DOI: 10.31073/onehealthjournal2026-I-06

Comparison of the antibacterial effect of Ciprofloxacin and Cephazoline to confirm the properties of the preparation

Babkina M. M.[1] (ORCID: 0009-0007-7544-5660), Romanko M. Ye.[1] (ORCID: 0000-0003-0285-5603), Kusturov V. B.[2] (ORCID: 0009-0006-2400-7727), Kulykova V. V.[1] (ORCID: 0009-0008-8827-030X), Bezditnyi P. M. (ORCID: 0009-0002-6428-8085), Pishchanskyi O. V.[1] (ORCID: 0009-0002-0111-4977), Deriabin O. M.[3] (ORCID: 0000-0001-5702-0190).
1 – State Scientific and Research Institute of Laboratory Diagnostics and Veterinary and Sanitary Expertise, Kyiv, Ukraine, e-mail: mariya.babkina86@gmail.com;
2 – State Service of Ukraine on Food Safety and Consumer Protection, Kyiv, Ukraine;
3 – SI «L. V. Gromashevsky Institute of Epidemiology and Infectious Diseases of the NAMS of Ukraine», Kyiv, Ukraine

Abstract. *The paper presents the results of a comprehensive study of the antibacterial activity of the drug Ciprofloxacin (in the form of a 10% solution for injection and a 5% solution for oral administration) against seven species of pathogenic and conditionally pathogenic microorganisms that are of important epizootological, veterinary-sanitary and zoonotic importance. The following reference and field strains were tested: Escherichia coli ATCC 25922, Salmonella enterica serovar typhimurium ATCC 14028, Pasteurella multocida (field isolate), Erysipelothrix rhusiopathiae (vaccine strain), Enterococcus faecalis ATCC 29212, Staphylococcus aureus ATCC 25923 and Bacillus anthracis (vaccine sterile strain). The relevance of the work is due to the rapid global growth of antimicrobial resistance in the world and in Ukraine, which leads to a decrease in the effectiveness of traditional antibiotic therapy regimens, increased mortality and significant economic losses in livestock farming. The assessment of antimicrobial activity was carried out by two complementary methods: the method of serial microdilutions in 96-well plates and the disk diffusion method on Mueller-Hinton agar using disks containing 5 µg of ciprofloxacin. The interpretation of the results was carried out in accordance with the current recommendations of CLSI (M100-S34, 2024) and EUCAST v.15.0 (2025). Ciprofloxacin showed high activity against all tested strains. The values of minimum inhibitory concentration (MIC_{50}/MIC_{90}) were E. coli – 0.008/0.015 µg/sm^3, S. typhimurium – 0.015/0.03 µg/sm^3, P. multocida – 0.004/0.008 µg/sm^3, E. rhusiopathiae – 0.06/0.12 µg/sm^3, E. faecalis – 0.5/1.0 µg/sm^3, S. aureus – 0.25/0.50 µg/sm^3, B. anthracis – 0.03/0.06 µg/sm^3. The diameters of the growth inhibition zones varied from 28.0±0.4 mm (E. faecalis) to 35.7 ± 0.25 mm (P. multocida), which corresponds to the category "susceptible" (S) according to both systems of criteria. Comparative analysis with cefazolin (30 µg/disk) showed a statistically significant ($p < 0.01$) advantage of ciprofloxacin in terms of the size of the zones of growth inhibition and MIC values against gram-negative bacteria and B. anthracis. The obtained data confirm that ciprofloxacin retains high antibacterial activity and a wide spectrum of action against the main pathogens of bacterial infections of agricultural and domestic animals even in conditions of the spread of resistance to β-lactams, macrolides and tetracyclines. The drug can be recommended as a drug of choice or alternative for colibacillosis, salmonellosis, pasteurellosis, swine erysipelas, staphylococcal and streptococcal infections. The results emphasize the need for regular monitoring of the sensitivity of circulating strains and rational use of fluoroquinolones in order to maintain their clinical effectiveness in the long term.*

Key words: antibacterial properties, ciprofloxacin, antibiotic resistance, microorganisms, cephalosporins.

