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Denysko T. V.

COMPARATIVE STUDY OF ANTIMICROBIAL PROPERTIES OF BIOMATERIALS AND DRESSINGS BASED ON ANTISEPTICS AGAINST GRAM-NEGATIVE BACTERIA AS PATHOGENS OF WOUND INFECTIONS

National Pirogov Memorial Medical University (Vinnytsya, Ukraine)
tanya.denisko@gmail.com

Given the global concerns about the spread of antibiotic resistance and the relatively limited therapeutic options for polyresistant strains of microorganisms that cause healthcare-associated infections, the development of bioactive biomaterials based on effective antiseptics is important and relevant.

The aim was to investigate the antimicrobial activity of new biomaterials developed on the basis of decamethoxine, polyvinyl alcohol and calcium alginate, and modern commercially available antimicrobial wound dressings against reference and clinical strains of K.pneumoniae, A .baumannii and P.aeruginosa.

Antimicrobial properties of new biomaterials with decamethoxine (DCM) and wound dressings Suprasorb® X + PHMB, SILVERCEL® Hydro-Alginate, Urgotul SSD®, GUANPOLISEPT®, Bétadine TULLE 10% DRESSING were studied on reference and clinical polyresistant strains of K.pneumoniae, A. baumannii, P.aeruginosa by Kirby-Bauer test with registration and comparison of the diameters of zones of inhibition.

Reference and clinical strains of A.baumannii show the greatest susceptibility to samples with DCM, as well as to biomaterials Suprasorb® and Guanpolisept® based on polyhexanide. Biomaterials with DCM, Suprasorb®, Guanpolisept® and Bétadine® were determined to be the most effective against reference and clinical strains of K.pneumoniae. Reference and clinical strains of P.aeruginosa are most susceptible to biomaterials with DCM and Bétadine®.

The developed biomaterials with DCM were not inferior in antimicrobial activity to modern effective wound dressings. The effectiveness of silver-containing wound dressings in vitro was inferior to the effectiveness of dressings with cationic detergents and iodophors.

Key words: *antimicrobial biomaterials, K.pneumoniae, A .baumannii, P.aeruginosa, antiseptics.*

Connection of the publication with planned research works.

The work was performed at the Department of Microbiology of National Pirogov Memorial Medical University, Vinnytsya during 2023, and is a fragment of the research works “Investigation of the biological properties of microorganisms included by the World Health Organization in the list of “priority pathogens”, which are the most threatening to human health, and the development of means of combating them” (state registration No. 0117U006903) and “Research of the biological properties of pathogens of healthcare-associated infections and the development of means of combating them” (state registration No. 0123U101070).

Introduction.

There is a worldwide need for new strategies to treat and achieve the fastest possible wound healing while minimizing patient discomfort and the appearance of scars [1, 2].

Critically colonized acute and chronic wounds require timely use of effective antibacterial agents [3], as wounds are a favorable niche for microbial colonization [4] with a high risk of infection with multidrug-resistant organisms (MDRO) [5].

Bacteria with a multidrug resistance (MDR) phenotype have become a serious threat in the clinic. The emergence of multiple drug resistance in bacteria has become one of the most terrible challenges of this century: the prevalence of infections that are difficult to treat is increasing, and there are no appropriate therapeutic alternatives [6-8].

The antimicrobial stewardship strategy stems from the need to counter resistant microorganisms and requires judicious use of available antimicrobial agents and treatment approaches to prevent the spread of resistance [9]. On the other hand, topical antibiotics are considered inappropriate or ineffective in combating wound biofilm [10]. Since the effective treatment of wounds today depends on non-antibiotic antimicrobial agents, scientists hope to use antiseptics in the management of patients with wound infections, which can replace, supplement (in the case of deep wound infections) or enhance (potentiate) the effect of antibiotics to prevent the spread of antibiotic-resistant strains [11-16].

But not only the activity of the medicinal compound, but also the method of delivery affects numerous factors that contribute to therapeutic effectiveness [17]. Therefore, active wound dressings based on biomaterials made of biocompatible polymers with the addition of effective antimicrobial compounds deserve special attention [18].

