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KONSERVANTLARNING KO'Z SHILLIQ QAVATIGA TA'SIRI, PH MUVOZANATI VA OSMOTIK BOSIMNI OPTIMALLASHTIRISH

Maxamatova Umidaxon Raxmonjonovna
Farg‘ona Jamoat Salomatligi Tibbiyot Instituti, Xalq tabobati va farmakologiya kafedrasi assistenti, Farg‘ona, O‘zbekiston
akbarxon2008@gmail.com
https://orcid.org/0009-0003-9413-392X

Annotatsiya: Ushbu maqolada ko‘z uchun qo‘llaniladigan oftalmik dori vositalarida konservantlar, pH muvozanati va osmotik bosimning ahamiyati kompleks tarzda tahlil qilindi. Zamonaviy farmakologiyada ko‘z tomchilari va boshqa oftalmik preparatlar keng qo‘llanilishi bilan birga, ularning xavfsizligi va bemorlar tomonidan qabul qilinishi muhim klinik masala bo‘lib qolmoqda. Konservantlar preparatning mikrobiologik barqarorligini ta’minlasa-da, ularning uzoq muddatli qo‘llanilishi ko‘z yuzasi epiteliysiga toksik ta’sir ko‘rsatib, quruqlik, qizarish, achishish va yallig‘lanish reaksiyalarini keltirib chiqarishi mumkinligi ilmiy adabiyotlarda keng yoritilgan. Shu sababli so‘nggi yillarda konservantsiz yoki minimal toksik konservantlarga ega bo‘lgan oftalmik preparatlarni ishlab chiqishga katta e’tibor qaratilmoqda. Maqolada shuningdek, ko‘z yoshi suyuqligining fiziologik pH darajasi bilan mos keladigan eritmalar bemorlar tomonidan yaxshi qabul qilinishi va nojo‘ya ta’sirlarni sezilarli darajada kamaytirishi tahlil qilindi. pH muvozanatining buzilishi esa ko‘zda tirnashish va reflektor noqulayliklarni kuchaytirishi mumkinligi ko‘rsatib o‘tildi.

Kalit so‘zlar: Konservantlar, oftalmik preparatlar, ko‘z shilliq qavati, pH muvozanati, osmotik bosim, ko‘z qurishi, farmakologiya, biotolerantlik.

ВЛИЯНИЕ КОНСЕРВАНТОВ НА СЛИЗИСТУЮ ОБОЛОЧКУ ГЛАЗА, БАЛАНС РН И ОПТИМИЗАЦИЯ ОСМОТИЧЕСКОГО ДАВЛЕНИЯ

Махамматова Умидахон Рахмонжоновна
Ферганский медицинский институт общественного здоровья, Ассистент кафедры народной медицины и фармакологии Фергана, Узбекистан
akbarxon2008@gmail.com
https://orcid.org/0009-0003-9413-392X

Аннотация: В данной статье комплексно рассматривается значение консервантов, pH-баланса и осмотического давления в офтальмологических лекарственных формах. В современной фармакологии глазные капли и другие офтальмологические препараты широко применяются, однако их безопасность и переносимость пациентами остаются важной клинической проблемой. Хотя консерванты обеспечивают микробиологическую стабильность препарата, их длительное применение может оказывать токсическое воздействие на эпителий поверхности глаза, вызывая сухость, покраснение, жжение и воспалительные реакции, что

широко описано в научной литературе. В последние годы особое внимание уделяется разработке офтальмологических препаратов без консервантов или с минимальной токсичностью. Также установлено, что растворы с физиологическим pH, близким к слезной жидкости, лучше переносятся пациентами и значительно уменьшают побочные эффекты. Нарушение pH может усиливать раздражение и дискомфорт глаз.

Ключевые слова: Консерванты, офтальмологические препараты, слизистая глаза, pH баланс, осмотическое давление, сухость глаза, фармакология, биосовместимость.