All countries of the world are searching for new substances to combat microorganisms. There is a constant competition between the processes of evolution of microorganisms and the creation of new drugs (Tymoshchuk, 2020). Today, antibiotic therapy remains one of the main means of treating diseases of bacterial etiology, and in some cases, their prevention, both in human and veterinary medicine (Petrosova, 2022).

Antibiotic resistance is also a significant economic problem. According to WHO, in the EU alone, the cost of treating patients with diseases caused by resistant pathogens is estimated at approximately 1,500,000,000 euros per year. The US Office of Technology Assessment has estimated that the costs of managing AMR in the United States are 0.1-10 billion US dollars per year (Ferri, 2020; Dai, 2020).

In Ukraine, since August 2022, antibiotics have been available only on prescription (Salmanov, 2019; Ministry of Health of Ukraine, 2021).

In addition, the State Strategy for Combating Antimicrobial Resistance has been developed for the period until 2030. This strategy defines directions for achieving goals, fulfilling tasks in the field of infection prevention and infection control, infection safety, animal welfare, veterinary-sanitary and epizootic welfare, and combating the spread of pathogens with antimicrobial resistance. The planned period for achieving the Strategy's target indicators is 2024–2030 (Hetman, 2020; Ferri, 2020; Lynch, 2022).

The formation of antibiotic resistance is due to the genetic properties of microorganisms, as a result of their acquisition of new genetic information, or due to changes in the level of expression of the bacterial cell's own genes (Mohsen, 2022).

Antimicrobial drugs used today in both human and veterinary medicine include penicillins, cephalosporins, tetracyclines, chloramphenicol, aminoglycosides, spectinomycin, lincosamides, macrolides, nitrofurans, nitroimidazoles, sulfonamides, trimethoprims, polymyxins, and quinolones (Klymniuk, 2021; Cabinet of Ministers of Ukraine, 2024).

Cephalosporins are natural, semi-synthetic antibiotics derived from 7-aminocephalosporin acid, and containing a cephem (also β-lactam) ring, i.e. they are structurally similar to penicillins. Cephalosporins are divided into:

– 1st generation cephalosporins: ceporin, cephalothin, cephalexin;

– 2nd generation cephalosporins: cefazolin (kefzol), cefamezin, cefamandol (mandol);

– 3rd generation cephalosporins: cefuroxime (ketocef), cefotaxime (claforan), cefuroxime axetil (zinnat), ceftriaxone (longacef), ceftazidime (fortum);

– 4th generation cephalosporins: cefepime, cefpirom (cefrom).

Third-generation cephalosporins (cefotaxime, cefoperazone, ceftazidime, ceftizoxime, ceftriaxone, ceftiofur) have higher in vitro activity against gram-negative bacteria than second-generation cephalosporins (Nikonov, 2021). An important property of third-generation cephalosporins is their ability to penetrate the blood-brain barrier. These antibiotics are used to treat animals with various severe infections caused by gram-negative microorganisms, including multidrug-resistant ones (pneumonia, pyelonephritis, osteomyelitis, abdominal infections, wound infections, abscesses, phlegmons, sepsis) (Salmanov, 2017). In severe cases, cephalosporins (cephalexin, ceftiofur, cefquinome) are used, which inhibit the synthesis of bacterial cell walls, especially in the phase of intensive reproduction of the microorganism (Klymniuk, 2018; Nikonov, 2021).

Broad-spectrum antibacterial drugs include drugs that act on gram-positive and gram-negative microorganisms. This group includes tetracyclines, phenicols, fluoroquinolones, third and fourth generation cephalosporins (Nikonov et al., 2021).

Therefore, **the aim of the study** was to test the antibacterial properties of Ciprofloxacin compared to Cefazolin on test cultures of microorganisms.

Materials and methods. In the research process, the antibiotic Ciprofloxacin (serial number 4009, production date 08.2024) was used.

Also strains of microorganisms were used, which are in the list in Table 1:

The following bacteriological methods were used in the research process:

– method of the serial microdilution;

– disk diffusion method.

For cultivation of microorganisms *S. aureus, S. faecalis, E. coli, S. typhimurium, P. multocida, E. rhusiopathiae and B. anthrax* Mueller-Hinton broth (MHB) was used.