Such a polymer as alginate (Alg), due to favourable properties such as biocompatibility and ease of gelation, has become particularly attractive for the development of biomaterials [19]. Polyvinyl alcohol (PVA), in the manufacture of composite biomaterials, shows synergism with additional functional components, including Alg, in improving wound healing and improving the physicochemical properties of biomaterials [2, 20].

Different forms of biomaterials (films, hydrogels, foams, etc.) with integrated antimicrobial drugs were

developed to enhance the antibacterial effect and to ensure the controlled release of the active compound [3].

The development and implementation of biomaterials in the form of bioactive or therapeutic wound dressings with integrated bioactive molecules (antiseptics) for achieving controlled antibacterial treatment is relevant and promising.

The aim of the study.

To investigate the antimicrobial activity of new biomaterials developed on the basis of decamethoxine, polyvinyl alcohol and calcium alginate, and modern commercially available antimicrobial wound dressings against reference and clinical strains of causative agents of healthcare-associated wound infections, *K.pneumoniae, A.baumannii and P.aeruginosa.*

Object and research methods.

For the study, developed biomaterials with decamethoxine and commercially available wound dressings containing antiseptics were used, which were marked with the appropriate numbers: №1 Decametoxine (DCM), №2 Decametoxine (DCM), №3 Decametoxine (DCM), №4 – Suprasorb® X + PHMB, №5 – SILVERCEL® Hydro-Alginate, №6 – Urgotul SSD®, №7- GUANPOLISEPT®, №8 – Bétadine® TULLE 10% DRESSING. The initial diameter of all tested materials was 6 mm.

Samples of biomaterials with decamethoxine were made from calcium alginate (Ca-Alg), polyvinyl alcohol (PVA) and antiseptic (0.05% DCM) by solvent casting method [21]. The composition of the studied samples: **№1 –** 0.05% DCM + PVA + Ca-Alg; **№2 –** 0.05% DCM + Ca-Alg; **№3** 0.05% DCM + PVA + Ca-Alg + EDTA.

Antimicrobial properties of biomaterials were tested on reference strains of the Museum for Living Cultures of the Department of Microbiology of the National Pirogov Memorial Medical University (Vinnytsya, Ukraine) *K.pneumoniae ATCC 700603, A. baumannii BAA-747, P.aeruginosa ATCC 27853* and clinical MDR isolates of these species of microorganisms, which were obtained from patients with infected burns and shrapnel wounds of various localization as a result of combat trauma.

Mueller-Hinton agar and Mueller-Hinton broth (HiMedia Laboratories, India) were used for the cultivation of microorganisms. The antibacterial activity of the developed biomaterials and commercially available wound dressings was studied on Mueller-Hinton agar (HiMedia Laboratories, India) using the generally accepted disk diffusion method (Kirby-Bauer test) with registration and comparison of the diameters of zones of inhibition (ZOI) based on the recommendations of the Clinical and Laboratory Standards Institute (CLSI, USA, 2021) and the European Committee on Antimicrobial Susceptibility Testing [22-24].

There are currently no approved European Committee on Antimicrobial Susceptibility Testing (EUCAST) or Clinical Laboratory Standards Institute (CLSI) guidelines with current Breakpoint Tables for the interpretation of zone diameters by susceptibility categories (S, I and R) for antiseptics and antimicrobial materials. Therefore, the interpretation of the results was carried out on the basis of a comparison of the diameters of the zones of inhibition around the cultures of reference and clinical strains of *K.pneumoniae, A.baumannii, P.aeruginosa* under the action of the studied biomaterials with the calculation of the arithmetic mean (M), the mean arithmetic error (m) and the the reliability of the difference (p). The Susceptibility of each strain was studied in four replicates.

Research results and their discussion.

As a result of the study of the activity of biomaterials against reference and clinical strains of *K.pneumoniae, A. baumannii and P.aeruginosa*, high antimicrobial properties of materials based on decamethoxine and commercially available wound dressings were revealed **(tables 1, 2)**.

