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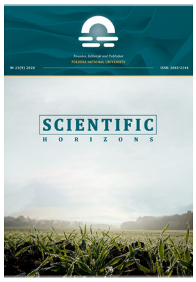

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Peculiarities of rearing poultry by floor method on deep bedding

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Abstract. In poultry rearing on deep bedding systems, microorganisms that cause infectious diseases develop within the bedding. This study aimed to determine the physical properties and microbial accumulation capacity of different types of bedding. Methods used included thermo-programmed desorption mass spectrometry, microbiological methods, and scanning electron microscopy. The hygroscopic properties of straw bedding deteriorated by 269.90% from the seventh to the forty-second day. In the experimental room, where a dry disinfectant was added to the straw

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bedding, the hygroscopic capacity was 86.70% at the end of the experiment, a difference of 183.2%. Wood shavings bedding, with the addition of disinfectant, exhibited a water absorption capacity 102.82% higher than the control on the forty-second day. Granulated bedding with disinfectant retained moisture 150.33% better compared to the control. At the end of the experiment, the pH of straw bedding was 8.13 in the control group compared to 7.56 in the treated group; for wood shavings was 7.95 versus 7.16; and for granule was 7.35 versus 6.35, due to the use of the disinfectant. At the conclusion of the experiment, granulated bedding exhibited the lowest pH compared to straw and wood shavings, affecting the growth and reproduction of microorganisms. Monitoring of microorganisms in the bedding revealed the presence of bacteria: *Escherichia coli*, *Salmonella typhimurium*, *Salmonella pullorum*, *Clostridium perfringens*, *Staphylococcus aureus*, *Klebsiella pneumonia*, *Listeria monocytogenes*, as well as microscopic fungi: *Fusarium sporotrichioides*, *Aspergillus niger*, and *Eimeria* oocysts. The use of disinfectant reduced bacterial contamination of straw bedding by 12.35-199.19%, fungal contamination by 633.91-1959.14%, and *Eimeria* by 676.50%. In the wood shavings bedding, bacterial contamination was reduced by 32.84-257.93%, fungal contamination by 487.08-1098.4%, and *Eimeria* by 570.21%. Granulated bedding showed reduced bacterial accumulation by 50.93-228.87%, fungal accumulation by 169.89-500.9%, and *Eimeria* by 301.56%. The practical significance of this study lies in the improved physical properties of poultry bedding and the reduction in bacterial, fungal, and *Eimeria* oocyst accumulation

Keywords: hygroscopic properties; bedding pH; bacteria; microscopic fungi; *Eimeria*

INTRODUCTION

The environment plays a crucial role in poultry productivity. When selecting bedding materials, factors such as cost-effectiveness, moisture absorption capacity, and environmental safety must be considered. The European Union's initiative to ban caged poultry by 2027 (European Commission, 2021) has prompted producers to adopt floor-keeping systems for broiler production. Rearing poultry on the floor necessitates the use of high-quality bedding materials. The intensive broiler production system has raised concerns about poultry welfare, leading to a search for alternative rearing systems (Çavuşoğlu & Petek, 2019; Kwon *et al.,* 2024).

In the management of pigs on the floor, researchers O. Shkromada *et al.* (2022) identified bacteria such as *A. Thiooxidans, S. aureus, E. coli, S. enteritidis, S. Choleraesuis, C. Perfringen* and fungi including *Cladosporium, Fusariums, Aspergillus*. Their research demonstrated that a dry disinfectant exhibited antimicrobial properties against field isolates of bacteria and fungi from the pig farm. While the experiment was conducted in a pigsty, poultry farming has unique conditions and requirements. Bacteria and fungi can lead to secondary infections, contamination of products, and environmental pollution in poultry houses. Studies by H.K. Sorour *et al.* (2023) found that methicillin-resistant coagulase-negative staphylococci caused polyserositis of internal organs, hepatic and myocardial necrosis.

Bacteria of the *Escherichia sp.* family have been linked to diseases such as enteritis, salpingitis, peritonitis, and septicaemia in poultry (Swelum *et al.,* 2021). These microorganisms have demonstrated high pathogenicity and resistance to a range of antibiotics, necessitating preventative measures to reduce the risk of poultry infection. The indiscriminate and frequent use of antibiotics to treat infectious diseases has led to the emergence of antibiotic-resistant strains of microorganisms, which can spread among poultry via bedding (Oxendine *et al.,* 2023). Additionally, researchers M. Kyakuwaire *et al.* (2019) determined that poultry bedding can serve as a source of infection and allergic reactions in both animals and humans. Consequently, there is a pressing need for research into the efficacy of preventive disinfection.

Floor-based poultry systems offer both advantages and disadvantages. A variety of materials, often agricultural by-products, are used as bedding (Brochu *et al.,* 2021). Wood shavings have been the most common bedding material in farms (70.2%). In an experiment conducted by T.L. Crippen *et al.* (2019), it was found that straw, sawdust, and wood bark are frequently used as poultry bedding. Changes in the bedding can affect the quantity and types of microorganisms present on the floor.

Research has also revealed the use of hulls of sunflower, legumes, straw, and other plant-based materials as bedding (Sieńkowska *et al.,* 2019). These materials have been found to contain pesticides, lead, cadmium, and toxins produced by fungi and bacteria. Therefore, when selecting bedding materials, it is crucial to consider factors such as toxicological and biological safety. Scientists M.H. Seyedtaghiya *et al.* (2021) explored the potential of using *Satureja hortensis L.* as a medicinal plant to eliminate bacteria. However, their study focused solely on the bactericidal properties of *Satureja hortensis L.* against *E. Coli* and *Salmonella*, which is insufficient to eliminate the associated microbiota. In the research of S.I. Cuevas-Cianca *et al.* (2023), the antimicrobial activity of extracts from Latin American medicinal plants was investigated as a solution to the problem of antibiotic resistance in microorganisms. However, the researchers did not propose a method for treating bedding with these extracts or essential oils.

This study aimed to conduct a comparative assessment of poultry bedding materials for safe floor-based rearing. To achieve this objective, the following tasks were undertaken: to investigate the moisture-holding capacity of different bedding types; to determine the pH of each bedding type; and to examine the microorganisms and *Eimeria* content in various bedding materials.

MATERIALS AND METHODS

Cobb-500 broiler chickens were kept in the veterinary clinic of Sumy National Agrarian University for a period of 40 days, from January 1 to February 9, 2024. The birds were divided into 6 groups: 3 control and 3 experimental (Table 1).

Table 1. *Experiment design*

Control		Experiment	
1C	Straw	1E	Straw + dry disinfectant
2C	Wood shavings	2E	Wood shavings + dry disinfectant
3C	Granule	3E	Granule + dry disinfectant

Note: *C – control; E – experimental*
Source: *developed by the authors*

The chicks were housed in a room with a concrete floor and bedded on: wood shavings (Fig. 1a), straw (Fig. 1b), and granule (Fig. 1c). For bedding, wood shavings from coniferous and soft deciduous species of 0.05-0.1 × 6-8 mm; chopped wheat and rye straw were used. The granules used in the experiment were a mixture of coniferous and deciduous wood, measuring up to 6.8 × 50 mm. The different types of bedding were spread on the floor to a depth of 20-30 cm before the birds were placed in the house. In the experimental groups, a dry powdered disinfectant was spread twice a week at a rate of 50 g/m^2. The experimental disinfectant, produced and supplied for testing by LLC “Brovapharma”, contained kaolin, calcium sulphate dihydrate, chloramine, copper sulphate, thymol, iron sulphate, and zeolite.

Figure 1. *Image of poultry housing on the floor with bedding*
Note: *a – wood shavings; b – straw; c – granule*
Source: *author’s photo*

The primary objective of the experiment was to investigate the varying performance characteristics of different bedding materials. Laboratory analyses were conducted in the Department of Veterinary Expertise, Microbiology, Zoohygiene and Safety and Quality of Livestock Products of the Faculty of Veterinary Medicine in the “Veterinary Pharmacy” laboratory of the Sumy National Agrarian University.