THE EFFECT OF PRESERVATIVES ON THE OCULAR MUCOSA, PH BALANCE, AND OPTIMIZATION OF OSMOTIC PRESSURE

Makhamatova Umidakhon Rakhmonjonovna
Fergana Medical Institute of Public Health Assistant Department of Folk Medicine and Pharmacology. Fergana, Uzbekistan
akbarxon2008@gmail.com
https://orcid.org/0009-0003-9413-392X

Abstract: This article provides a comprehensive analysis of the importance of preservatives, pH balance, and osmotic pressure in ophthalmic drug formulations. In modern pharmacology, eye drops and other ophthalmic preparations are widely used; however, their safety and patient tolerability remain important clinical issues. Although preservatives ensure microbiological stability, their long-term use may cause toxic effects on the ocular surface epithelium, leading to dryness, redness, burning sensation, and inflammatory reactions as reported in scientific literature. In recent years, increasing attention has been given to the development of preservative-free or minimally toxic ophthalmic formulations. It has also been shown that solutions with physiological pH close to tear fluid are better tolerated by patients and significantly reduce adverse effects. Imbalance in pH may increase ocular irritation and discomfort.

Keywords: Preservatives, ophthalmic preparations, ocular mucosa, pH balance, osmotic pressure, dry eye, pharmacology, biocompatibility.

Introduction

In modern pharmacology and ophthalmology, improving the safety and effectiveness of ophthalmic drug formulations is considered one of the most important scientific directions. Preservatives are widely used in eye drops, gels, and ophthalmic solutions to prevent microbial contamination and maintain sterility during storage and use. Although these substances play a significant role in protecting pharmaceutical products from bacterial growth, they may also cause adverse effects on the ocular mucosa and corneal epithelial cells. Long-term exposure to preservatives can lead to irritation, inflammation, dryness of the ocular surface, epithelial cell damage, and allergic reactions. Therefore, determining the optimal and safe concentration of preservatives in ophthalmic preparations has become an important issue in pharmaceutical technology and clinical pharmacology.

The effectiveness and tolerability of ophthalmic preparations are strongly associated not only with preservatives but also with the pH balance and osmotic pressure of the solution. The normal physiological pH of tear fluid ranges approximately from 7.0 to 7.4, and deviations from this range may cause burning sensation, redness, tearing, and discomfort in patients. Maintaining an appropriate pH balance is essential for improving drug stability, enhancing bioavailability, and reducing ocular irritation. In addition, osmotic pressure plays a crucial role in maintaining normal cellular function and protecting the integrity of ocular tissues. Hypertonic or hypotonic solutions may disrupt cellular homeostasis, resulting in dehydration or swelling of epithelial cells and subsequent impairment of the ocular surface.

Recent advances in pharmaceutical research have focused on the development of preservative-free ophthalmic formulations and the use of less toxic preservative agents. Modern ophthalmic drug delivery systems aim to increase biocompatibility, minimize toxic effects on ocular tissues, and optimize physicochemical properties such as pH and osmolarity. These improvements contribute to better patient compliance and reduced incidence of side effects during long-term therapy. This article discusses the pharmacological impact of preservatives on the ocular mucosa, the importance of physiological pH balance, and the optimization of osmotic pressure in ophthalmic formulations.

Relevance

The relevance of this topic is associated with the increasing use of ophthalmic medications in modern medicine and the growing number of patients suffering from chronic eye diseases. Eye drops and other ophthalmic formulations are widely applied in the treatment of glaucoma, dry eye syndrome, conjunctivitis, allergic conditions, and postoperative eye care. Most ophthalmic preparations contain preservatives to maintain sterility and prolong shelf life. However, prolonged exposure to preservatives may negatively affect the ocular surface, leading to irritation, inflammation, epithelial damage, and tear film instability. These complications reduce patient comfort and may decrease the effectiveness of long-term treatment.

Aim

The aim of this study is to investigate the effects of preservatives on the ocular mucosa and to evaluate the importance of pH balance and osmotic pressure optimization in ophthalmic formulations. The study also aims to analyze the relationship between physicochemical properties of ophthalmic solutions and their safety, tolerability, and therapeutic effectiveness. Furthermore, the research focuses on identifying approaches for reducing ocular toxicity and improving the quality and biocompatibility of ophthalmic drug preparations.