The reference strain *K.pneumoniae ATCC 700603* was most susceptible to Suprasorb® (№4), Guanpolisept® (№7), Bétadine® (№8) and samples with DCM №1-3. Among them, the action of samples with decamethoxine №1 and №2 was determined to be the most effective **(table 1)**. ZOIs around DCM №1 and DCM №2 exceeded those around silver-containing materials (№5 and №6) by 2.34-2.84 times (p<0.001). Dressings based on polyhexanide Suprasorb® and Guanpolisept® were more effective than silver-containing dressings by 2.24-2.68 (p<0.001) and 1.84-2.21 times (p<0.001), respectively. Susceptibility of *K. pneumoniae ATCC 700603* to biomaterial with povidone-iodine was higher, compared to susceptibility to silver-containing ones by 1.48-1.8 times (p<0.001).

Table 1 – Effectiveness of antimicrobial biomaterials against reference strains of *K.pneumoniae, A.baumannii and P.aeruginosa* (mean values of ZOIs, M±m, mm)

Biomaterials / Strains	*K. pneumoniae* ATCC 700603	*A. baumannii* BAA-747	*P.aeruginosa* ATCC 27853
№1 DCM	20.18±0.22	15.61±0.01	13.47±0.28
№2 DCM	19.13±0.19	15.41±0.01	14.01±0.36
№3 DCM	19.98±0.1	15.76±0.02	13.78±0.19
№4 Suprasorb®	19.06±0.19	16.31±0.15	11.02±0.18
№5 Silvercel®	7.1±0.02	7.61±0.03	7.2±0.25
№6 Urgotul®	8.51±0.04	8.43±0.04	7.82±0.29
№7 Guanpolisept®	15.69±0.01	14.11±0.21	7.14±0.32
№8 Bétadine®	12.56±0.26	9.08±0.13	10.13±0.004

Thus, based on the average ZOIs of *K. pneumoniae ATCC 700603*, the following activity of biomaterials was established (from the most effective):

№1 DCM > **№3** DCM > **№2** DCM > **№4**-Suprasorb® > **№7**-Guanpolisept® > **№8**-Bétadine® >**№6**-Urgotul®> **> №5**-Silvercel®.

Clinical strains turned out to be much more tolerant, but the tendency of *K. pneumoniae* to show sensitivity to certain biomaterials was also observed in clinical strains. Antimicrobial properties of Suprasorb® and samples with decamethoxine were most actively demonstrated **(table 2, fig.)**. Biomaterial №4 – Suprasorb® was determined to be the most active biomaterial based on ZOI data, but its average ZOI values did not differ significantly from those of biomaterials based on decamethoxine №1, №2, and №3 (p>0.05), so their effectiveness should be considered equivalent.

The ranking of the effectiveness of biomaterials against clinical strains of *K. pneumoniae* based on the average values of ZOIs (from the most effective) was as follows **(table 2)**:

№4 – Suprasorb®>**№1** DCM > **№ 3** DCM >**№2** DCM > **№7**- Guanpolisept®> **№8** – Bétadine®>**№6**- Urgotul®>**№5** – Silvercel®

As a result of the study of the activity of biomaterials against reference and clinical strains of *A.baumannii*, similar patterns were revealed: biomaterials based on decamethoxine and polyhexanide (Suprasorb®, Guanpolisept® and No. 1-3 DCM) were the most effective, but the difference in the susceptibility of reference strains compared to clinical ones was not as pronounced as for *K. pneumoniae* **(tables 1, 2)**. The highest efficiency against the reference strain *A.baumannii BAA-747* was observed in Suprasorb® wound dressing and the difference in values was significant (from p<0.01 to p<0.001). ZOIs against clinical strains of *A.baumannii* were also found to be the greatest for Suprasorb®, but the mean ZOIs were not significantly different from those of decamethoxin-based biomaterials №1, №2, and №3 (p>0.05), and thus they were equally effective **(table 2, fig.)**.

