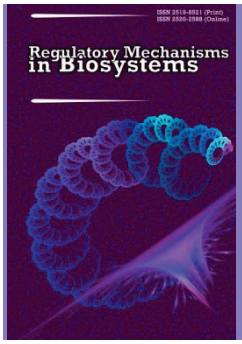


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# Zoonotic and commensal bacteria from pigs with acquired antimicrobial resistance

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The growing prevalence of foodborne zoonotic infections increases the risk of emergence of microorganisms with acquired resistance to antimicrobial drugs. Such microorganisms are capable of horizontal transmission of R-plasmids of antibiotic resistance to other types of bacteria. The results of our monitoring in 2021, in accordance with the State Strategy of Ukraine to curb the development of antimicrobial resistance and reduce the risks of the formation and spread of antimicrobial-resistant strains of microorganisms, showed high resistance of enterobacteria, enterococci and *Campylobacter* isolated from pigs to antibiotics of various groups. Among the isolated cultures of *Escherichia coli*, the ability of some strains to produce extended-spectrum β-lactamases (ESBL) was found. Testing of the experimental isolates for antibiotic resistance and screening for possible production of acquired resistance enzymes was carried out by the disc diffusion method with antibiotic disks of different groups. Out of 542 samples of appendix from pigs from farms in different regions of Ukraine, 138 isolates were isolated and identified. Among them: *Escherichia coli* – 68 strains; *Enterococcus faecalis* – 57; *Enterococcus faecium* – 9; *Salmonella* spp. – 2 and *Campylobacter* spp. – 2. Antibiotic resistance testing showed that 10 (7.3% of the isolates) of different bacterial species remained susceptibile to all antibiotics used. The remaining 128 test isolates (93.5% of the isolates) showed antibiotic resistance. The largest number of antibiotic-resistant commensal and zoonotic bacteria was detected in pig farms of Donetsk, Kyiv, Dnipro, Kirovohrad and Chernihiv regions. *Escherichia coli* and *Enterococcus* spp. were most often isolated from pigs; in smaller quantities *Salmonella* spp. and *Campylobacter* spp. All strains of *Salmonella* spp. faecium showed resistance to 1 to 3 antibiotics of different groups. Among the antibiotic-resistant *E. faecalis*, 1 strain with resistance to vancomycin was detected. Polyantibiotic resistance was inherent in *E. coli* strains. Among the polyantibiotic-resistant *E. coli* strains, 4 strains were found and confirmed to have acquired resistance due to the production of ESBL.

*Keywords*: commensal bacteria; *Escherichia coli*; *Salmonella* spp.; *Enterococcus faecalis*; *Enterococcus faecium*; *Campylobacter* spp.

## Introduction

In the process of Ukraine's integration into the international community, the main task of the agricultural sector is to increase the production of livestock products. Livestock production plays a key role in the stability of the country's food security. In Ukraine, the main component of livestock production is pig production (Stepasiuk, 2019). The current state of pig production, according to scientists and producers, is characterized by optimization of production costs by unlocking the biological potential of animals and resource-saving technologies for the production of high-quality and safe raw materials and livestock products (Voloshchuk, 2014; Bankovska et al., 2016; Hnatyshyn, 2019; Samoilyk et al., 2021; Susharnyk, 2021).

At the present stage of development, Ukraine's livestock industry faces a number of problems. One of these problems is the increase in the spread of foodborne zoonotic toxicoinfections. It is known that the number of such diseases is growing in all EU Member States. The infection is transmitted to humans through direct contact with animals and humans, drinking water or products of animal origin. Most often, infections with foodborne toxicoinfections occur during pig rearing, slaughter, carcass processing, non-compliance with sanitary and hygienic standards and violations of animal products' manufacturing technology. In most EU Member States, the prevalence of enteropathogenic strains of *Escherichia coli*, pathogens of the genera *Salmonella* spp., *Enterococcus* spp. and *Campylobacter* spp. is defined as high and very high. These pathogens represent a large proportion of other infections of bacterial etiology in pigs (Polishko et al., 2011). An additional problem is the development of antimicrobial drug resistance in such bacteria. Polyantibiotic resistance of bacteria and the emergence of strains with acquired resistance to antibiotics is a problem of global importance. It poses serious threats to humanity. Microorganisms with acquired resistance to antibiotics are able to transmit it to other types of bacteria through direct transmission of R-plasmids.