Main part

Ophthalmic pharmaceutical formulations play a significant role in the prevention, diagnosis, and treatment of various ocular diseases in modern medicine. These formulations include eye drops, ointments, gels, suspensions, emulsions, and advanced drug delivery systems designed specifically for ocular administration. The eye is a highly sensitive and protected organ with unique anatomical and physiological barriers that limit drug absorption and reduce therapeutic effectiveness. Because of this complexity, ophthalmic preparations must be carefully formulated to ensure sterility, safety, stability, and patient compatibility. The primary objective of ophthalmic formulations is to deliver the active pharmaceutical ingredient directly to the target tissue while minimizing systemic absorption and adverse effects. Modern ophthalmology relies heavily on topical ocular medications for the management of glaucoma, conjunctivitis, dry eye syndrome, corneal inflammation, allergic conditions, and postoperative care. Ophthalmic formulations are designed to provide rapid therapeutic action and prolonged drug retention on the ocular surface. The development of effective ophthalmic products requires consideration of several physicochemical parameters such as pH balance, osmolarity, viscosity, particle size, and preservative content. Sterility is one of the most critical requirements because microbial contamination may lead to severe ocular infections and vision impairment. Therefore, preservatives are commonly added to multidose ophthalmic preparations to inhibit microbial growth and maintain product stability during repeated use. However, increasing evidence suggests that some preservatives may induce toxic effects on the ocular surface, especially during long-term therapy. In addition, patient comfort and compliance are directly associated with the physicochemical compatibility of ophthalmic solutions with natural tear fluid. Pharmaceutical scientists continue to develop advanced ophthalmic delivery systems with improved bioavailability and reduced toxicity. The integration of nanotechnology, biodegradable polymers, and preservative-free systems has significantly contributed to the advancement of ocular pharmacotherapy. As ocular diseases continue to increase globally due to aging, environmental pollution, and digital device

exposure, the importance of safe and effective ophthalmic pharmaceutical formulations becomes even more critical in contemporary healthcare.

Preservatives are essential components in multidose ophthalmic preparations because they prevent microbial contamination and maintain the sterility of pharmaceutical products throughout their period of use. Ophthalmic solutions are particularly vulnerable to bacterial and fungal contamination due to repeated opening and direct contact with the external environment. To reduce the risk of infection and preserve product stability, different types of antimicrobial preservatives are incorporated into eye drops and other ocular formulations. Preservatives used in ophthalmic products are generally classified into several groups, including quaternary ammonium compounds, oxidative preservatives, alcohol-based preservatives, and organomercury compounds. Benzalkonium chloride is the most commonly used preservative in ophthalmology because of its strong antimicrobial activity and chemical stability. It acts by disrupting microbial cell membranes and causing leakage of intracellular components. Other preservatives such as chlorobutanol, sodium perborate, stabilized oxychloro complex, and polyquaternium compounds are also widely used in ophthalmic formulations. Each preservative has specific pharmacological properties, antimicrobial effectiveness, and toxicity profiles that influence ocular tolerance and therapeutic safety. Although preservatives are highly effective in preventing microbial growth, many studies have demonstrated their potential harmful effects on the ocular surface and tear film stability. Long-term use of preserved eye drops may result in epithelial cell damage, inflammatory responses, disruption of lipid layers, and apoptosis of conjunctival cells. The toxic effects are often dose-dependent and more pronounced in patients with chronic ocular diseases such as glaucoma or dry eye syndrome who require lifelong therapy. Pharmacologically, preservatives may interact with cell membranes and alter normal physiological processes within ocular tissues. The selection of appropriate preservatives therefore requires a careful balance between antimicrobial efficacy and ocular biocompatibility. Recent pharmaceutical research has focused on developing less toxic preservative systems and preservative-free multidose packaging technologies. Advances in formulation science aim to improve patient safety while maintaining adequate antimicrobial protection. The growing understanding of preservative-related ocular toxicity has significantly influenced the development of modern ophthalmic medications and regulatory recommendations in pharmaceutical practice.

The ocular mucosa and corneal epithelial cells represent the first protective barrier of the eye against environmental factors, microorganisms, and chemical exposure. These structures are highly sensitive and vulnerable to toxic substances present in ophthalmic formulations, particularly preservatives used in multidose eye drops. Preservatives are added primarily to maintain sterility and prevent microbial contamination, but prolonged exposure to these chemicals may produce significant adverse effects on ocular tissues. One of the most widely studied preservatives is benzalkonium chloride, which has been associated with cytotoxicity, tear film instability, and inflammatory changes in the ocular surface. Preservatives may disrupt the lipid layer of the tear film, leading to increased tear evaporation and symptoms of dry eye syndrome. In addition, they can damage epithelial cell membranes, alter cellular metabolism, and induce apoptosis through oxidative stress mechanisms. Chronic exposure to preserved ophthalmic solutions may result in conjunctival inflammation, epithelial erosion, corneal staining, and decreased mucin production. These pathological changes impair the protective function of the ocular surface and reduce patient tolerance to long-term treatment. Individuals with preexisting ocular disorders, contact lens users, and elderly patients are particularly susceptible to preservative-induced toxicity. Histological studies have demonstrated structural changes in corneal epithelial cells following continuous administration of preserved eye drops. Inflammatory mediators released during preservative exposure may further aggravate tissue damage and contribute to chronic ocular discomfort. The severity of ocular toxicity often depends on preservative concentration, duration of exposure, frequency of administration, and individual sensitivity. Modern ophthalmic research emphasizes the importance of minimizing preservative-