The multiplicity of the difference in ZOI values of clinical strains for Suprasorb® and silver-containing materials was 1.93-2.21 times (p<0.001), and in comparison with povidone-iodine dressing – 1.72 times (p<0.001). ZOIs around decamethoxin-containing samples were 1.81-2.16 times larger compared to silver-containing ones (p<0.001) and 1.62-1.68 times larger compared to povidone-iodine dressings (p<0.001).

Rating scale of the effectiveness of biomaterials in relation to the reference strain *A.baumannii BAA-747* (from the most active):

№ 4 – Suprasorb®> **№3** DCM > **№ 1** DCM >**№2** DCM >**№7**- Guanpolisept®>**№8** – Bétadine®>**№ 6**- Urgotul®>**№5** – Silvercel®,

And with regard to clinical strains –

№ 4 – Suprasorb®> **№2** DCM > **№ 3** DCM >**№1** DCM >**№7**- Guanpolisept®>**№8** – Bétadine®>**№ 6**- Urgotul®>**№5** – Silvercel®

The smallest ZOIs were observed for *P.aeruginosa* (Tables 1, 2). *Pseudomonas aeruginosa* is the most antimicrobial-resistant wound pathogen. Reference strains have natural, and clinical strains have natural and acquired resistance to biocides [25-27].

Biomaterials according to their effectiveness against the reference strain *P.aeruginosa ATCC 27853* (based on average ZOIs) were distributed as follows (from the most effective):

№2 DCM >**№3** DCM >**№1** DCM >**№4**-Suprasorb® >**№8**-Bétadine®>

№6- Urgotul®>**№5**-Silvercel®>**№7**-Guanpolisept®.

Table 2 – Effectiveness of antimicrobial biomaterials against clinical strains of *K.pneumoniae, A.baumannii and P.aeruginosa* (mean values of ZOIs, M±m, mm)

Biomaterials / Strains	*K. pneumoniae* (n=11)	*A. baumannii* (n=14)	*P.aeruginosa* (n=12)
№1 DCM	12.47±0.89	13.4±0.44	11.93±0.38
№2 DCM	11.52±0.69	13.91±0.28	12.57±0.35
№3 DCM	12.01±0.91	13.6±0.3	12.3±0.64
№4 Suprasorb®	13.49±0.7	14.26±0.2	8.51±0.47
№5 Silvercel®	6.68±0.13	6.45±0.16	6.32±0.11
№6 Urgotul®	8.03±0.28	7.38±0.28	7.58±0.2
№7 Guanpolisept®	10.99±0.75	10.13±0.27	6.25±0.11
№8 Bétadine®	9.69±0.27	8.27±0.27	9.52±0.14

Ranking of biomaterials by efficiency rating against clinical strains of *P.aeruginosa* based on the average values of ZOIs (from the most effective):

№2 DCM >**№3** DCM >**№1** DCM M >**№8**-Bétadine® >**№4**-Suprasorb® >

№6- Urgotul®>**№5**-Silvercel®>**№7**-Guanpolisept®

Samples with decamethoxin № 1-3 were the most effective against reference and clinical strains of *P.aeruginosa*, their average values of ZOIs were not significantly different from each other (p>0.05), and the effectiveness was equivalent, and the reliability of the difference in values with other biomaterials was equally high (p<0.001).

For example, sample № 2 DCM against clinical strains of P.aeruginosa was 1.48 times more effective than No. 4-Suprasorb® (p<0.001), 1.99 times more effective than Silvercel® (p<0.001), 1.66 times more effective than Urgotul ® (p<0.001), 2.01 times – for Guanpolisept® (p <0.001), 1.32 times – for Bétadine® (p<0.001) **(table 2, fig.)**.