The World Health Organization (WHO, 2017) states that antimicrobial resistance can significantly reduce global health, hinder sustainable development, and negatively affect the global well-being of humanity as a whole (Salmanov, 2017; Skliar et al., 2018; Harkavenko et al., 2020; Obe et al., 2023).

In accordance with the provisions of the World Health Organization (WHO) Global Strategy to Contain Antimicrobial Resistance, the State Strategy of Ukraine on the implementation of the state policy to contain the development of antimicrobial resistance and reduce the risks of the formation and spread of antibiotic-resistant strains in livestock was introduced. For this purpose, within the framework of the State Strategy of Ukraine, active monitoring of antimicrobial resistance of zoonotic and commensal bacteria in veterinary medicine is carried out, which includes monitoring of enterobacteria with acquired extended-spectrum beta-lactamases (ESBL), AmpC-beta-lactamases, carbapenemases (OXA-48 and OXA-48-like enzymes) that can produce antibiotic-resistant isolates of *E. coli* and *Salmonella* spp. Recently, there has been a tendency to increase in the number of antibiotic-resistant strains of microorganisms isolated from animals and animal products (Pokas et al., 2013; Dwornic-

zek et al., 2014; Rhouma et al., 2016; Vranic et al., 2016). It is known that the mechanisms of resistance of enterobacteria to beta-lactam antibiotics are based on the acquisition of genes responsible for the production of β-lactamases, which are able to destroy the β-lactam ring of the antibiotic. According to scientists, β-lactamases produced by antibiotic-resistant commensal and zoonotic microorganisms are the main factor of resistance to many or all beta-lactam AMPs. Antibiotic-resistant Gram-negative bacteria, due to their synthesis of β-lactamases, quickly adapt to the selective pressure of antibiotics (Salmanov et al., 2017; Garza-Ramos et al., 2018; Laws et al., 2019; Romaniuk et al., 2019). According to scientists from the European Union Member States and our scientists, there is a tendency to increase in the number of antibiotic-resistant pathogens among bacteria of the genera *Enterococcus* spp. and *Campylobacter* spp. These pathogens are of great epidemiological importance among zoonotic diseases. It is known that zoonotic microorganisms are widespread in nature, present in the organism of humans, animals and poultry. They are capable of long-term persistence in the environment under unfavorable conditions. Therefore, scientists emphasize that their role in modern infectious pathology of animals and humans is rapidly increasing (Zhang et al., 2015; Buckel et al., 2018; Zazharskyi et al., 2019, 2020; Fanelli et al., 2020).

## Material and methods

*Compliance with bioethical requirements.* The pigs were slaughtered by qualified slaughterhouse operators in compliance with the requirements for stunning and bleeding animals in accordance with Council Directive 93/119/EC of December 22, 1993 on the protection of animals at the time of slaughter or killing; Council Directive 98/58/EC of July 20, 1998 on the protection of animals kept for agricultural purposes, the Decision of the first scientific congress on bioethics (Kyiv, 2001) and in compliance with the biotic requirements for animals in accordance with the Law of Ukraine "On Animal Protection of Animals from Cruelty". The sampling of pathological material was carried out by specialists familiar with the rules of sampling pathological and biological material from animals, its packaging, labeling and delivery to the laboratory within the appropriate time frame.

*Place of research.* The research was conducted at the State Scientific Research Institute for Laboratory Diagnostics and Veterinary and Sanitary Expertise in 2021 in accordance with the Procedure for Active Monitoring of Antimicrobial Resistance of Zoonotic and Commensal Bacteria and the State Strategy of Ukraine.