related damage through the development of safer formulations and preservative-free delivery systems. Advances in pharmaceutical technology have enabled the production of sterile single-dose containers and multidose systems with antimicrobial filters that reduce the need for traditional preservatives. Understanding the effects of preservatives on ocular mucosa and epithelial cells is essential for improving therapeutic outcomes, patient comfort, and long-term ocular health in ophthalmic pharmacotherapy.

Long-term exposure to preservatives in ophthalmic preparations can lead to a variety of toxicological and inflammatory reactions affecting the ocular surface. These reactions are mainly related to the cumulative cytotoxic effects of chemical agents such as benzalkonium chloride, which is widely used in eye drops. Continuous contact with preservatives may disrupt cellular membrane integrity, increase oxidative stress, and trigger inflammatory signaling pathways in conjunctival and corneal tissues. As a result, patients may develop symptoms such as burning sensation, redness, foreign body feeling, and excessive tearing. Chronic inflammation induced by preservatives can also impair normal wound healing processes of the corneal epithelium. In addition, infiltration of inflammatory cells into the ocular surface may lead to progressive tissue damage and instability of the tear film. Long-term use of preserved eye drops has been associated with decreased goblet cell density, which reduces mucin secretion and worsens dry eye symptoms. The toxic effects are often dose-dependent and become more pronounced in patients requiring lifelong therapy, such as those with glaucoma. Repeated exposure may also induce subclinical changes that are not immediately symptomatic but gradually compromise ocular surface health. Therefore, understanding and minimizing preservative-induced toxicity is essential for improving long-term treatment outcomes.

The pH balance of ophthalmic preparations plays a crucial role in ensuring both drug stability and ocular compatibility. The normal physiological pH of tear fluid ranges between 7.0 and 7.4, and any significant deviation from this range may cause discomfort and irritation upon application. If the pH of an eye drop is too acidic or too alkaline, it can stimulate sensory nerve endings in the cornea, leading to burning sensation, stinging, and reflex tearing. Moreover, inappropriate pH levels can alter the ionization state of active pharmaceutical ingredients, thereby affecting their solubility, absorption, and therapeutic efficacy. Maintaining an optimal pH also contributes to preserving the structural integrity of ocular tissues and minimizing protein denaturation on the eye surface. Buffer systems are commonly used in ophthalmic formulations to stabilize pH within a physiologically acceptable range. However, excessive buffering capacity may itself cause irritation due to resistance against natural tear adjustment mechanisms. Therefore, formulation scientists aim to design eye drops with pH values that closely match natural tear fluid while ensuring drug stability. Proper pH adjustment enhances patient comfort, improves drug retention time, and increases overall treatment compliance. In clinical practice, well-balanced pH is especially important for patients with sensitive or already compromised ocular surfaces.

Osmotic pressure is an essential physicochemical parameter that significantly influences the safety and effectiveness of ophthalmic solutions. It refers to the concentration of solutes in a solution and determines the movement of water across cell membranes. The osmotic pressure of ophthalmic preparations should ideally be close to that of natural tear fluid, which is approximately isotonic with body fluids. If an eye drop is hypertonic, it draws water out of ocular epithelial cells, leading to cellular dehydration, irritation, and discomfort. Conversely, hypotonic solutions may cause water influx into cells, resulting in swelling and potential disruption of cellular structure. Both conditions can impair the normal function of the ocular surface and reduce patient tolerance to treatment. Maintaining isotonicity is therefore critical for preserving corneal epithelial integrity and tear film stability. In addition, osmotic balance affects drug absorption and distribution across ocular tissues. Pharmaceutical formulations often use tonicity-adjusting agents such as sodium chloride or mannitol to achieve physiological compatibility. Proper control of osmotic pressure not only improves comfort but also enhances therapeutic effectiveness by ensuring stable drug delivery to the target site. Modern

ophthalmic formulation research continues to focus on optimizing osmolarity alongside pH and preservative selection to achieve maximum safety and efficacy.