Biomaterial №8-Bétadine® was identified as the next most effective. The average diameters of ZOIs in relation to clinical strains of *P.aeruginosa* for Bétadine® differed significantly from those for Suprasorb® by 1.12 times (p<0.05), for Silvercel by 1.51 times (p<0.001), for Urgotul® by 1.26 times (p<0.001), for Guanpolisept® by 1.52 times (p<0.001). Suprasorb® was 1.35 times more effective than Silvercel® (p<0.001), 1.36 times more effective than Guanpolisept® (p<0.001). The values of ZOIs for Suprasorb® and Urgotul® were not significantly different (p>0.05). Urgotul® was 1.2 times more effective than Silvercel® (p<0.001), 1.21 times more effective than Guanpolisept® (p<0.001). Some clinical strains of

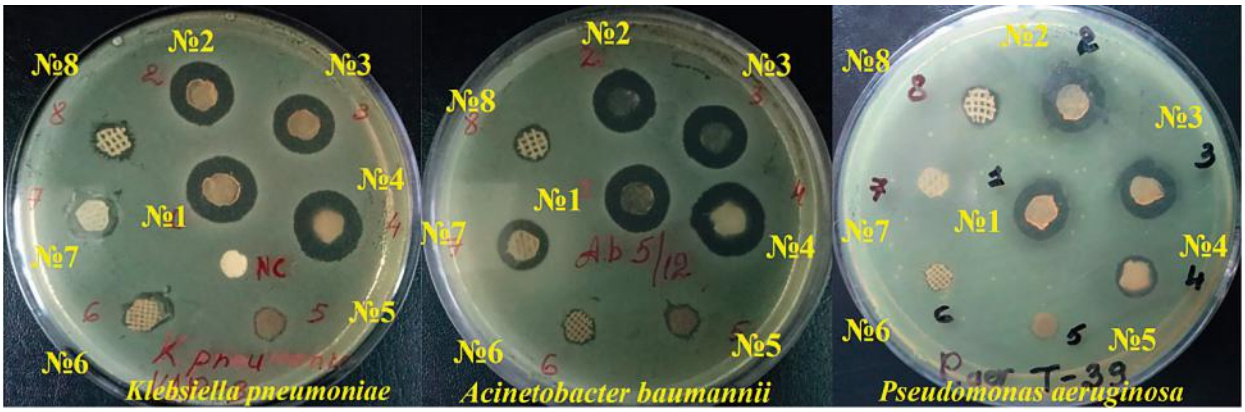

Figure – Zones of inhibition around samples of biomaterials №1-8.

P.aeruginosa were completely resistant to Silvercel® and Guanpolisept®.

Thus, reference and clinical strains of *P.aeruginosa* were most susceptible to antimicrobial biomaterials based on decamethoxine, as well as to Bétadine® biomaterial.

The prevention and treatment of healthcare-associated infections (HCAI) remains a global public health challenge [28].

Surgical site infections (SSIs), infectious complications of wounds and burns (including combat wounds) are mainly caused by microorganisms resistant to the most commonly used antimicrobial drugs and are characterized by multiple drug resistance. Carbapenem-resistant *K.pneumoniae* (CRKP), *P.aeruginosa* (CRPA) and *A.baumannii* (CRAB) are among the dominant and threatening agents in the structure of pathogens [29-36].

New technologies and materials can help in this fight against HCAI, so the development of biomaterials with antibacterial properties is a promising area of research [37].

As a result of research and comparative assessment of antimicrobial properties of new and commercially available biomaterials based on antiseptics, a high level of antimicrobial activity of new biomaterials based on decamethoxine was revealed. The developed biomaterials were not inferior to modern effective wound dressings based on cationic detergents and silver-containing wound dressings, they actively inhibited the growth of reference and clinical strains of *K.pneumoniae, A.baumannii, P.aeruginosa*, and were often the most active.

The results of the study showed that Suprasorb® and Guanpolisept®, which contain polyhexanide, have the highest activity against *K.pneumoniae* and *A.baumannii* among commercially available modern wound dressings; against *P.aeruginosa* – Suprasorb®, and Bétadine® containing povidone-iodine. The effectiveness of silver-containing wound dressings in vitro was inferior to the effectiveness of dressings with cationic detergents and iodophors.