*Monitoring microbiological studies.* The study of 542 samples of appendix with the content according to the State Monitoring Plan for Antimicrobial Resistance in Veterinary Medicine was conducted. The test samples of appendix were collected after slaughter of pigs from pig farms in different regions of Ukraine. 138 isolates of pathogenic bacteria were isolated. Among them: *Esherichia coli* isolates – 68 strains; *Enterococcus faecalis* – 57; *Enterococcus faecium* – 9; *Salmonella* spp. – 2 and *Campylobacter* spp. To identify pathogens, the primary material was cultured on liquid selective media for accumulation. Next, the material was recultured onto solid differential diagnostic media. Individual characteristic colonies were selected and cultures were identified using diagnostic tests. All studies were performed by standardized methods in accordance with current regulations (IDT: DSTU ISO 10272-1: 2007 "Microbiology of food products and feedstuffs. Horizontal method of detection and treatment of *Campylobacter* spp. Part 1."; DSTU 4769:2007 "Bacteriological determination of pathological material from food. Methods of detection of *Salmonella*"; Committee on Antimicrobial Susceptibility Testing. Breakpoint tables for interpretation of MICs and zone diameters. Tables v. 12.0, http://www.eucast.org / The European Committee on Antimicrobial Susceptibility Testing. Breakpoint tables for interpretation of MICs and zone diameters. Version 12.0, 2022).

*Media used.* For the study, media and diagnostic tests manufactured by HiMedia (India) were used. All media and diagnostic tests were previously tested for performance, selectivity, specificity and had satisfactory results. The growth properties of the media were tested using test cultures from the ATCC collection. Studies to determine the susceptibility of the experimental isolates were performed on Mueller-Hinton agar (MH).

*Research methods.* The study of antibiotic resistance was carried out by the disc diffusion method. Identified bacterial strains were tested for susceptibility to antibiotics of the first panel. Bacterial strains resistant to cefotaxime, ceftazidime or meropenem were selected. With the selected strains, a disc diffusion method was used to screen for the production of acquired resistance enzymes with antibiotics of the second panel to detect the production of extended-spectrum beta-lactamases (ESBL), class C beta-lactamases (AmpC enzymes), carbapenemases (OXA-48 and OXA-48-like enzymes) (Harkavenko et al., 2021).

*Testing bacterial suspensions.* Daily bacterial suspensions were prepared using the suspension method. The daily colonies of the studied strains of *E. coli*, *Salmonella* spp., *Enterococcus faecium*, *Enterococcus faecalis*, *Campylobacter* spp. were resuspended in sterile physiological solution to an optical density of 0.5 McFarland optical units (OU). The prepared bacterial suspensions were thoroughly homogenized, inoculated with 0.5 $cm^3$ of the suspension of the corresponding bacterial strain on the surface of MX agar, rubbed thoroughly and placed disks containing the corresponding antibiotics. Incubated in a thermostat at 37 °C for 18–22 h.

*Antibiotics used.* Antibiotic disks manufactured by HiMedia (India) were used: ampicillin (10 μg), amikacin (30 μg), azithromycin (15 μg), chloramphenicol (30 μg), ciprofloxacin (5 μg), meropenem (10 μg), gentamicin (10 μg), nalidixic acid (20 μg), sulfamethoxazole (25 μg), tetracycline (30 μg), trimethoprim (5 μg), tigecycline (15 μg), ceftazidime (10 μg), erythromycin (15 μg), vancomycin (5 μg), teicoplanin (30 μg), linezolid (10 μg).

*Test cultures used.* The test culture of *Escherichia coli* ATCC 25922 was used for quality control of disks containing antibiotics. Test cultures of *Enterococcus* species were used as positive controls with *Enterococcus faecalis* ATCC 51299 and *Enterococcus faecium* NCTC 12202, resistant to vancomycin, for quality control of antibiotic disks. The test culture of *Enterococcus faecalis* ATCC 29212, which is susceptibile to vancomycin, was used as a negative control for assessing the quality of antibiotic disks.