The principle of the serial dilution method is based on the use of tenfold serial dilutions of concentrations of drugs that have antibacterial activity. The serial microdilution method was used according to the standard protocol proposed in the monograph (Salmanov et al., 2022). The results were recorded visually.

The disk diffusion method was used according to the standard protocol recommended in the monograph (Salmanov et al., 2017). The disk diffusion method was used to confirm the action of the antibiotic by the serial dilution method.

Results. In order to confirm the antibacterial properties of Ciprofloxacin, seven species of bacteria from the *Enterobacteriaceae* family were used. Gram-positive and gram-negative microorganisms represented the group (Table 2).

The results of minimum inhibitory concentration and diameter of growth inhibition zones of antibiotics Cefazolin are shown in Table 3.

Table 1

List and characteristics of microorganisms used in the studies

№	Name of microorganism	Strain	Characteristics of microorganism
1	*Escherichia coli*	ATCC 25922	Standard quality control strain in microbiology labs especially antibiotic susceptibility testing, SSRILDVSE
2	*Salmonella enterica serovar typhimurium*	ATCC 14028	Standard model organism in salmonellosis research, resistant to some antibiotics, SSRILDVSE
3	*Pasteurella multocida*	Field's isolate	For the production and quality control of inactivated vaccines against avian *Pasteurella*, SSRILDVSE
4	*Erysipelothrix rhusiopathiae*	Strain for vaccines	For the production of vaccines against swine erysipelas, SSRILDVSE
5	*Enterococcuss faecalis*	ATCC 29212	Standard reference strain of the bacterium *Enterococcus faecalis*, essential in clinical microbiology labs for quality control in antimicrobial susceptibility testing, SSRILDVSE
6	*Staphylococcus aureus*	ATCC 25923	Standard strain for control in microbiology laboratories to test the sensitivity of bacteria to antibiotics, SSRILDVSE
7	*Bacillus anthracis*	Strain for vaccines	Strain for vaccines, SSRILDVSE

As can be seen from the results of Tables 2 and 3, the antibacterial drug Ciprofloxacin showed a wide spectrum of antibacterial activity. The values of the minimum inhibitory concentration (MIC_{50}/MIC_{90}) were: *E. coli* – 0.008/0.015 μg/sm^3, *S. enterica serovar typhimurium* – 0.015/0.03 μg/sm^3, *P. multocida* – 0.004/0.008 μg/sm^3, *E. rhusiopathiae* – 0.06/0.12 μg/sm^3, *E. faecalis* – 0.5/1.0 μg/sm^3, *S. aureus* – 0.25/0.5 μg/sm^3 and *B. anthracis* –

0.03/0.06 μg/sm^3, respectively. The diameters of the zones of inhibition of growth of microorganisms ranged from 28.0 ± 0.40 mm (*Enterococcuss faecalis*) to 35.7 ± 0.25 mm (*Pasteurella multocida*). The most sensitive culture was *P. multocida* with (MIC_{50}/MIC_{90}) 0.004/0.008 μg/cm^3 and a zone of inhibition of growth of 35.70±0.25 mm, respectively. The least sensitive culture was *E. faecalis* with (MIC_{50}/MIC_{90}) 0.500/1.000 μg/sm^3 and a zone of inhibition of growth of 28.0±0.4 mm, respectively. The activity of Ciprofloxacin was confirmed by 2 methods, which proves its high antibacterial activity against the tested test cultures of microorganisms.

Table 2

Minimum inhibitory concentration and diameter of growth inhibition zones of antibiotics Ciprofloxacin

№	Name of microorganism	MIC_{50}, μg/sm^3, n=6*	MIC_{90}, μg/sm^3, n=6*	M±m, mm, n=6*
1	*Escherichia coli*	0,008	0,015	30,30±0,33
2	*Salmonella enterica serovar typhimurium*	0,015	0,030	32,50±0,22
3	*Pasteurella multocida*	0,004	0,008	35,70±0,25
4	*Erysipelothrix rhusiopathiae*	0,065	0,120	30,30±0,33
5	*Enterococcuss faecalis*	0,500	1,000	28,00±0,40
6	*Staphylococcus aureus*	0,250	0,500	29,50±0,22
7	*Bacillus anthracis*	0,030	0,060	29,50±0,22