Guiomar, A. J. et al. also report high antibacterial activity of their developed and control commercial (Suprasorb®) polyhexanide-releasing membranes against *K.pneumoniae, A.baumannii* and *P.aeruginosa* based on the disk diffusion test. The authors also note that *P.aeruginosa* was the bacterial species that most often resisted the antibacterial activity of the polyhexanide-based biomaterials developed by the authors and commercial analogues. In one large-scale study, biomaterials loaded with 0.1% PHMB (polyhexamethylene biguanide) demonstrated antibacterial activity that exceeded that of a commercial silver-based wound dressing, but was sometimes inferior to equivalent membranes loaded with the antiseptics octenidine and povidone-iodine [38].

Garcia, L. V. and co-authors found good antimicrobial properties of casein hydrogel dressings based on polyhexanide or Octiset® against *S.aureus* and *P.aeruginosa*, and some samples with polyhexanide were more effective [39].

Eberlein, T et al found that dressings with PHMB removed the bacterial load significantly faster and better than dressings with silver in patients with locally infected or critically colonized wounds [40].

Stuermer, E. K, and others studied the antibiofilm activity of antimicrobial dressings, including silver-containing and polyhexanide-containing ones. The authors note that silver-containing wound dressings showed no bacteriostatic or bactericidal activity in a P.aeruginosa biofilm model, whereas a polyhexanide dressing showed a significant inhibitory effect [41]. Dydak K, et al also found that dressings chemisorbed with polyhexanide or povidone-iodine provided equivalent or even higher antibiofilm activity than dressings containing silver molecules [42].

Conclusions.

Comparative studies of antimicrobial properties of developed biomaterials and commercially available antimicrobial dressings revealed high antimicrobial properties of new decamethoxin-based biomaterials against reference and clinical strains of target microorganisms, which are leading pathogens of wounds and burns.

Reference and clinical strains of *A.baumannii* show the greatest susceptibility to samples with decamethoxin (№ 1-3 DCM), as well as to biomaterials Suprasorb® X + PHMB and Guanpolisept® based on polyhexanide.

Biomaterials with decamethoxin №1, №2 and №3, Suprasorb®, Guanpolisept® and Bétadine® were determined to be the most effective against reference and clinical strains of *K.pneumoniae*.

Reference and clinical strains of *P.aeruginosa* are most susceptible to biomaterials with decamethoxin №1, №2 and №3 and Bétadine®.

Prospects for further research.

In the future, we plan to adapt this biomaterial composition to different physical forms of wound dressings. The developed biomaterials are presented in the form of a film. These polymer films, made by casting from a solvent, are well suited as a base layer in multilayer compositions, hydrogels, plasters. Hydrogel alginates are also very useful in lyophilized form. We plan to expand the range of polymers that serve as a matrix for the controlled release of decamethoxine (for example, cellulose, chitosan, hyaluronic acid), and to investigate the microbiological and physicochemical parameters of new compositions. In order to increase the efficiency of the system with controlled release of the active substance, it is planned to investigate the preprogramming of the system (biomaterial) using the combination of physical and chemical techniques.

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ПОРІВНЯЛЬНЕ ДОСЛІДЖЕННЯ АНТИМІКРОБНИХ ВЛАСТИВОСТЕЙ БІОМАТЕРІАЛІВ ТА ПОВ'ЯЗОК НА ОСНОВІ АНТИСЕПТИКІВ ПО ВІДНОШЕННЮ ДО ГРАМНЕГАТИВНИХ БАКТЕРІЙ ЯК ЗБУДНИКІВ РАНОВИХ ІНФЕКЦІЙ

Денисько Т. В.

Резюме. *Вступ.* Виникнення множинної лікарської стійкості у бактерій стало одним із найстрашніших викликів цього століття: зростає поширеність інфекцій, які важко лікувати, відповідні терапевтичні альтернативи відсутні. Тому розробка та впровадження біоматеріалів у формі біоактивних, чи лікувальних ранових пов'язок з інтегрованими біоактивними молекулами (антисептиками) для досягнення контрольованого антибактеріального лікування є актуальною і перспективною.