## Results

Isolates from pigs were isolated and the following species composition determined: *Esherichia coli* (12.6% of all bacterial species isolated), *Enterococcus faecalis* (10.5%), *E. faecium* (1.6%), *Salmonella* spp. (0.4%), *Campylobacter* spp. (0.4%), respectively. The total proportion of isolates of commensal and zoonotic bacteria *Escherichia* and *Salmonella* was about 13.0%, respectively. The number of isolated enterococci – *Enterococcus faecalis* and *E. faecium* – represented 12.1% of the total number of isolated bacteria. 0.4% of isolates were *Campylobacter* spp. (Table 1). When testing for resistance to AMD among isolated 68 cultures of commensal *E. coli*, susceptibility to all antibiotic groups used was detected in 3 cases, which is 4.4%. Resistance to 2–3 antibiotics was detected in 10 (14.7%) strains of the studied *Escherichia*. Such strains of *E. coli* most often showed resistance to the antibiotics group fluoroquinolones, tetracyclines and penicillins. Multi-antibiotic resistance to penicillins, macrolides, cephalosporins, fluoroquinolones, tetracyclines, chloramphenicols was detected in 55 cases, which is 80.9% of the tested *E. coli* strains. Among the studied commensal *Escherichia*, resistance to ceftazidime, cefotaxime or meropenem was detected in 7 (10.3%) strains. According to the screening results, among 7 strains of *E. coli*, 4 cases revealed the production of acquired resistance enzymes – extended-spectrum beta-lactamases (ESBL) to third-generation cephalosporins. ESBL production was confirmed by positive testing with the indicator antibiotics cephalosporin ceftazidime. It was found that these strains circulate in pig farms in Odeska (1 strain detected) and Chernivetska (3 strains detected) regions of Ukraine (Table 2).

In addition to the commensal *E. coli*, 2 strains of zoonotic pathogens of the genus *Salmonella* resistant to antibiotics from the groups of tetracyclines – tetracycline, fluoroquinolones – nalidixic acid and a group of various drugs – chloramphenicol, were detected among enterobacteria.

It was found that among the 57 studied cultures of *Enterococcus faecalis*, susceptibility to all antibiotics used was detected in 7 cases (12.3% of the detected enterococci). The rest of the tested strains – 87.7% of *E. faecalis* showed resistance to 1 to 4 antibacterial drugs in different variations. In one of the pig farms in Donetsk region, 1 vancomycin-resistant strain of *E. faecalis* was found (Table 3).

**Table 1**
Results of bacteriological studies of samples of appendix taken from pigs from pig farms in Ukraine during active monitoring in 2021 (N = 542)

| Region | Samples tested | Positive samples | *E. coli* | *E. faecalis* | *E. faecium* | *Salmonella* spp. | *Campylobacter* spp. |
|---|---|---|---|---|---|---|---|
| Vinnytska | 155 | 8 | 5 | 3 | – | – | – |
| Volynska | 18 | 8 | 4 | 4 | – | – | – |
| Dnipropetrovska | 22 | 7 | 2 | 5 | – | – | – |
| Donetska | 22 | 13 | 6 | 7 | – | – | – |
| Odeska | 12 | 7 | 5 | 1 | 1 | – | – |
| Zaporizhska | 36 | 4 | 1 | 1 | 2 | – | – |
| Kyivska | 45 | 11 | 4 | 6 | 1 | – | – |
| Kirovohradska | 29 | 10 | 5 | 5 | – | – | – |
| Poltavska | 12 | 3 | 1 | 2 | – | – | – |
| Rivnenska | 18 | 6 | 4 | 2 | – | – | – |
| Ternopilska | 26 | 12 | 7 | 2 | 2 | – | 1 |
| Khersonska | 20 | 7 | 3 | 2 | 1 | 1 | – |
| Cherkaska | 20 | 5 | 2 | 2 | – | 1 | – |
| Chernivetska | 12 | 5 | 3 | – | 2 | – | – |
| Khmelnytska | 10 | 4 | 2 | 2 | – | – | – |
| Chernihivska | 15 | 9 | 3 | 5 | – | – | 1 |
| Luhanska | 30 | 11 | 7 | 4 | – | – | – |
| Lvivska | 4 | 3 | 2 | 1 | – | – | – |
| Zhytomyrska | 6 | 2 | – | 2 | – | – | – |
| Zakarpatska | 30 | 3 | 2 | 1 | – | – | – |
| Total | 542 | 138 | 68 | 57 | 9 | 2 | 2 |
| % out of positive strains | – | 100.0 | 12.6 | 10.5 | 1.7 | 0.4 | 0.4 |