Investigation of hygroscopic properties of bedding samples using TPD MS. The Thermo-Programmed Desorption Mass Spectrometry (TPD MS) MX-7304 (SELMI OJSC, Sumy, Ukraine) was used to determine the moisture content of the bedding samples. Samples weighing 5-10 mg were heated from 40 to 200°C at a rate of 15°C/min, with the release of moisture being recorded every minute. The mass spectrometer was used to determine the H_2O content (Murphy *et al.,* 2021).

Determination of the pH of the bedding. The selected bedding samples were kept for 60 minutes in distilled water, and the pH of the bedding was measured using a pH meter. Measurements were taken at the beginning and end of the experiment, after 42 days.

Investigation of bedding contamination with microorganisms and Eimeria. Weekly, samples of each bedding type were collected along with faecal matter into sterile containers to which 250 ml of water was added for a ten-fold dilution. The resulting suspension was added to selective media. Endo agar was used for the isolation of enterobacteria, and salt agar for staphylococci (Hanišáková *et al.,* 2022). Sabouraud agar was used to cultivate microscopic fungi (Suwannarach *et al.,* 2022). For the cultivation of clostridia, Wilson-Blair agar was used. After the cultivation of the microorganisms in a thermostat, the number of colony-forming units per gram of sample (CFU/g) was counted using an automatic counter Scan 4000 Ultra HD (Interscience, China). Samples of bedding and faeces were examined for *Eimeria* using the Fülleborn method. The number of *Eimeria* oocysts per gram of sample (OPG index) was counted using the method of S.K. Sadhukhan (2022).

Scanning electron microscopy. Microscopy of straw, wood shaving, and granules bedding samples was performed using a REM 106 (SELMI OJSC, Sumy, Ukraine) at electron-optical magnification ranging from 200 to 5,000 times.

Statistical analysis. Statistical analysis of the data was performed using the Fisher-Student method (Fisher & Mosteller, 1948), considering a significance level of greater than 95% ($p < 0.05$). The research was conducted by DSTU EN ISO/IEC 17025:2019 (2019), adhering to the rules of bioethics and humane treatment of vertebrate animals 2010/63/EU (Hartung, 2010), the European Convention for the Protection of Vertebrate Animals… (1986) and Law of Ukraine No. 249 (2012).

RESULTS AND DISCUSSION

Results of determining the hygroscopic properties of bedding samples using TPD MS. At the first stage of the research, the hygroscopic properties of the bedding were determined (Table 2). In the first control room, the moisture content of the straw bedding increased by 38.76% on the seventh day, 81.07% on the fourteenth ($P < 0.05$), 111.76% on the twenty-first, 140.07% on the twenty-eighth, 205.78% on the thirty-fifth, and 269.90% on the forty-second, compared to the beginning of the experiment.

Table 2*. Moisture content in different types of bedding of control rooms, M ± m, n = 5*

Bedding type	Hygroscopic property, %						
	Start of the experiment	Day 7	Day 14	Day 21	Day 28	Day 35	Day 42 end of the experiment
1C straw	15.22 ± 0.06	21.12 ± 0.09	27.56 ± 1.12*	32.23 ± 1.16*	36.54 ± 1.20*	46.54 ± 3.21*	56.30 ± 3.35*
2C wood shavings	15.35 ± 0.04	19.42 ± 0.08	24.18 ± 1.10*	26.48 ± 1.15*	32.25 ± 1.13*	39.12 ± 2.14*	43.48 ± 3.36*
3C granule	10.14 ± 0.07	12.10 ± 0.06	16.14 ± 0.03	20.35 ± 1.34*	24.76 ± 1.17*	30.23 ± 1.15*	33.18 ± 2.20*

Note: **P < 0.05 – results are significant compared to the start of the experiment*
Source: *developed by the authors*

Straw bedding has a sufficient level of water absorption capacity for the first two weeks. However, with prolonged use, even with the periodic addition of fresh straw, the moisture content increases severalfold. In the control room with wood shavings, the hygroscopic property of the bedding increased by 26.51% on the seventh day, 57.52% on the fourteenth (*$P < 0.05$), 72.50% on the twenty-first, 110.09% on the twenty-eighth, 154.85% on the thirty-fifth, and 183.25% on the forty-second. Wood shavings, as bedding, demonstrate a higher water absorption capacity compared to straw.

In the case of granulated bedding, the hygroscopic properties gradually deteriorated by 19.32% on the seventh day, 59.17% on the fourteenth (*$P < 0.05$), 100.69% on the twenty-first, 144.18% on the twenty-eighth, 198.12% on the thirty-fifth, and 227.21% on the forty-second, compared to the initial value. In the experimental rooms, where a dry powdered disinfectant was added twice a week, the moisture-retention capacity of the bedding decreased relatively slowly compared to the control rooms (Table 3).

Table 3*. Moisture content in different types of bedding in the experimental rooms, M ± m, n = 5*

Bedding type	Hygroscopic property, %						
	Start of the experiment	Day 7	Day 14	Day 21	Day 28	Day 35	Day 42 end of the experiment
1E straw	15.19 ± 0.04	18.43 ± 0.08	20.26 ± 0.15	22.45 ± 0.22	26.13 ± 1.22*	27.43 ± 1.25*	28.36 ± 1.35*
2E wood shavings	15.18 ± 0.05	17.40 ± 0.07	18.22 ± 0.14	20.07 ± 0.19	22.25 ± 1.13*	25.12 ± 1.34*	27.39 ± 1.36*
3E granule	10.34 ± 0.04	11.15 ± 0.05	12.09 ± 0.19	13.22 ± 0.21	14.05 ± 1.15*	15.45 ± 1.23*	18.29 ± 1.32*

Note: **P < 0.05 – results are significant compared to the start of the experiment*
Source: *developed by the authors*

In the experimental room with straw bedding, humidity increased by 21.32% on the seventh day, 33.37% on the fourteenth, 47.79% on the twenty-first, 72.02% (*$P < 0.05$) on the twenty-eighth, 80.57% on the thirty-fifth, and 86.70% on the forty-second, compared to the beginning of the experiment. Straw with the addition of a powdered disinfectant loses its hygroscopic properties twice as slowly as the control.

In the second experimental room, the bedding lost its water absorption capacity by 14.62% on the seventh day, 20.02% on the fourteenth, 32.21% on the twenty-first, 46.57% (*$P < 0.05$) on the twenty-eighth, 65.48%

on the thirty-fifth, and 80.43% on the forty-second. In the room where shavings with added disinfectant were used as bedding, the increase in moisture occurred more slowly than in the control and straw. The hygroscopic properties of the bedding in the third experimental room decreased by 7.83% on the seventh day, 16.92% on the fourteenth, 30.37% on the twenty-first, 35.88% (*$P < 0.05$) on the twenty-eighth, 49.41% on the thirty-fifth and 76.88% on the forty-second, compared to the beginning of the experiment. The water absorption capacity of the granulated bedding with added disinfectant was maintained at a high level for almost the entire experimental period, compared to other types of bedding.

Results of bedding pH determination. The average pH value of the bedding on the fourteenth day increased in 1C by 5.30%, in 2C by 3.92%, and in 3C by 5.69% compared to the seventh day (Fig. 2).