Note: * – number of research repetitions (6)

The antibacterial drug Cefazolin also showed activity against the tested test cultures of microorganisms, but at higher concentrations. The values of the minimum inhibitory concentration (MIC_{50}/MIC_{90}) were for the following cultures: *E. coli* – 0.0016/0.03 μg/sm^3, S. *enterica serovar typhimurium* – 0.03/0.057 μg/sm^3, *P. multocida* – 0.007/0.015 μg/sm^3, *E. rhusiopathiae* – 0.014/0.25 μg/sm^3, *E. faecalis* – 1.15/2.0 μg/sm^3, *S. aureus* – 0.55/0.98 mcg /cm^3 and *B. anthracis* – 0.06/0.13 μg/sm^3, respectively. Thus, the diameter of the growth inhibition zones ranged from 22.5 ± 0.12 mm (*S. enterica serovar typhimurium*) to 26.3 ± 0.23 mm (*E. coli*).

Table 3

Minimum inhibitory concentration and diameter of growth inhibition zones of antibiotics Cefazolin

№	Name of microorganism	MIC_{50}, μg/sm^3; n=6*	$MIC_{90,}$ μg/sm^3; n=6*	M±m; mm; n=6*
1	*Escherichia coli*	0,016	0,030	26,30±0,23
2	*Salmonella enterica serovar typhimurium*	0,030	0,057	22,50±0,12
3	*Pasteurella multocida*	0,007	0,015	23,60±0,36
4	*Erysipelothrix rhusiopathiae*	0,014	0,250	24,00±0,31
5	*Enterococcuss faecalis*	1,150	2,000	25,30±0,23
6	*Staphylococcus aureus*	0,550	0,980	23,50±0,12
7	*Bacillus anthracis*	0,060	0,130	24,50±0,12

Note: * – number of research repetitions (6)

Discussion. The obtained data confirm that Ciprofloxacin retains high antibacterial activity and a wide spectrum of action against the main pathogens of bacterial infections of agricultural and domestic animals even in conditions of the spread of resistance to β-lactams, macrolides and tetracyclines. The drug can be recommended as a drug of choice or alternative for colibacillosis, salmonellosis, pasteurellosis, swine erysipelas, staphylococcal and streptococcal infections. The results emphasize the need for regular monitoring of the sensitivity of circulating strains and rational use of fluoroquinolones in order to maintain their clinical effectiveness in the long term. An analysis of literary sources showed the existence of the problem of antibiotic resistance in microorganisms is in 2025.

Conclusion.

1. The antibiotic Ciprofloxacin showed antibacterial activity on all 7 microorganisms which studied.
2. Ciprofloxacin showed antibacterial activity by the disco-diffusion method on the entire spectrum of microorganisms, which studied with a growth inhibition zone from 28.0±0.4 mm to 35.70±0.25 mm.
3. The antibiotic Ciprofloxacin showed antibacterial activity on the entire spectrum of microorganisms studied with MIC_{50} from 0.008 μg/sm^3 to 0.500 μg/sm^3 and MIC_{90} from 0.057 μg/sm^3 to 2.0 μg/sm^3 by the serial microdilution method and a growth inhibition zone from 28.0±0.4 mm to 35.70±0.25 mm.
4. Ciprofloxacin continues to be a relevant drug with a broad spectrum of antibacterial activity.
5. It is necessary to establish a system of epidemiological surveillance of microbial resistance at the local, regional and national levels.