**Table 2**
Antibiotic resistance of *Esherichia coli* strains isolated from pigs from pig farms in different regions of Ukraine in 2021 (N = 68)

| Region | Total | Susceptibile | Resistant to 2–3 antibiotics | Polyre-sistant | Resistant to antibiotics used | Resistant to ceftazidime, cefotaxime or meropenem | Results of screening for the production of acquired resistance enzymes |
|---|---|---|---|---|---|---|---|
| Vinnytska | 5 | 0 | 0 | 5 | ampicillin azithromycin chloramphenicol ciprofloxacin gentamicin, nalidixic acid sulfamethoxazole ceftazidime | 1 | 1 – not confirmed ESBL products |
| Volynska | 4 | 0 | 0 | 4 | ampicillin azithromycin chloramphenicol ciprofloxacin gentamicin, nalidixic acid sulfamethoxazole tetracycline trimethoprim | 0 | 0 |
| Dnipropetrovska | 2 | 0 | 2 | 0 | ciprofloxacin nalidixic acid | 0 | 0 |
| Donetska | 6 | 0 | 6 | 0 | nalidixic acid tetracycline ampicillin | 0 | 0 |
| Odeska | 5 | 0 | 0 | 5 | ampicillin azithromycin chloramphenicol ciprofloxacin gentamicin nalidixic acid sulfamethoxazole ceftazidime | 2 | 1 – confirmed ESBL products; 1 – not confirmed ESBL products |
| Zaporizhska | 1 | 0 | 0 | 1 | –"– | 0 | 0 |
| Kyivska | 4 | 0 | 0 | 4 | ampicillin azithromycin chloramphenicol ciprofloxacin gentamicin nalidixic acid sulfamethoxazole ceftazidime | 1 | 1 – not confirmed ESBL products |
| Kirovohradska | 5 | 0 | 0 | 5 | –"– | 0 | 0 |
| Poltavska | 1 | 0 | 0 | 1 | –"– | 0 | 0 |
| Rivnenska | 4 | 0 | 0 | 4 | –"– | 0 | 0 |
| Ternopilska | 7 | 0 | 0 | 7 | –"– | 0 | 0 |
| Khersonska | 3 | 0 | 0 | 3 | –"– | 0 | 0 |
| Cherkaska | 2 | 0 | 0 | 2 | –"– | 0 | 0 |
| Chernivetska | 3 | 0 | 0 | 3 | ampicillin azithromycin | 3 | 3 – confirmed ESBL products |

| Region | Total | Susceptibile | Resistant to 2–3 antibiotics | Polyre-sistant | Resistant to antibiotics used | Resistant to ceftazidime, cefotaxime or meropenem | Results of screening for the production of acquired resistance enzymes |
|---|---|---|---|---|---|---|---|
| | | | | | chloramphenicol ciprofloxacin colistin gentamicin nalidixic acid sulfamethoxazole ceftazidime | | |
| Khmelnytska | 2 | 0 | 2 | 0 | ciprofloxacin nalidixic acid | 0 | 0 |
| Chernihivska | 3 | 0 | 0 | 3 | ampicillin azithromycin chloramphenicol ciprofloxacin gentamicin, nalidixic acid sulfamethoxazole tetracycline trimethoprim trimethoprim | 0 | 0 |
| Luhanska | 7 | 1 | 0 | 6 | –"– | 0 | 0 |
| Lvivska | 2 | 2 | 0 | 0 | –"– | 0 | 0 |
| Zhytomyrska | 0 | 0 | 0 | 0 | –"– | 0 | 0 |
| Zakarpatska | 2 | 0 | 0 | 2 | ampicillin azithromycin chloramphenicol ciprofloxacin gentamicin, nalidixic acid sulfamethoxazole tetracycline trimethoprim | 0 | 0 |
| Total | 68 | 3 | 10 | 55 | – | incl. 7 | 4 strains – confirmed ESBL products, 3 strains – not confirmed ESBL products |
| % to the isolated strains of *E. coli* | 100.0 | 4.4 | 14.7 | 80.9 | | 10.3 | |

*Note*: – " – duplication of previous data.

Nine strains of *E. faecium* from pig farms in 6 regions of Ukraine were isolated and identified. The isolated strains were resistant to the AMD used and in different variations were resistant to 1 to 3 antibiotics, representatives of the macrolides – erythromycin, tetracyclines – tigecycline, fluoroquinolones – ciprofloxacin (Table 4).

