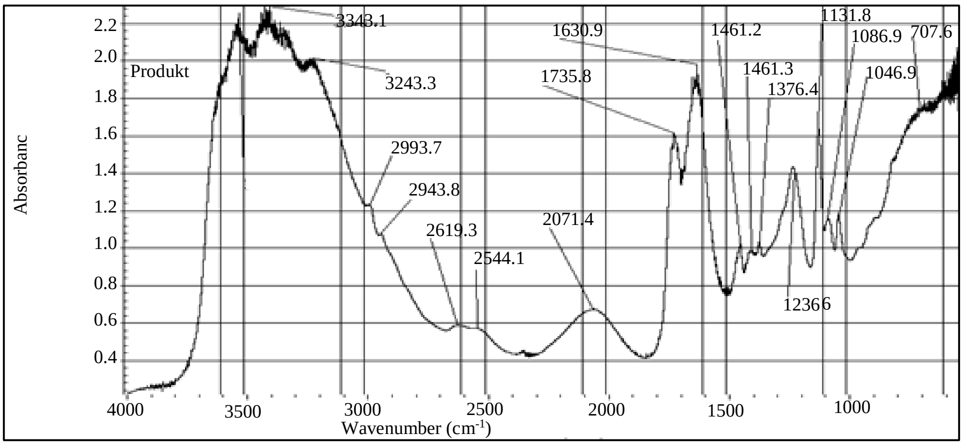

Fig. 2: IR spectrum of Yodizol

Table 4: Results of premise sanitation with a 1.5% Yodizol preparation in the presence of piglets (M ± m)

	Sanitation results CFU(10^5)		
The object of assessment	Before disinfection	After disinfection	Disinfection effectiveness, %
Walls	11.8±0.3	0.6±0.7	95.2
Equipment unit	7.6±0.8	0.5±0.4	93.0
Air, CFU/m^3	51.0±0.7	1.8±0.2	96.3

Note: Data are mean ± standard error mean

After establishing the high bactericidal activity of Yodizol with respect to sanitary-positive microorganisms in laboratory conditions, aerosol disinfection was carried out using a self-propelled fan aerosol generator LOMA Cyclone-4. The results obtained are presented in Table 4.

The table displays the data on objects with the greatest accumulation of microbes (walls, equipment, and air) 30 days after prophylactic disinfection. As a result of sanitation with Yodizol by the aerosol method, the reduction in the concentration of microorganisms on the studied objects is 95.2% for walls, 93.0% for equipment units, and 96.3% for air. After the sanitation measures, a general improvement is observed in the general condition of animals and microclimate parameters along with reduced gas contamination and less foul smells. The greatest reduction in the considered parameters is found for the aerial environment.

During the use of Yodizol, piglets showed no allergic reactions or other changes indicating the toxicity of the drug to the animal body.

Studying the influence of the technological regime of preventive disinfection on some physiological indicators of the bodies of piglets.

The results of testing the effectiveness of the employed technological modes of disinfection are presented in Tables 5-6.

The study indicates that the proposed combined disinfection method (wet, foam, and aerosol) shows better effectiveness than the wet method currently employed in production. In particular, the live weight of piglets in the studied group is 7.99 kg, which is 1.12 kg (or 14%) more than in the control groups. The life safety of piglets in the experimental group is 5% higher than that in the control group.

The physiological condition of piglets and the effectiveness of the aerosol method of disinfection were assessed based on changes in the blood levels of piglets (Table 6).

The data presented above indicate that the blood levels of the studied group of piglets are much higher than those in the control groups. Specifically, the level of lymphocytes is 8.2% higher, the level of hemoglobin 8.1% higher, hematocrit 6.9% higher and platelets 4.6% higher.

Proceeding from the results of the conducted studies on the effectiveness of various technological disinfection modes, a cyclogram is compiled (Fig. 3).

Figure 3 demonstrates that compared to the adopted mode of disinfection in production, the proposed mode, i.e., the combined method of disinfection (wet + foam) raises the effectiveness of disinfection measures by 8.9-9.6% in contrast to the control disinfection mode.