REFERENCES

1. Cabinet of Ministers of Ukraine. (2024). *Derzhavna stratehiia borotby iz stiikistiu do protymikrobnykh preparativ na period do 2030 roku* [National Strategy for Combating Antimicrobial Resistance until 2030]; https://www.kmu.gov.ua/storage/app/uploads/public/676/022/185/-676022185589300624410.pdf
2. Dai L., Sahin O., Grover M., Zhang Q. (2020). New and alternative strategies for the prevention, control, and treatment of antibiotic resistance. *Translational Research*; 223:76–88.
3. Ferri M., Ranucci E., Romagnoli P., Giaccone V. (2017). Antimicrobial resistance: A global emerging threat to public health systems. *Critical Reviews in Food Science and Nutrition*; 57:2857–2876.
4. Hetman L. (2023). *Tsentr hromadskoho zdorovia MOZ Ukrainy* [Public Health Center of the Ministry of Health of Ukraine]; https://phc.org.ua/news/poyasnyuemo-chomu-antibiotikorezistentnist-seryozna-zagroza-dlya-lyudstva [In Ukrainian].
5. Klymniuk S. I. (Ed.). (2021). *Monitorynh pryznachennia antybiotykiv sered medychnykh pratsivnykiv za rezultatamy anketuvannia* [Monitoring of antibiotic prescribing among healthcare workers based on a survey]. In *Proceedings of the All-Ukrainian Educational and Scientific Conference "Topical Issues of Pharmacology and Pharmacotherapy"*; Ternopil: TDMU Ukrmedknyha [In Ukrainian].
6. Klymniuk S., Sytnyk I., Shyrobokov V. (2018). *Praktychna mikrobiolohiia: Navchalnyi posibnyk* [Practical Microbiology: Textbook]; Vinnytsia: Nova Knyha. [In Ukrainian].
7. Lynch J. P., Nina M. C., Zhanel G. G. (2022). Infections due to *Acinetobacter baumannii–calcoaceticus* complex: Escalation of antimicrobial resistance and evolving treatment options. *Respiratory and Critical Care Medicine*; 43:97–124.

8. Ministry of Health of Ukraine. (2021). *Nakaz № 1318/36940 Pro orhanizatsiiu profilaktyky infektsii ta infektsiinoho kontroliu*; [Order No. 1318/36940 on the organization of infection prevention and control in healthcare and social institutions]. [In Ukrainian].
9. Mohsen N., Antimicrobial Resistance Collaborators. (2022). Global burden of bacterial antimicrobial resistance in 2019: A systematic analysis. *The Lancet*; 399:629–655. doi:10.1016/S0140-6736(21)02724-0.
10. Nikonov V. V., Lyzohub K. I., Lyzohub M. V. (2021). Mozhlyvosti zastosuvannia tsefalosporyniv III pokolinnia v ambulatornii khirurhii [Possibilities of using third-generation cephalosporins in outpatient surgery]. *Emergency Medicine*; (3):30–35. [In Ukrainian].
11. Petrosova V. I. (2022). Antybiotykorezystentnist: problema “tykhoi pandemii” [Antibiotic resistance: The problem of the “silent pandemic”]. *Scientific Bulletin of Uzhhorod University: Biology Series*; (52):59–66. [In Ukrainian].
12. Salmanov A. (2019). Borotba z antymikrobnoiu rezystentnistiu: plan dii Ukrainy [Combating antimicrobial resistance: Ukraine’s action plan]. *Infection Control*; (11), 23–25. [In Ukrainian].
13. Salmanov A. H., Muzyka V. P. (2017). Borotba z rezystentnistiu do antybiotykiv na pryntsypakh kontseptsii “Yedyne zdorovia” [Fighting antibiotic resistance through the One Health concept]. *International Journal of Antibiotics and Probiotics*; 1(2):8–29. [In Ukrainian].
14. Salmanov A., Shchehlov D., Art’omenko V. (2022). *Strymuvannia antymikrobnoi rezystentnosti na pidkhodakh “Yedyne zdorovia”: Monohrafiia*; [Containing antimicrobial resistance through the One Health approach: Monograph]. Kyiv: AhrarMediaHrup. [In Ukrainian].
15. Tymoshchuk S. A., Symochko L. Yu. (2020). Poshyrennia antybiotykorezystentnykh mikroorhanizmiv u navkolyshnomu pryrodnomu seredovyshchi [Spread of antibiotic-resistant microorganisms in the natural environment]; *Ecological Sciences*; 2(29):11–15. [In Ukrainian].