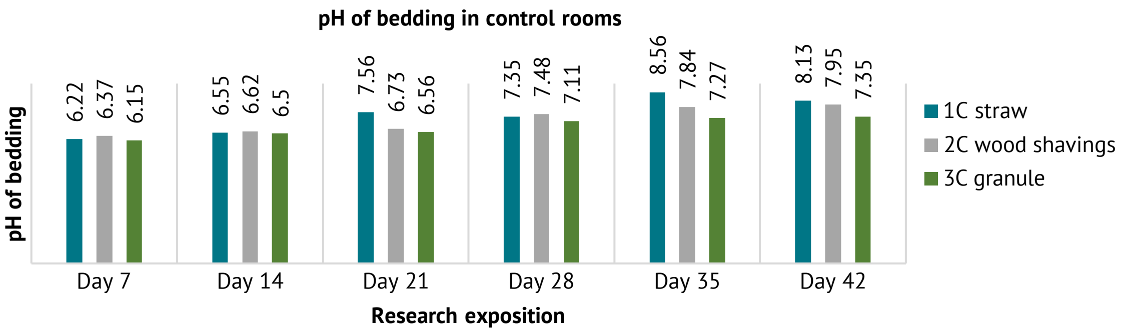

Figure 2*. pH of bedding in control rooms for keeping poultry on deep bedding of different types*
Source: *developed by the authors*

By the twenty-first day of the experiment, the pH of the bedding increased by 21.54% in 1C, 5.65% in 2C, and 6.66% in 3C. The pH value on the twenty-eighth day increased by 18.16% in the first control room, 17.42% in the second, and 15.60% in the third. The pH values in all types of bedding gradually shifted towards the alkaline side, which led to an increase in the spectrum of microorganisms.

The average pH of the bedding on the thirty-fifth day of the experiment increased by 37.62% in the first experimental room, 23.07% in the second, and 18.21% in the third. At the end of the experiment, the pH of the bedding had increased by 30.70% in 1C, 24.80% in 2C, and 19.51% in 3C. Granulated bedding had the lowest average pH on the forty-second day compared to straw and shavings. In experimental rooms where a powdered disinfectant was added to the bedding in the presence of poultry, the pH tended to increase throughout the experiment (Fig. 3).

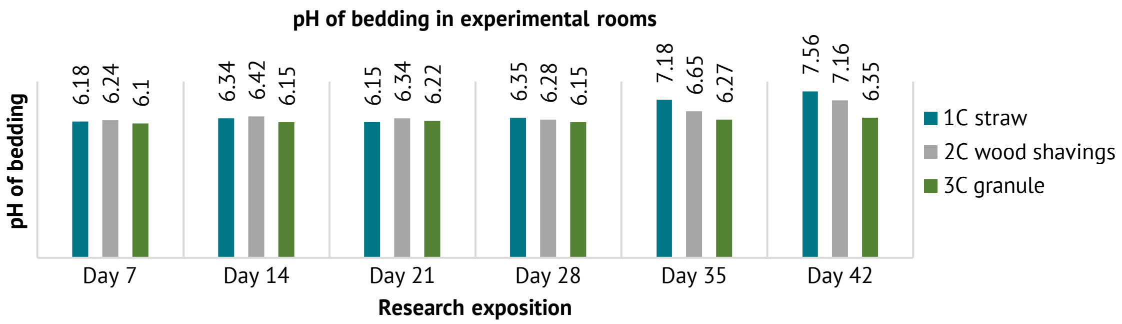

Figure 3*. pH of bedding in experimental rooms for keeping poultry on deep bedding of different types*
Source: *developed by the authors*

By the fourteenth day of the experiment, the pH of the bedding increased by 2.58% in the first experimental room, 2.88% in the second, and 0.81% in the third, compared to the seventh day. The pH value on the twenty-first day decreased by 0.48% in the first room, increased by 1.60% in the second, and 1.96% in the third. The addition of disinfectant to the bedding slowed down the shift of pH towards the alkaline side. On the twenty-eighth day, the pH increased by 2.75% in 1E, 0.64% in 2E, and 0.81% in 3E. The average pH on the thirty-fifth day increased by 16.18% in the first room, 6.57% in the second, and 2.78% in the third. At the end of the experiment, the pH had increased by 22.33% in the first experimental room, 14.74% in the second, and 4.09% in the third. On the forty-second day, the pH of the granulated bedding with added powdered dry disinfectant had hardly increased.

Results of the study of bedding contamination by microorganisms and Eimeria. In the poultry house, as a result of prolonged use, the bedding became soaked with moisture and faeces. A large number of microorganisms harmful to poultry also accumulated in the room. During the experiment, the accumulation of microflora in different types of bedding was determined (Figs. 4-10). In the straw bedding of the control room, the content of *Escherichia coli* increased by 18.72% on the fourteenth day, 31.84% on the twenty-first, 49.76% on the twenty-eighth, 99.2% on the thirty-fifth, and 146.88% on the forty-second, compared to the seventh day of the study (Fig. 4).

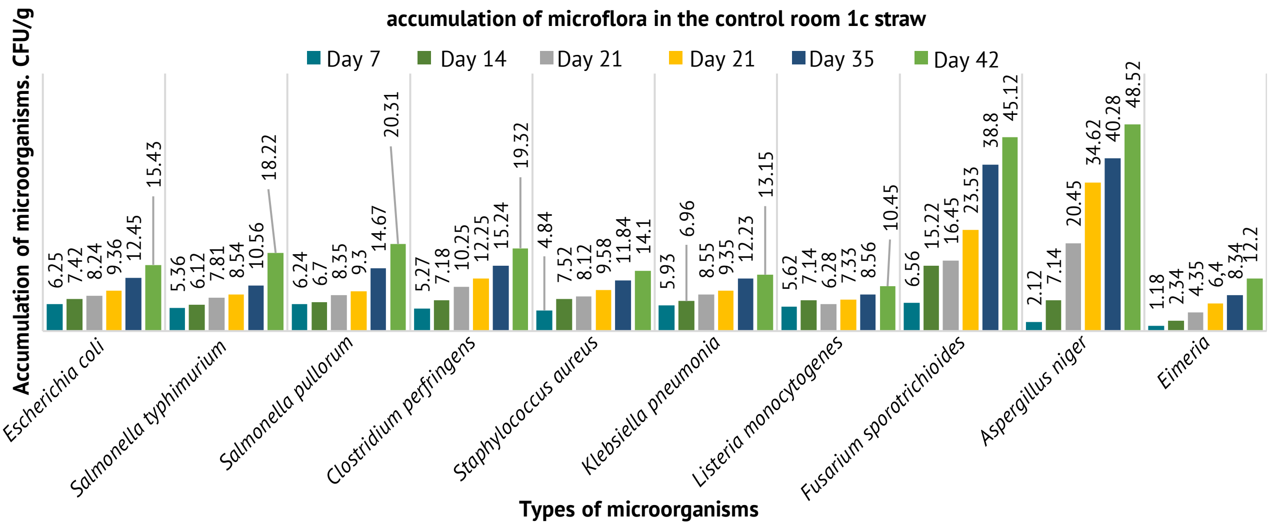

Figure 4. *Accumulation of microorganisms in the control room with straw bedding*
Source: *developed by the authors*

The concentration of *Salmonella typhimurium* increased by 14.17% on the fourteenth day, 45.70% on the twenty-first day, 59.32% on the twenty-eighth day, 97.01% on the thirty-fifth day, and 239.92% on the forty-second day. After the twenty-first day, the number of intestinal microorganisms in the straw bedding increased by nearly 50%. Specifically, the concentration of *Salmonella pullorum* increased by 7.37% on the fourteenth day, 33.81% on the twenty-first day, 49.03% on the twenty-eighth day, 135.09% on the thirty-fifth day, and 225.48% on the forty-second day. On the fourteenth day of the experiment, the concentration of *Clostridium perfringens* increased by 36.24%, 94.49% on the twenty-first day, 132.44% on the twenty-eighth day, 189.18% on the thirty-fifth day, and 266.60% on the forty-second day.