Modern ophthalmic formulation science places strong emphasis on optimizing both pH balance and osmolarity to ensure maximum safety, comfort, and therapeutic efficacy. One of the key approaches is the use of physiological buffer systems that maintain pH within the tear fluid range of approximately 7.0 to 7.4. These buffer systems are carefully selected to provide stability of the active pharmaceutical ingredient while minimizing irritation to ocular tissues. Another important strategy is the adjustment of osmolarity using tonicity agents such as sodium chloride, potassium chloride, or mannitol to achieve isotonic conditions similar to natural tears. Advanced formulation techniques also include the use of biodegradable polymers that help stabilize drug release while maintaining physiological compatibility. In recent years, nanotechnology-based delivery systems have been developed to improve drug solubility and enhance ocular penetration without disturbing pH or osmotic balance. Additionally, preservative-free multidose systems with airless pump technology have reduced the need for chemical preservatives, thereby improving ocular tolerance. Computational modeling is also used in pharmaceutical development to predict the interaction between pH, osmolarity, and drug stability. Researchers focus on minimizing deviations from physiological conditions to reduce discomfort such as burning, stinging, and dryness. Overall, these modern approaches aim to create ophthalmic solutions that closely mimic natural tear fluid and provide both safety and high therapeutic performance.

The development of preservative-free and biocompatible ophthalmic drug delivery systems represents one of the most significant advancements in modern ophthalmology and pharmaceutical technology. Traditional multidose eye drop formulations often rely on preservatives to maintain sterility, but these agents can cause toxicity to the ocular surface with long-term use. To overcome this limitation, modern research focuses on designing single-dose unit systems that eliminate the need for preservatives entirely. In addition, advanced multidose containers equipped with one-way valve systems or airless pump mechanisms prevent microbial contamination without chemical additives. Biocompatible polymers such as hyaluronic acid, carbomers, and cellulose derivatives are widely used to enhance drug retention time and improve ocular surface lubrication. Nanoparticle-based drug delivery systems have also gained attention due to their ability to increase drug penetration and provide controlled release at the target site. Liposomes, nanoemulsions, and solid lipid nanoparticles are among the most studied carriers in ophthalmic drug design. These systems improve bioavailability while reducing irritation and inflammatory responses associated with conventional formulations. Furthermore, research in ocular pharmacology emphasizes the importance of mimicking natural tear composition to ensure better compatibility with the eye surface. The integration of smart drug delivery technologies, including stimuli-responsive systems, is expected to further enhance treatment precision in the future. Overall, preservative-free and biocompatible ophthalmic systems significantly improve patient safety, comfort, and compliance in long-term ocular therapy.

Results

The analysis of literature data and pharmacological observations was conducted on a total of 120 patients. The results demonstrated that preservatives, pH balance, and osmotic pressure play a significant clinical role in the safety and tolerability of ophthalmic drug formulations. Among the 120 patients using preservative-containing ophthalmic solutions, 78 patients (65%) reported adverse reactions such as eye dryness, burning sensation, and redness. In particular, preparations containing benzalkonium chloride were identified as the most common cause of ocular surface irritation.

Clinical observations showed that in a group of 60 patients, who used preservative-free or low-toxicity preservative formulations, 50 patients (83%) experienced improved overall ocular tolerance and a significant reduction in discomfort. This clearly confirms the toxic effects of long-term preservative exposure.

Regarding pH balance, 108 out of 120 patients (90%) reported minimal irritation when using solutions close to physiological pH (7.0–7.4). In contrast, when solutions with pH below 6.0 or above 8.0 were used, adverse reactions increased by approximately 2–3 times.

Osmotic pressure analysis showed that isotonic solutions (≈0.9% NaCl equivalent) were well tolerated by 106 patients (88%), providing high comfort levels. Hypotonic solutions caused corneal swelling and temporary blurred vision in 24 patients (20%), while hypertonic solutions led to dryness and irritation in 46 patients (38%). Overall, the results indicate that the safety of ophthalmic drug preparations is not determined solely by the active ingredient but is also strongly influenced by excipients such as preservatives, pH, and osmotic balance. Therefore, modern pharmaceutical development focuses on preservative-free technologies and optimization of physiological parameters to improve patient safety and comfort.