Порівняння антибактеріальної дії ципрофлоксацину з цефазоліном для підтвердження властивостей препарату

Бабкіна М. М.[1] (ORCID: 0009-0007-7544-5660), Романько М. Є.[1] (ORCID: 0000-0003-0285-5603), Кустуров В. Б.[2] (ORCID: 0009-0006-2400-7727), Куликова В. В.[1] (ORCID: 0009-0008-8827-030X), Бездітний П. М.[2] (ORCID: 0009-0002-6428-8085), Піщанський О. В.[1] (ORCID: 0009-0002-0111-4977), Дерябин О.М.[3](ORCID: 0000-0001-5702-0190).
1 – Державний науково-дослідний інститут лабораторної діагностики та ветеринарно-санітарної експертизи, м. Київ, Україна; *e-mail: mariya.babkina86@gmail.com
2 – Державна служба з питань безпечності харчових продуктів та захисту споживачів, м. Київ, Україна;
3 – Державна установа "Інститут епідеміології та інфекційних хвороб ім. Л.В. Громашевського НАМН України", м. Київ, Україна,
Резюме *У роботі представлено результати комплексного дослідження антибактеріальної активності препарату Ципрофлоксацин (у формі 10 % розчину для ін’єкцій та 5 % розчину для перорального застосування) щодо семи видів патогенних та умовно-патогенних мікроорганізмів, які мають важливе епізоотологічне, ветеринарно-санітарне та зоонозне значення. Досліджено референсні та польові штами: Escherichia coli ATCC 25922, Salmonella enterica serovar typhimurium ATCC 14028, Pasteurella multocida (польовий ізолят), Erysipelothrix rhusiopathiae (вакцинний штам), Enterococcus faecalis ATCC 29212, Staphylococcus aureus ATCC 25923 та Bacillus anthracis (вакцинний стерильний штам). Актуальність роботи зумовлена стрімким глобальним зростанням антимікробної резистентності у світі та в Україні, що призводить до зниження ефективності традиційних схем антибіотикотерапії, збільшення летальності та значних економічних втрат у тваринництві. Оцінку антимікробної активності проводили двома взаємодоповнювальними методами: методом серійних мікророзведень у 96-лункових планшетах та диско-дифузійним методом на агарі*

Мюллера–Хінтона з використанням дисків, що містять 5 мкг ципрофлоксацину. Інтерпретацію результатів здійснювали відповідно до актуальних рекомендацій CLSI (M100-S34, 2024) та EUCAST v.15.0 (2025). Ципрофлоксацин виявив високу активність щодо всіх досліджених штамів. Значення мінімальної інгібуючої концентрації (МІК$_{50}$/МІК$_{90}$) становили: E. coli – 0,008/0,015 мкг/см^3, S. typhimurium – 0,015/0,03 мкг/см^3, P. multocida – 0,004/0,008 мкг/см^3, E. rhusiopathiae – 0,06/0,12 мкг/см^3, E. faecalis – 0,5/1,0 мкг/см^3, S. aureus – 0,25/0,5 мкг/см^3, B. anthracis – 0,03/0,06 мкг/см^3. Діаметри зон затримки росту варіювали від 28,0 ± 0,40 мм (E. faecalis) до 35,7 ± 0,25 мм (P. multocida), що відповідає категорії «чутливий» (S) за обома системами критеріїв. Порівняльний аналіз з цефазоліном (30 мкг/диск) показав статистично достовірну (p<0,01) перевагу ципрофлоксацину за величиною зон затримки росту та значеннями МІК щодо грамнегативних бактерій та B. anthracis. Отримані дані підтверджують, що ципрофлоксацин зберігає високу антибактеріальну активність та широкий спектр дії щодо основних збудників бактеріальних інфекцій сільськогосподарських і домашніх тварин навіть за умов поширення резистентності до β-лактамів, макролідів та тетрациклінів. Антибактеріальний препарат може бути рекомендований як препарат вибору або альтернативи при колібактеріозі, сальмонельозі, пастерельозі, рожі свиней, стафілококових та стрептококових інфекціях. Результати підкреслюють необхідність регулярного моніторингу чутливості циркулюючих штамів та раціонального використання фторхінолонів з метою збереження їхньої клінічної ефективності в довгостроковій перспективі.

Ключові слова: антибактеріальні властивості, ципрофлоксацин, антибіотикорезистентність, мікроорганізми, цефалоспорини.

DOI: 10.31073/onehealthjournal2026-I-06