Table 5: Increase in the live weight and life safety of piglets (M ± m)

	Group of animals		
Indicators	No. 1 control	No. 2 control	No. 3 experimental
Weight gain of piglets, kg			
Live weight of newborn piglets, kg	1.49±0.06	1.47±0.04	1.49±0.06
Live weight 15-days-old piglets, kg	4.39±0.20	4.41±0.22	4.47±0.21
Live weight one-month-old piglets, kg	6.87±0.31	6.96±0.34	7.99±0.33
Life safety of piglets, %			
Total number of piglets	259	254	251
Number of deceased piglets	21	15	8
Life safety	91.8%	94.0%	96.8%

Note: Data are mean ± standard error mean

Table 6: Blood levels of piglets (M ± m)

	Groups of animals (under 1 month of age)		
Blood levels	No. 1 control	No. 2 control	No. 3 experimental
Leukocytes, 10^9/l	10.6±1.3	11.2±2.1	12.6±1.4
Lymphocytes, %	41.5±1.2	43.3±1.7	49.7±1.6
Monocytes, %	2.2±1.4	2.7±1.6	3.6±2.2
Granulocytes, %	8.1±1.6	8.8±1.9	9.5±1.5
Erythrocytes, 10^{12}/l	6.2±1.3	6.4±1.2	7.0±1.6
Hemoglobins, g/l	9.2±1.5	9.6±2.0	10.2±1.2
Hematocrits, %	32.8±1.8	33.4±1.2	39.7±1.6
Platelets, 10^9/l	209.0±2.6	213.0±2.2	221.0±2.8

Note: Data are mean ± standard error mean

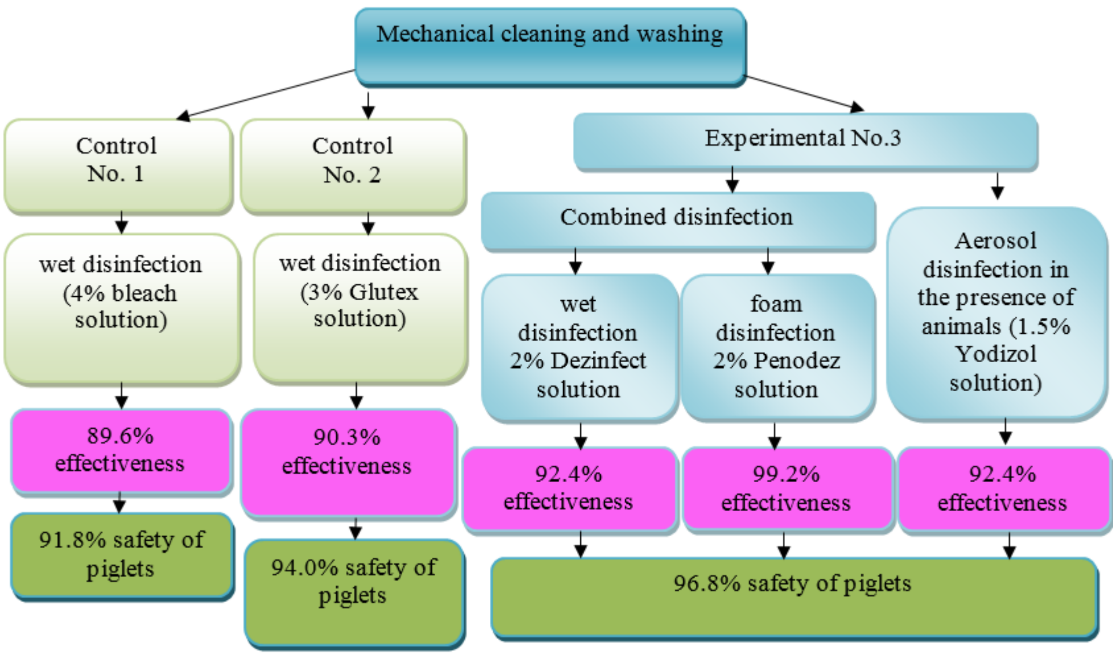

Fig. 3: Cyclogram of the efficiency of technological modes of preventive disinfection for pig farming facilities