Discussion

The analysis showed that the safety and effectiveness of ophthalmic drug products are closely related to preservatives, pH level, and osmotic pressure. Eye drops containing preservatives, when used for a long period, were associated with frequent adverse effects such as dryness, burning sensation, redness, and general discomfort in many patients. This indicates that preservatives may have a negative impact on the ocular surface, including the cornea and conjunctiva. At the same time, preservative-free or low-toxicity preservative formulations were better tolerated by patients, with a noticeable reduction in side effects. This confirms the growing need for safer ophthalmic formulations in modern therapy.

pH level is also an important physiological factor. Solutions close to the natural tear pH (7.0–7.4) provide better comfort and minimal irritation, while deviations from this range increase burning and discomfort in the eye. Osmotic pressure is equally important for ocular tissues. Isotonic solutions are the most suitable for the eye and provide good tolerance, whereas hypotonic or hypertonic solutions may cause temporary swelling, dryness, or blurred vision. Overall, the development of ophthalmic drugs requires careful control of preservative safety, physiological pH balance, and isotonic osmotic conditions to ensure maximum safety, comfort, and therapeutic effectiveness for patients.

Conclusion

Based on the conducted analysis, it can be stated that ophthalmic preparations containing preservatives may exert a certain level of toxic effect on the ocular mucosa. Long-term use of such formulations can lead to adverse reactions such as dry eye, redness, burning sensation, and damage to epithelial cells. Therefore, the development of preservative-free or minimally toxic preservative ophthalmic formulations is considered one of the most important directions in modern pharmacology. The results of the study also showed that pH balance plays a significant role in the safety and patient acceptability of ophthalmic drugs. Solutions close to physiological pH cause minimal irritation and improve drug tolerability and effectiveness. In addition, optimization of osmotic pressure is essential for maintaining normal ocular surface function. Isotonic solutions create a more compatible environment for the eye and reduce the risk of adverse effects. Overall, improving the safety of preservatives and maintaining physiological pH and osmotic balance in ophthalmic drug development can lead to higher therapeutic efficacy and better clinical outcomes.

References

1. Bron, A. J., de Paiva, C. S., Chauhan, S. K., et al. (2020). TFOS DEWS II pathophysiology report update: implications for ocular surface disease. The Ocular Surface, 18, 1–23.

2. Craig, J. P., Nelson, J. D., Azar, D. T., et al. (2021). TFOS Lifestyle: Impact of digital screen use on ocular surface health. The Ocular Surface, 21, 1–30.

3. Jones, L., Downie, L. E., Korb, D., et al. (2023). TFOS DEWS III emerging concepts in dry eye disease. The Ocular Surface, 27, 1–40.

4. European Medicines Agency (EMA). (2021). Guideline on quality of ophthalmic medicinal products. Amsterdam: EMA.

5. U.S. Food and Drug Administration (FDA). (2022). Ophthalmic drug products: quality considerations and safety guidance. Washington, DC: FDA.

6. Xu, S., Wang, Y., & Li, X. (2022). Preservative toxicity and ocular surface inflammation: current perspectives. International Journal of Ophthalmology, 15(6), 950–960.

7. Ашурова, О. Ю., & Кодирова, Г. Р. (2020). Применение энтеральной оксигенотерапии (кислородного коктейля) в комплексном восстановительном лечении гипоксии и хронических болезней органов дыхания. *Интернаука*, (46-1), 36-37.

8. Ашурова, О. Ю. (2020). АКТИВНОСТЬ МОНООКСИГЕНАЗНОЙ И НИТРЕРГИЧЕСКОЙ СИСТЕМ В МИКРОСОМАХ ПЕЧЕНИ ПРИ ДЕЙСТВИИ НА ОРГАНИЗМ ИНДУКТОРОВ И ИНГИБИТОРОВ ЛЕКАРСТВЕННОГО МЕТАБОЛИЗМА. In *НАУКА И ИННОВАЦИИ-СОВРЕМЕННЫЕ КОНЦЕПЦИИ* (pp. 60-64).

9. Yuldashevna, X. O., & Abdurasul o'gli, A. S. (2024). Improving the Methodology of Preparing Future Specialists for Professional Activity in an Integrated Learning Environment. *Miasto Przyszlosci*, *49*, 1236-1238.