The concentration of *Staphylococcus aureus* increased by 55.37% on the fourteenth day, 67.76% on the twenty-first day, 97.93% on the twenty-eighth day, 144.62% on the thirty-fifth day, and 191.32% on the forty-second day. The accumulation of *Klebsiella pneumoniae* increased by 17.36% on the fourteenth day, 44.18% on the twenty-first day, 57.67% on the twenty-eighth day, 106.23% on the thirty-fifth day, and 121.75% on the forty-second day. The microbial count of *Listeria monocytogenes* increased by 27.04% on the fourteenth day, 11.74% on the twenty-first day, 23.60% on the twenty-eighth day, 52.31% on the thirty-fifth day, and 85.94% on the forty-second day.

Microscopic fungi thrive in the moist environment of straw bedding (Fig. 5). Spores of the fungus *Fusarium sporotrichioides* enter the bedding in two ways: through feed and in untreated straw. The concentration of *Fusarium sporotrichioides* increased by 132.0% on the fourteenth day, 150.76% on the twenty-first day, 258.68% on the twenty-eighth day, 491.46% on the thirty-fifth day, and 711.51% on the forty-second day. With a significant accumulation of microscopic fungi in the bedding, it becomes a hazardous source of spores that can infect poultry, leading to disease and mortality. The growth of *Aspergillus niger* colonies increased by 236.79% on the fourteenth day, 864.62% on the twenty-first day, 1,533.01% on the twenty-eighth day, 1,800% on the thirty-fifth day, and 2,174.52% on the forty-second day.

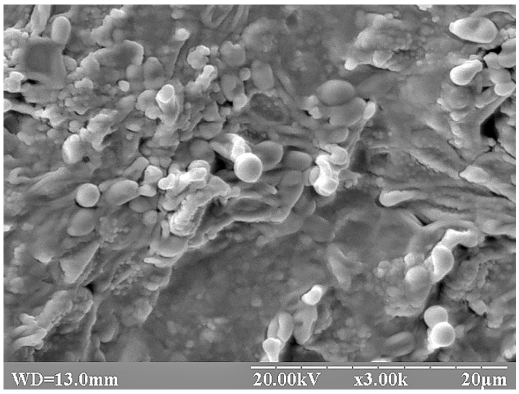

Figure 5. *Scanning electron microscope image of microscopic fungal colonies in a sample of straw bedding*
Source: *developed by the authors*

Infected birds release *Eimeria* oocysts into the bedding along with their faeces, which leads to the disease known as coccidiosis. On the fourteenth day, the number of *Eimeria* oocysts had increased by 98.30%, 268.64% on the twenty-first day, 442.37% on the twenty-eighth day, 606.77% on the thirty-fifth day, and by 933.89% on the forty-second day. In the control room with wood shavings bedding, the amount of *Escherichia coli* increased by 40.36% on the fourteenth day, 61.69% on the twenty-first day, 88.07% on the twenty-eighth day, 109.86% on the thirty-fifth day, and 132.56% on the forty-second day, compared to the start of the experiment (Fig. 6).

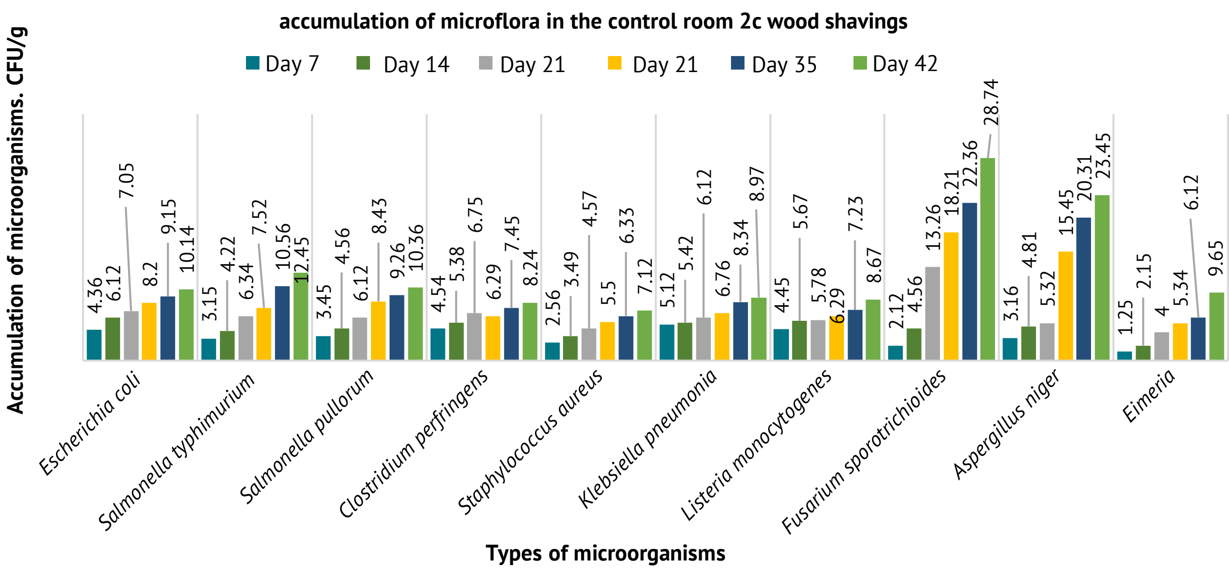

Figure 6. *Accumulation of microorganisms in the control room with wood shaving bedding*
Source: *developed by the authors*

In the second control room, the level of *Salmonella typhimurium* increased by 33.96% on the fourteenth day, 101.26% on the twenty-first day, 138.73% on the twenty-eighth day, 235.23% on the thirty-fifth day, and 295.23% on the forty-second day. The accumulation of *Salmonella pullorum* in the wood shavings bedding increased by 32.17% on the fourteenth day, 77.39% on the twenty-first day, 144.34% on the twenty-eighth day, 168.40% on the thirty-fifth day, and 200.28% on the forty-second day, compared to the seventh day. Thus, on the twenty-first day of the study, there was a rapid increase in the number of colonies of intestinal microflora (*E. coli* and *Salmonella*) in the wood shavings bedding.

The content of *Clostridium perfringens* increased by 18.50% on the fourteenth day of exposure, 48.67% on the twenty-first day, 38.54% on the twenty-eighth day, 64.09% on the thirty-fifth day, and 81.49% on the forty-second day. On the fourteenth day, *Staphylococcus aureus* had increased by 36.32%, 78.51% on the twenty-first day, 114.84% on the twenty-eighth day, 147.26% on the thirty-fifth day, and 178.12% on the forty-second day. Results indicated that colonies of *Klebsiella pneumoniae* and *Clostridium perfringens* constituted a relatively small percentage throughout the study period in the wood shavings bedding. On the fourteenth day of the experiment, the level of *Klebsiella pneumoniae* had increased by 5.85%, 19.53% on the twenty-first day, 32.03% on the twenty-eighth day, 62.89% on the thirty-fifth day, and 75.19% on the forty-second day. The content of *Listeria monocytogenes* increased by 27.41% on the fourteenth day, 29.88% on the twenty-first, 41.34% on the twenty-eighth, 62.47% on the thirty-fifth, and 94.83% on the forty-second. The growth of the microscopic fungus *Fusarium sporotrichioides* showed a tendency to increase by 115.09% on the fourteenth day, 525.47% on the twenty-first, 758.96% on the twenty-eighth, 954.71% on the thirty-fifth, and 1,355.66% on the forty-second. Even though wood shavings are a mixture of deciduous and coniferous wood species, which contain resins and essential oils, the number of microscopic fungi increased by a thousand per cent by the end of the experiment. The content of *Aspergillus niger* increased by 52.21% on the fourteenth day, 68.35% on the twenty-first, 388.92% on the twenty-eighth, 542.72% on the thirty-fifth, and 642.08% on the forty-second. The number of *Eimeria* oocysts in the wood shavings increased by 72.0% on the fourteenth day, 220.0% on the twenty-first, 327.2% on the twenty-eighth, 389.6% on the thirty-fifth, and 672.0% on the forty-second, compared to the initial values.