The isolated 2 strains of *Campylobacter* spp. from pigs from pig farms in Cherkaska and Khersonska regions were resistant to AMD and showed resistance to 1 to 2 antibiotics of the macrolide group – erythromycin and fluoroquinolones – ciprofloxacin.

## Discussion

The analysis of the results of the studies complements the data of other scientists on the polyantimicrobial resistance of *E. coli* commensal strains and zoonotic bacteria of *Salmonella* spp. and confirms the seriousness of the epizootic situation and the social problems they create (Voloshchuk, 2014; Vergalli et al., 2020; Stetsko et al., 2023).

Scientists in the fields of human and veterinary medicine emphasize the low activity of ampicillin in its effect on clinical isolates of *E. coli*, as the level of resistance of *Escherichia*, according to their information, reaches about 90.0% (Kotsiuba et al., 2014). Our data confirm the results of studies conducted by other researchers. Based on the analysis of the results of our studies, we confirmed the low effectiveness of ampicillin for the neutralization of the studied isolates of *Escherichia* obtained from the appendix of pigs from farms in different regions of Ukraine. According to our data, as well as other scientists, a high level of resistance of the studied *Escherichia* isolates to aminoglycosides (gentamicin), fluoroquinolones (ciprofloxacin, norfloxacin), and tetracyclines (tetracycline) was confirmed. Our studies of *E. coli* strains revealed resistance to the macrolide antibiotic azithromycin.

The results of our studies showed that 1 vancomycin-resistant strain of *E. faecalis* has been detected in one pig farm of Donetska region. This raises concerns about the direct transmission of antibiotic resistance to other species of microorganisms that inhabit the gastrointestinal tract of animals and humans. Doubts are being raised about the safety and quality of livestock products. Vancomycin is a representative of the latest generation of antibiotics. The results of our monitoring of vancomycin resistance in the experimental strain of *E. faecalis* from pigs encourages further research to determine the prevalence of vancomycin-resistant enterococci in farms, to eliminate the causes of their occurrence for the safety of animal products for humans (Jean et al., 2015; Akpinar et al., 2020).

**Table 3**

Antibiotic resistance of *Enterococcus faecalis* strains isolated from pigs in farms in different regions of Ukraine in 2021 (N = 57)

| Region | Total | Suscep-tibility | Resistant to 1–3 antibiotics | Resistant to antibiotics used |
|---|---|---|---|---|
| Vinnytska | 3 | 0 | 3 | 0 |
| Volynska | 4 | 0 | 4 | tigecycline erythromycin teicoplanin chloramphenicol |
| Dnipropetrovska | 5 | 0 | 5 | tigecycline erythromycin |
| Donetska Odeska | 7 | 0 | 6 | tigecycline erythromycin teicoplanin |
| | | | 1 | vancomycin tetracycline teicoplanin |
| Zaporizhska | 1 | 0 | 1 | tigecycline |
| Kyivska | 1 | 1 | 1 | tigecycline |
| Kirovohradska | 6 | 1 | 5 | tigecycline erythromycin teicoplanin tetracycline |
| Poltavska | 5 | 0 | 4 | tigecycline erythromycin teicoplanin tetracycline |
| Rivnenska | 2 | 0 | 2 | tigecycline erythromycin tetracycline |
| Ternopilska | 2 | 0 | 2 | tigecycline erythromycin teicoplanin |
| Khersonska | 2 | 0 | 2 | tigecycline |
| Cherkaska | 2 | 0 | 2 | erythromycin |

| Region | Total | Susceptibility | Resistant to 1–3 antibiotics | Resistant to antibiotics used |
|---|---|---|---|---|
| | | | | tetracycline |
| Chernivetska | 2 | 0 | 2 | chloramphenicol erythromycin |
| Khmelnytska | 2 | 5 | 2 | erythromycin teicoplanin |
| Chernihivska | 5 | 0 | 0 | erythromycin tigecycline chloramphenicol |
| Luhanska | 4 | 0 | 4 | erythromycin teicoplanin tigecycline |
| Lvivska | 1 | 0 | 1 | teicoplanin |
| Zhytomyrska | 2 | 0 | 2 | tigecycline |
| Zakarpatska | 1 | 0 | 1 | erythromycin |
| Total | 57 | 7 | 50 | 1 – vancomycin-resistant |
| % to the isolated strains of *E. faecalis* | 100.0 | 12.3 % | 87.7 % | |