Discussion

The research demonstrated the opportunity to improve the quality of disinfection. In particular, improvement in the process of site cleaning with water and highly effective modern disinfectants (by the traditional method) raise the effectiveness of disinfection to 90.3%. In turn, the use of the new preparation Dezinfekt in experimental facilities increases the effectiveness of disinfection by up to 92.4%. Additional disinfection (after wet treatment) with the foam method using the preparation Penodez for foam treatment elevates the effectiveness to 99.2%. After the application of Yodizol with aerosol disinfection in the presence of piglets (30 days later), the degree of elimination of microorganisms lowered to 94.8%. Overall, a comparative analysis of the modes of disinfection administered in farrowing sites indicates that additional sanitary treatment of premises surfaces with foam preparations significantly decreases (35-40%) microbial contamination of facilities and facilitates the improvement of animal housing conditions (Ilyasova and Mannapova, 2016; Kikuti *et al*., 2022).

These findings point to the need to perform disinfection measures after a certain period of animals' stay in the facility. However, in farm conditions, it is not always feasible to temporarily free the room from animals to conduct disinfection. Furthermore, preparations that are safe for animals and can be used for disinfection in their presence are not always available. At present, this is one of the unsolved problems in veterinary medicine (Gao *et al*., 2021). The use of such safe agents for prophylactic disinfection in the presence of animals is an essential condition for the preservation of animal health. For this purpose, the composite preparation of Yodizol is developed and tested under production conditions. Based on the obtained spectrograms of graphic templates of IR spectra of the studied substances, we can conclude that all the organic substances making up the Yodizol preparation retain their spectrum in the process of interaction. This is evidenced by the values of vibrations of the main vertices of the graphical peaks. The absorption band of the stretching vibrations of the -C=O- carbonyl group in the product is shifted to the high-frequency side of the spectrum by 5 cm^{-1} compared to lactic acid. This shift may owe to the interaction of iodine with the carbonyl group of lactic acid. As a result of applying the specified preparation in the presence of animals in safe disinfection (by aerosol method), the number of microorganisms in the air is reduced by 96.3%.

One of the ways to enhance the effectiveness of safe disinfection is to conduct it in a technologically timely manner (Tenzin *et al*., 2019; Tian *et al*., 2021). For this purpose, the study was conducted in the pig house (in the presence of piglets) and the time points of the accumulation of microbes (15, 30, and 45 days) on various surfaces and in the air were determined. After 15-30 days of animals' stay in the facility, there is an increase in the total number of microbes exceeding the permissible norms. Thus, it is desirable to carry out safe preventive disinfection of the area within the specified time frame.

After the timing of prophylactic disinfection was identified, disinfection with Yodizol was performed in the presence of piglets. As a positive result of disinfection, the microclimate parameters have improved, the concentration of harmful gases in the air decreased and the physiological state of animals has improved. Other scientists hold the same opinion (Martelli *et al*., 2017; Montagnin *et al*., 2022).

To raise the effectiveness of prophylactic disinfection in farms, a cyclogram of the technological regime of disinfection was made. It was found that the safety of piglets in the studied group is 2.8-5% higher in comparison with the control groups.

Conclusion

The combined disinfection method (using the preparations Dezinfekt and Penodez) is more effective compared to the wet disinfection method adopted at the farm. In the process of animal housing, there is a gradual accumulation of microorganisms, which reaches the permissible limits in the control group on day 15 and in the experimental group on day 30. This indicates the need for disinfection and other sanitary measures in the studied sites in the presence of animals to optimize the sanitary and hygienic conditions of their housing. An environmentally safe iodine-based preparation Yodizol has high bactericidal properties against hygienically significant microorganisms and is safe for piglets (no allergic or toxicological effects).

The study proposes a technological mode of safe prophylactic disinfection for pig farms: In prophylactic periods (in the absence of animals) disinfection should be combined (wet and foam); in productive periods (in the presence of animals) prophylactic disinfection should be performed by the aerosol method 30 days after the introduction of animals into the facility using the Yodizol preparation.

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Author's Contributions

All authors equally contributed to this study.

Ethics

This article is original and contains unpublished material. The corresponding author confirms that all of the other authors have read and approved the manuscript and no ethical issues are involved.

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