Despite heat treatment of the wood shavings before use as bedding, the number of bacteria, microscopic fungi, and coccidia oocysts was very high. The accumulation of microorganisms in granulated bedding in the third experimental room over a period of forty-two days was also determined (Fig. 7).

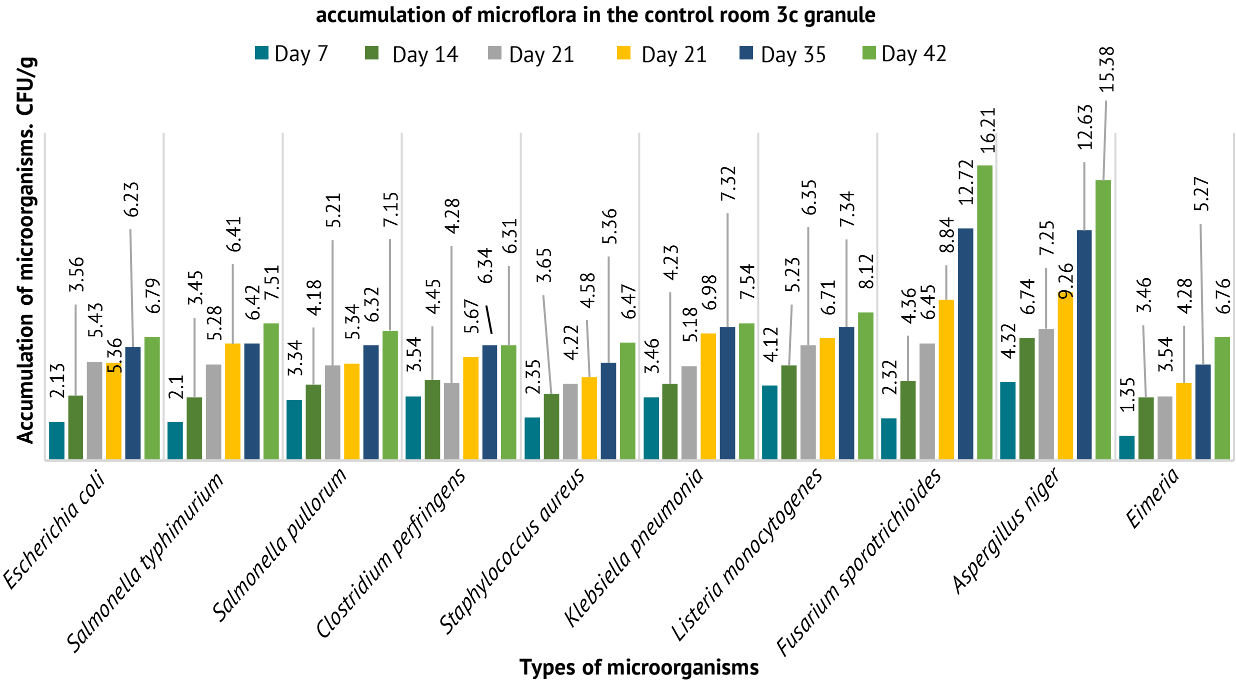

Figure 7*. Accumulation of microorganisms in the control room with granulated bedding*
Source: *developed by the authors*

By the fourteenth day of the experiment, the content of *Escherichia coli* had increased by 67.13%, 154.92% on the twenty-first, 151.64% on the twenty-eighth, 192.48% on the thirty-fifth, and 218.77% on the forty-second, compared to the beginning. The content of *Salmonella typhimurium* increased by 64.28% on the fourteenth day, 151.42% on the twenty-first, 205.23% on the twenty-eighth, 205.71% on the thirty-fifth, and 257.61% on the forty-second. At the same time, the number of *Salmonella pullorum* microbial cells in the granulated bedding increased by 25.14% on the fourteenth day, 55.98% on the twenty-first, 59.88% on the twenty-eighth, 89.22% on the thirty-fifth, and 114.07% on the forty-second. At the end of the experiment, the content of intestinal bacteria in the granulated bedding was lower compared to straw and wood shavings.

By the fourteenth day of exposure, the content of *Clostridium perfringens* increased by 25.70%, 20.90% on the twenty-first, 60.16% on the twenty-eighth, 79.09% on the thirty-fifth, and 78.24% on the forty-second. The content of *Staphylococcus aureus* increased by 55.31% on the fourteenth day, 79.57% on the twenty-first, 94.89% on the twenty-eighth, 128.08% on the thirty-fifth, and 175.31% on the forty-second. The accumulation of *Klebsiella pneumoniae* occurred by 22.25% on the fourteenth day, 54.1271% on the twenty-first, 101.73% on the twenty-eighth, 111.56% on the thirty-fifth, and 117.91% on the forty-second.

In the third experimental room, the content of *Listeria monocytogenes* increased by 26.94% on the fourteenth day, 54.12% on the twenty-first, 62.86% on the twenty-eighth, 78.15% on the thirty-fifth, and 97.08% on the forty-second. The growth of microscopic fungi in the granulated bedding was lower compared to straw and wood shavings throughout the experiment. The quantity of *Fusarium sporotrichioides* increased by 87.93% on the fourteenth day, 178.01% on the twenty-first, 281.03% on the twenty-eighth, 448.27% on the thirty-fifth, and 598.7% on the forty-second. The content of *Aspergillus niger* increased by 56.01% on the fourteenth day, 67.82% on the twenty-first, 114.35% on the twenty-eighth, 192.36% on the thirty-fifth, and 256.01% on the forty-second.

The quantity of *Eimeria* oocysts in the granulated bedding increased by 156.29% on the fourteenth day, 162.22% on the twenty-first, 217.03% on the twenty-eighth, 290.37% on the thirty-fifth, and 400.74% on the forty-second compared to the beginning of the study. A similar room with straw bedding but with the addition of a dry disinfectant was studied for the content of microorganisms over a period of forty-two days (Fig. 8).

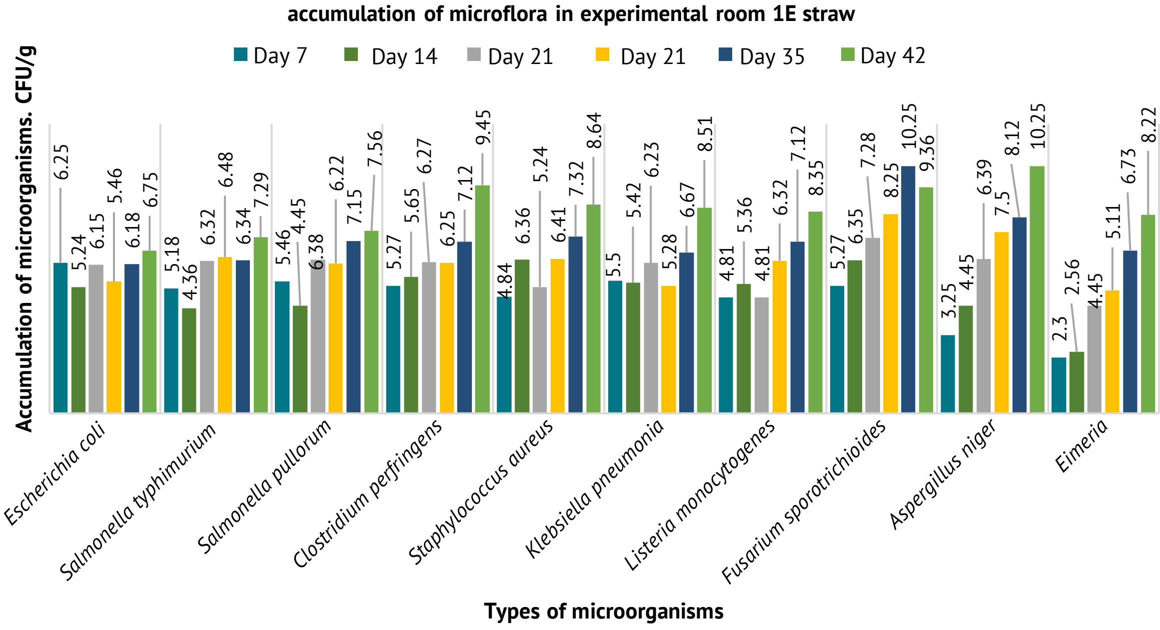

***Figure 8**. Accumulation of microorganisms in the experimental room with straw bedding*
***Source:** developed by the authors*