**Table 4**

Antibiotic resistance of *Enterococcus faecium* strains isolated from pigs in farms in different regions of Ukraine in 2021 (n = 9)

| Region | Totally isolated | Susceptibility | Resistant to 1–3 antibiotics | Resistant to antibiotics used |
|---|---|---|---|---|
| Odeska | 1 | 0 | 1 | tigecycline |
| Zaporizhska | 2 | 0 | 2 | chloramphenicol erythromycin ciprofloxacin |
| Kyivska | 1 | 0 | 1 | tigecycline |
| Ternopilska | 2 | 0 | 2 | erythromycin tigecycline chloramphenicol |
| Khersonska | 1 | 0 | 1 | erythromycin tigecycline |
| Chernivetska | 2 | 0 | 2 | chloramphenicol erythromycin |
| Total | 9 | 0 | 9 | X |
| Isolated strains *E. faecium*, % | 100.0 | 0 | 100.0 | |

The results of our research and the data of other scientists show that due to the high prevalence of polyresistant strains of commensal *E. coli*, salmonellosis pathogens, *E. faecalis*, *E. faecium* and *Campylobacter* spp. circulating in different regions of Ukraine, there is an urgent need for continuous monitoring of antibiotic resistance on livestock farms and enterprises for the production and processing of animal products. Our research results and scientific data from other scientists and practitioners confirm the correctness of the state policy chosen by Ukraine to curb the development of antimicrobial resistance (Huyghebaert et al., 2011; Polishko et al., 2011; Salmanov, 2017; Skliar et al., 2018; Obe et al., 2023).

The policy of antibiotic use in livestock and poultry farming should be based on local data on AMB resistance, as confirmed by the data obtained from our studies of enterobacterial isolates for AMB susceptibility. It is now important to establish a system of microbial resistance surveillance at the local, regional and national levels.

Scientists and practitioners in the field of veterinary and human medicine observe the trend of emergence of antibiotic-resistant pathogens not only of classical infections but also microorganisms that are representatives of the microbiota of different human and animal biotopes (Champagne et al., 2011; Chung et al., 2014).

Scientists believe that the main ways to prevent and overcome antibiotic resistance are to prevent the spread of antibiotic-resistant microorganisms through the rational use of antibiotics and to prevent the ingress of animal products contaminated with antibiotic-resistant bacterial strains into human or animal consumption (Campos et al., 2014; Akpinar et al., 2020).

This is the focus of the actions of the Government of Ukraine, scientists and specialists in the livestock industry to monitor the antibiotic resistance of microbial isolates obtained from animals and animal products, some of the results of which are presented in this paper.

## Conclusion

It was found that out of 138 identified bacteria of different species, complete sensitivity to all used antibiotic groups was detected in 10 cases (7.2% of the isolates). In the remaining 129 isolates (93.5% of the isolates), antibiotic resistance of various levels was found. Among the studied antibiotic-resistant isolates, 58 were found to be resistant to 1–3 antibiotics and 61 cultures of bacteria of different species were found to be polydrug-resistant. The largest number of commensal and zoonotic pathogens was isolated on farms in Donetsk (7 isolates), Kyiv (6), Dnipropetrovsk, Kirovohrad and Chernihiv (5 each) regions. It was found that *E. coli* and *Enterococcus* spp. were most often isolated among pigs, about 13.0% each among the studied samples. *Salmonella* spp. and *Campylobacter* spp. were isolated in a smaller amount of 0.5% each.

Among 68 strains of *E. coli*, 55 strains were found to be polydrug-resistant, among which 4 strains had acquired resistance and produced ESBL. Among 50 antibiotic-resistant *E. faecalis*, 1 vancomycin-resistant strain was detected. Both isolates of *Salmonella* spp. and *Campylobacter* spp. and 9 isolates of *E. faecium* isolates showed resistance to 1 to 3 antibiotics of different groups.

The perspective is to investigate environmental objects in livestock farms by testing them for antibiotic resistance in order to study their impact on the food chain to help reduce the risk of contamination of raw materials and products of animal origin.

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