By the fourteenth day of the experiment, the content of *Escherichia coli* decreased by 16.16%, 1.6% on the twenty-firs, 12.64% on the twenty-eighth, 1.12% on the thirty-fifth, and increased by 8.0% on the forty-second compared to the beginning. However, the level of accumulation of *E. coli* in the control room with straw bedding was 146.88%. The quantity of *Salmonella typhimurium* decreased by 15.83% on the fourteenth day, increased by 22.00% on the twenty-first, 25.09% on the twenty-eighth, 22.39% on the thirty-fifth, and 40.73% on the forty-second (versus 239.92% in the control). Similarly, the content of *Salmonella pullorum* decreased by 18.49% on the fourteenth day, increased by 16.84% on the twenty-first, 13.91% on the twenty-eighth, 30.95% on the thirty-fifth, and 38.46% on the forty-second. For comparison, in the first control room, the content of *Salmonella pullorum* increased by 225.48% at the end of the experiment.

By the fourteenth day of the experiment, the content of *Clostridium perfringens* increased by 7.21%, 18.97% on the twenty-first, 18.59% on the twenty-eighth, 35.10% on the thirty-fifth, and 79.31% on the forty-second (compared to 266.60% in the control). The content of *Staphylococcus aureus* increased by 31.40% on the fourteenth day, 8.26% on the twenty-first, 32.43% on the twenty-eighth, 32.43% on the thirty-fifth, and 78.51% on the forty-second (compared to 191.32% in 1C). The level of *Klebsiella pneumoniae* decreased by 1.45% on the fourteenth day and 4.0% on the twenty-eighth, increased by 13.27% on the twenty-first, 21.27% on the thirty-fifth, and 54.72% on the forty-second (compared to 121.75% in 1C). By the fourteenth day, the content of *Listeria monocytogenes* increased by 11.43%, but returned to the initial values by the twenty-first day, however, on the twenty-eighth it increased again by 19.92%, 35.10% on the thirty-fifth, and 73.59% on the forty-second (as opposed to 85.94% in the control).

The growth of the microscopic fungus *Fusarium sporotrichioides* increased by 20.49% on the fourteenth day, 38.14% on the twenty-first, 56.54% on the twenty-eighth, 94.49% on the thirty-fifth, and 77.60% on the forty-second, compared to 711.51% in the control. The content of *Aspergillus niger* increased by 36.92% on the fourteenth day, 96.61% on the twenty-first, 130.76% on the twenty-eighth, 149.84% on the thirty-fifth, and 215.38% on the forty-second (versus 2,174.52% in 1C). The addition of a dry disinfectant to the bedding also affected the reduction in the number of oocysts in the straw bedding. The content of *Eimeria* oocysts increased by 11.30% on the fourteenth day, 93.47% on the twenty-first, 122.17% on the twenty-eighth, 192.60% on the thirty-fifth, and 257.39% on the forty-second, compared to 933.89% in the control. The microflora in the second experimental room with wood shavings bedding and the addition of an experimental dry powdered disinfectant was monitored (Fig. 9).

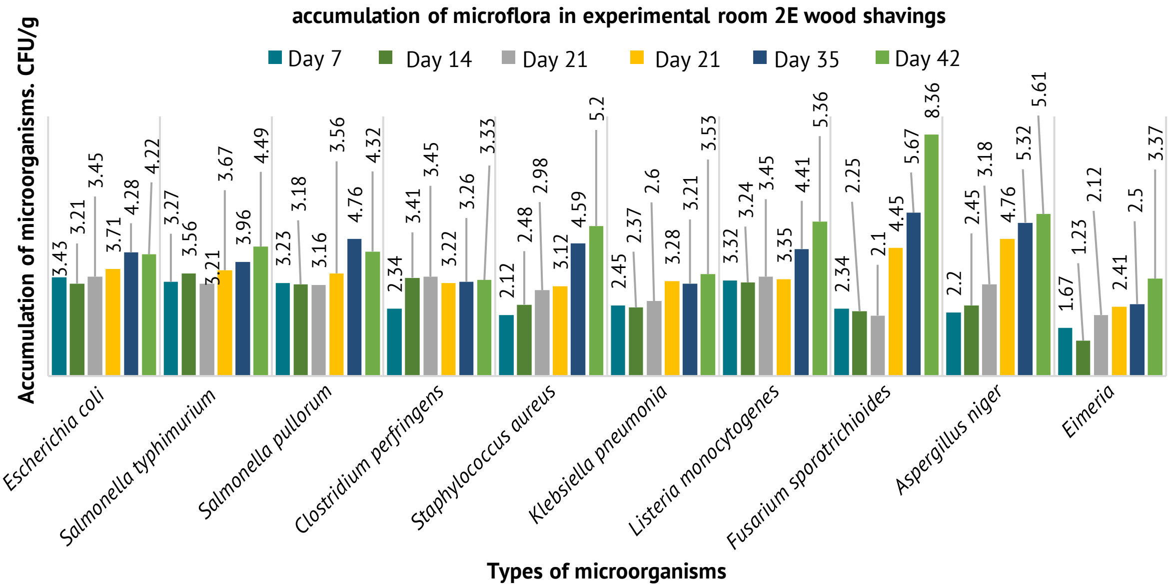

Figure 9*. Accumulation of microorganisms in the experimental room with wood shavings bedding*
Source: *developed by the authors*

By the fourteenth day, the content of *Escherichia coli* decreased by 6.41%, returned to the initial values on the twenty-first, increased by 8.16% on the twenty-eighth, 24.78% on the thirty-fifth, and 23.03% on the forty-second (compared to 132.56% in 2C). In the second experimental room, the content of *Salmonella typhimurium* increased by 8.86% on the fourteenth day, decreased by 1.83% on the twenty-first, and increased by 12.23% on the twenty-eighth, 21.10% on the thirty-fifth, and 37.30% on the forty-second, compared to 295.23% in the second control. The content of *Salmonella pullorum* remained at the same level on the fourteenth, twenty-first, and twenty-eighth days, increased by 47.36% on the thirty-fifth, and 33.74% on the forty-second, compared to 200.28% in 2C.

The results obtained show that the levels of *E. coli* and *Salmonella* decreased when a dry disinfectant was added to the wood shavings bedding. The level of *Clostridium perfringens* gradually increased by 45.72% on the fourteenth day, 47.43% on the twenty-first, 37.60% on the twenty-eighth, 39.31% on the thirty-fifth, and 42.30% on the forty-second, compared to 81.49%. The content of *Staphylococcus aureus* increased by 16.98% on the fourteenth day, 40.56% on the twenty-first, 47.16% on the twenty-eighth, 116.50% on the thirty-fifth, and 145.28% on the forty-second, compared to 178.12% in the second control. By the fourteenth day of the experiment, the content of *Klebsiella pneumoniae* decreased by 3.26%, increased by 6.12% on the twenty-first, 33.87% on the twenty-eighth, 31.02% on the thirty-fifth, and 44.08% on the forty-second (versus 75.19% in 2C). By the fourteenth day, the accumulation of *Listeria monocytogenes* decreased by 2.40%, increased by 3.91% on the twenty-first, 0.90% on the twenty-eighth, 32.83% on the thirty-fifth, and 61.44% on the forty-second, compared to 94.83% in 2C. When using a disinfectant, the content of *Fusarium sporotrichioides* decreased by 3.84% on the fourteenth day, 10.25% on the twenty-first, increased by 90.17% on the twenty-eighth, 142.30% on the thirty-fifth, and 257.26% on the forty-second, compared to 1,355.66% in the second control. The quantity of *Aspergillus niger* gradually increased by 11.36% on the fourteenth day, 44.54% on the twenty-first, 116.36% on the twenty-eighth, 49.06% on the thirty-fifth, and 155.00% on the forty-second (versus 642.08% in the control).

The content of *Eimeria* oocysts in the wood shavings bedding decreased by 26.34% on the fourteenth day, increased by 26.94% on the twenty-first, 44.31% on the twenty-eighth, 49.70% on the thirty-fifth, and 101.79% on the forty-second, compared to 672.0% in the second control. The use of a dry disinfectant in the bedding reduced the level of *Eimeria* oocysts in the wood shavings bedding. In the third experimental room with granulated bedding and the addition of a disinfectant, the content of *Escherichia coli* decreased by 2.24% on the fourteenth day, increased by 7.17% on the twenty-first, 14.79% on the twenty-eighth, 39.91% on the thirty-fifth, and 43.94% on the forty-second (compared to 218.77% in 3C) (Fig. 10).

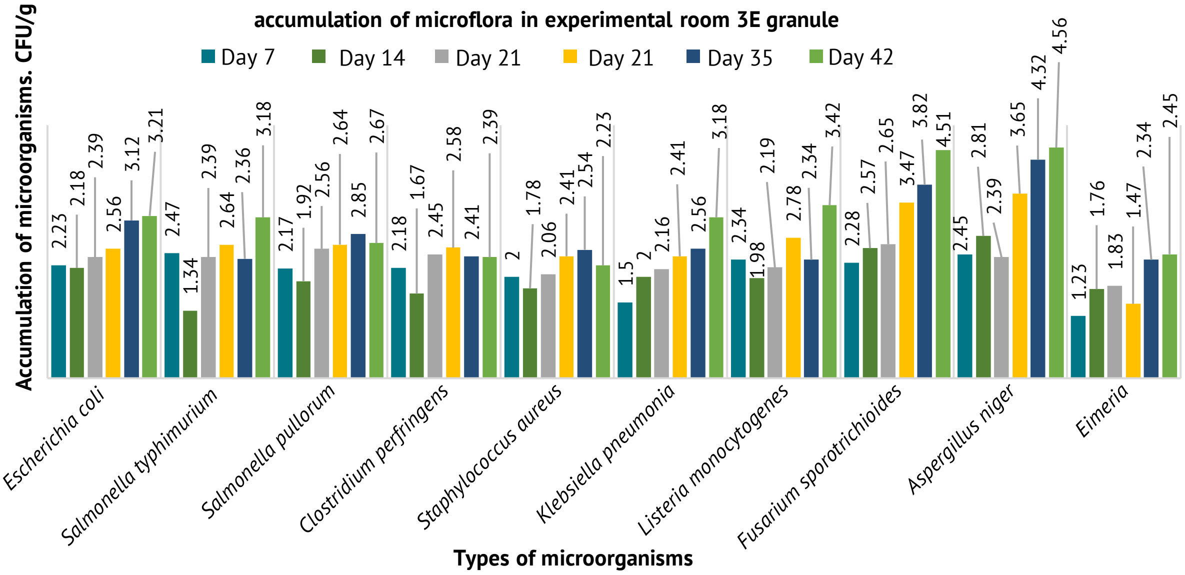

Figure 9*. Accumulation of microorganisms in the experimental room with wood shavings bedding*
Source: *developed by the authors*

The content of *Salmonella typhimurium* decreased by 45.74% on the fourteenth day, 3.23% on the twenty-first, and 4.45% on the thirty-fifth, but increased by 6.88% on the twenty-eighth and 28.74% on the forty-second, compared to 257.61% in the control. The quantity of Salmonella pullorum decreased by 11.52% on the fourteenth day but increased by 17.97% on the twenty-first, 21.65% on the twenty-eighth, 31.33% on the thirty-fifth, and 19.81% on the forty-second, compared to 114.07% in the control. The content of *Clostridium perfringens* increased by 23.39% after fourteen days of exposure, 12.38% on the twenty-first, 18.34% on the twenty-eighth, 10.55% on the thirty-fifth, and 9.63% on the forty-second (versus 78.24% in 3C). A decrease in *Staphylococcus aureus* was observed on the fourteenth day by 11.00%, but it increased by 3.00% on the twenty-first, 29.00% on the twenty-eighth, 20.5% on the thirty-fifth, and 11.5% on the forty-second, compared to 175.31% in the third control room.

Accumulation of *Klebsiella pneumoniae* increased by 33.33% on the fourteenth day, 44.00% on the twenty-first, 60.67% on the twenty-eighth, 70.66% on the thirty-fifth, and 112.00% on the forty-second, compared to 117.91% in the granule control. The content of *Listeria monocytogenes* decreased by 15.38% on the fourteenth day and 6.41% on the twenty-first, but increased by 18.80% on the twenty-eighth, returned to initial values on the thirty-fifth, and increased by 46.15% on the forty-second, versus 97.08% in the control. The quantity of *Fusarium sporotrichioides* increased by 12.71% on the fourteenth day, 16.22% on the twenty-first, 52.19% on the twenty-eighth, 67.54% on the thirty-fifth, and 97.80% on the forty-second, compared to 598.7% in the third control. The content of *Aspergillus niger* decreased by 2.44% on the twenty-first day, but increased by 14.69% on the fourteenth, 48.97% on the twenty-eighth, 76.32% on the thirty-fifth, and 86.12% on the forty-second, compared to 256.01% in the control. The quantity of *Eimeria* oocysts in granulated bedding with the added dry disinfectant increased by 43.08% on the fourteenth day, 48.78% on the twenty-first, 19.51% on the twenty-eighth, 90.24% on the thirty-fifth, and 99.18% on the forty-second (versus 400.74% in the control). The results of this experiment demonstrate that the application of a dry powdered disinfectant contributes to a reduction in the number of microorganisms in straw, wood shavings, and granulated bedding.

The research found that the hygroscopic properties of straw bedding deteriorated from the seventh to the forty-second day, reaching 269.90%. In the experimental room where a dry disinfectant was added to the straw bedding, the hygroscopicity at the end of the experiment was 86.70%, a difference of 183.2%. Wood shavings bedding with the addition of a disinfectant exhibited a water absorption capacity of 102.82% more on the forty-second day compared to the control. Granulated bedding with a disinfectant retained moisture 150.33% better compared to the control. The obtained results of the water absorption capacity of the bedding materials coincide with the findings of P. Gerber *et al.* (2020).

Research by A. Gutierrez and K. Schneider (2022) demonstrates that prolonged use of wet bedding leads to avian diseases such as contact dermatitis, intestinal infections, and reduced feed conversion. It was established that the addition of a dry powdered disinfectant inhibited the increase in bedding pH. At the end of the experiment, the pH levels in straw bedding were 8.13 in the control group compared to 7.56 in the experimental group; in wood shavings, 7.95 versus 7.16; and in granules, 7.35 versus 6.35. The results obtained show low pH levels for all bedding types at the beginning of the study and an increase at the end. The optimal pH range for bacterial growth is 6-8. Without the use of a disinfectant, the growth and multiplication of microorganisms in the bedding under favourable conditions of high humidity and neutral pH will increase. Similar results were obtained in studies by M.J. Rothrock *et al.* (2017) with rye straw bedding for poultry.

The contamination of straw bedding with *Escherichia coli* at the end of the experiment was reduced by 138.88% in the experimental group, *Salmonella typhimurium* by 199.19%, *Salmonella pullorum* by 187.02%, *Clostridium perfringens* by 187.29%, *Staphylococcus aureus* by 112.81% #, *Klebsiella pneumoniae* by 67.03%, *Listeria monocytogenes* by 12.35%, *Fusarium sporotrichioides* by 633.91%, *Aspergillus niger* by 1,959.14%, and *Eimeria* by 676.50% due to the use of a disinfectant. The obtained results coincide with the data of D. Milanov *et al.* (2019)when studying the accumulation of microflora in poultry manure and bedding.

On the forty-second day of the experiment, the levels of *Escherichia coli* in wood shavings bedding were reduced by 109.53% in the disinfectant-treated group, *Salmonella typhimurium* by 257.93%, *Salmonella pullorum* by 166.54%, *Clostridium perfringens* by 39.19%, *Staphylococcus aureus* by 32.84%, *Klebsiella pneumoniae* by 31.11%, *Listeria monocytogenes* by 33.39%, *Fusarium sporotrichioides* by 1098.4%, *Aspergillus niger* by 487.08%, and *Eimeria* by 570.21%. The trend of microbial accumulation, shown in the research of S. Winkler *et al.* (2017), coincides with the data obtained in this study. In all types of bedding, the majority of bacteria consisted of *E. coli* and *Salmonella* (Bindari *et al.,* 2021). The conducted studies have proven the rapid accumulation of microscopic fungi in the bedding. As established by researchers Y. Wang *et al.* (2020), fungi of the genus *Fusarium* affect cereal crops and cause toxicosis in animals and humans. Studies by J. Chu *et al.* (2017) have shown that microscopic fungi of the genus *Aspergillus* lead to severe pneumonia in poultry. The accumulation of *Escherichia coli* in granulated bedding was reduced by 174.83% in the disinfectant-treated group at the end of the experiment, *Salmonella typhimurium* by 228.87%, *Salmonella pullorum* was 94.26% lower, *Clostridium perfringens* was 68.61% lower, *Staphylococcus aureus* by 163.81%, *Klebsiella pneumoniae* by 5.91%, *Listeria monocytogenes* by 50.93%, *Fusarium sporotrichioides* by 500.9%, *Aspergillus niger* by 169.89%, and *Eimeria* by 301.56%.

In the experiment conducted by C. Mesa *et al.* (2021), bedding samples were analysed to determine the level of contamination with *Eimeria* oocysts on broiler farms. The studies revealed a significant concentration of *Eimeria* oocysts in various types of bedding, despite the use of coccidiostats in poultry. As a result of the experiment, the physical properties of different types of poultry bedding and the spectrum and trend of microbial accumulation were determined. Additionally, the effectiveness of using a dry powdered disinfectant to kill microorganisms and *Eimeria* oocysts was proven.

CONCLUSIONS

It was found that the addition of dry powdered disinfectant improved the hygroscopic properties of straw bedding by 183.2%, wood shavings by 102.82%, and granules by 150.33%. At the end of the experiment, the pH levels in straw bedding were 8.13 in the control group compared to 7.56 in the treated group; in wood shavings, 7.95 versus 7.16; and in granules, 7.35 versus 6.35, due to the use of the disinfectant. Additionally, by the end of the experiment, the levels of *Escherichia coli* in straw bedding were reduced by 138.88% with disinfectant use, *Salmonella typhimurium* by 199.19%, *Salmonella pullorum* by 187.02%, *Clostridium perfringens* by 187.29%, *Staphylococcus aureus* by 112.81%, *Klebsiella pneumoniae* by 67.03%, *Listeria monocytogenes* by 12.35%, *Fusarium sporotrichioides* by 633.91%, *Aspergillus niger* by 1959.14%, and *Eimeria* by 676.50%.

In the wood shavings bedding, the content of *Escherichia coli* was reduced by 109.53% in the experimental group with disinfectant, *Salmonella typhimurium* by 257.93%, *Salmonella pullorum* by 166.54%, *Clostridium perfringens* by 39.19%, *Staphylococcus aureus* by 32.84%, *Klebsiella pneumoniae* by 31.11%, *Listeria monocytogenes* by 33.39%, *Fusarium sporotrichioides* by 1,098.4%, *Aspergillus niger* by 487.08%, and *Eimeria* by 570.21%. The study also showed that the concentration of *Escherichia coli* in granulated bedding at the end of the experiment was lower by 174.83%, *Salmonella typhimurium* by 228.87%, *Salmonella pullorum* by 94.26%, *Clostridium perfringens* by 68.61%, *Staphylococcus aureus* by 163.81%, *Klebsiella pneumoniae* by 5.91%, *Listeria monocytogenes* by 50.93%, *Fusarium sporotrichioides* by 500.9%, *Aspergillus niger* by 169.89%, and *Eimeria* by 301.56%. Future research should focus on determining the quality of bedding for poultry rearing under production conditions.

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significant bacterial diseases of animals on the basis of use of innovative technologies".

CONFLICT OF INTEREST

None.

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Особливості вирощування птиці підлоговим способом на глибокій підстилці

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Анотація. При утриманні птиці на глибокій підстилці в ній розвиваються мікроорганізми, які є збудниками інфекційних захворювань. Метою дослідження було визначити фізичні властивості та здатність накопичення мікроорганізмів у різних типах підстилки. Використані методи: термопрограмована мас-спектрометрія; мікробіологічний метод; сканувальна електронна мікроскопія. Гігроскопічні властивості солом'яної підстилки погіршувались з сьомої до сорок другої доби на 269,90 %. У дослідному приміщенні, де до солом'яної підстилки додавали сухий дезінфектант гігроскопічність складала на момент завершення експерименту 86,70 % , різниця – 183,2 %. Підстилка стружка за додавання дезінфектанту проявляла водопоглинаючу здатність на сорок другу добу на 102,82 % більше ніж у контролі. Гранульована підстилка з дезінфектантом втримувала вологу на 150,33 % краще, порівняно з контролем. На момент завершення дослідження pH солом'яної підстилки складала у контролі 8,13 проти 7,56 у досліді; стружка – 7,95 проти 7,16; гранула – 7,35 проти 6,35, за рахунок застосування дезінфектанту. Підстилка гранула на період завершення експерименту мала найнижчий показник pH, порівняно з соломою та тирсою, що вплинуло на ріст та розмноження мікроорганізмів. При проведенні моніторингу мікроорганізмів в підстилці були виділені бактерії: *Escherichia coli*, *Salmonella typhimurium, Salmonella pullorum, Clostridium perfringens, Staphylococcus aureus, Klebsiella pneumonia, Listeria monocytogenes,* мікроскопічні гриби: *Fusarium sporotrichioides,Aspergillus niger* та ооцисти *Eimeria*. За використання дезінфектанту ураження солом'яної підстилки бактеріями зменшилось на 12,35-199,19 %, мікроскопічними грибами на 633,91-1959,14 %, *Eimeria* – на 676,50 %. Контамінація підстилки стружка у досліді була менше бактеріями на 32,84-257,93 %, мікроскопічними грибами на 487,08-1098,4 %, *Eimeria* – на 570,21 %. Накопичення у підстилці гранула бактерій було менше на 50,93-228,87 %, мікроскопічних грибів на 169,89-500,9 %, *Eimeria* – на 301,56 %. Практичною цінністю роботи є покращення фізичних властивостей підстилки для птиці та зниження накопичення в ній бактерій, мікроскопічних грибів та ооцист *Eimeria*

Ключові слова: гігроскопічні властивості; pH підстилки; бактерії; мікроскопічні гриби; *Eimeria*