Мета – дослідження антимікробної активності нових біоматеріалів, розроблених на основі декаметоксину, полівінілового спирту та альгінату кальцію, та сучасних комерційно доступних антимікробних ранових пов'язок щодо референтних та клінічних штамів збудників ранових інфекцій, пов'язаних із наданням медичної допомоги, *K.pneumoniae, A.baumannii* та *P.aeruginosa.*

Об'єкт і методи дослідження. Антимікробні властивості нових біоматеріалів із декаметоксином (ДКМ№1-3) та комерційно доступних ранових пов'язок Suprasorb® X + PHMB, SILVERCEL® Hydro-Alginate, Urgotul SSD®, GUANPOLISEPT®, Bétadine TULLE 10% DRESSING вивчали на референтних та клінічних полірезистентних штамах *K.pneumoniae*, *A. baumannii, P.aeruginosa* методом дискової дифузії (Kirby-Bauer тест) з реєстрацією та порівнянням діаметрів зон затримки росту (ЗЗР).

Результати. Порівняльні дослідження протимікробних властивостей розроблених біоматеріалів та комерційно доступних антимікробних пов'язок виявили високі антимікробні властивості нових біоматеріалів на основі декаметоксину проти референтних та клінічних штамів цільових мікроорганізмів, що є провідними патогенами ран та опіків.

Штами *A.baumannii* проявляли найбільшу чутливість до зразків з декаметоксином (№1-3 ДКМ), а також до біоматеріалів Suprasorb® та Guanpolisept® на основі полігексаніду. По відношенню до референтного та клінічних штамів *K.pneumoniae* найефективнішими було визначено біоматеріали із декаметоксином №1, №2 та №3, Suprasorb®, Guanpolisept® та Bétadine®. Референтні та клінічні штами *P.aeruginosa* є найбільш чутливими до біоматеріалів із декаметоксином №1, №2 та №3 та Bétadine® на основі повідон-йоду.

Висновки. Розроблені біоматеріали з декаметоксином не поступалися сучасним ефективним рановим покриттям на основі катіонних детергентів та срібло-вмісним покриттям, активно пригнічували ріст референтних та клінічних штамів *K.pneumoniae*, *A. baumannii, P.aeruginosa,* часто виявлялись найбільш активними. *In vitro* ефективність срібло-вмісних ранових пов'язок поступалася ефективності пов'язок з катіонними детергентами та йодофорами.

Ключові слова: антимікробні біоматеріали, *K.pneumoniae, A.baumannii, P.aeruginosa,* антисептики.

COMPARATIVE STUDY OF ANTIMICROBIAL PROPERTIES OF BIOMATERIALS AND DRESSINGS BASED ON ANTISEPTICS AGAINST GRAM-NEGATIVE BACTERIA AS PATHOGENS OF WOUND INFECTIONS

Denysko T. V.

Abstract. *Introduction.* The emergence of multiple drug resistance in bacteria has become one of the most terrible challenges of this century: the prevalence of infections that are difficult to treat is increasing, and there are no appropriate therapeutic alternatives. Therefore, the development and implementation of biomaterials in the form of bioactive or therapeutic wound dressings with integrated bioactive molecules (antiseptics) for achieving controlled antibacterial treatment is relevant and promising.

Aim. To investigate the antimicrobial activity of new biomaterials developed on the basis of decamethoxine, polyvinyl alcohol and calcium alginate, and modern commercially available antimicrobial wound dressings against reference and clinical strains of causative agents of healthcare-associated wound infections, *K.pneumoniae, A .baumannii and P.aeruginosa.*

Object and methods. Antimicrobial properties of new biomaterials with decamethoxine (DCM №1-3) and commercially available wound dressings Suprasorb® X + PHMB, SILVERCEL® Hydro-Alginate, Urgotul SSD®, GUANPOLISEPT®, Bétadine TULLE 10% DRESSING were studied on reference and clinical polyresistant strains of *K.pneumoniae, A. baumannii, P.aeruginosa* by the disk diffusion method (Kirby-Bauer test) with registration and comparison of the diameters of zones of inhibition (ZOI).

Results. Comparative studies of antimicrobial properties of developed biomaterials and commercially available antimicrobial dressings revealed high antimicrobial properties of new decamethoxin-based biomaterials against ref-

erence and clinical strains of target microorganisms, which are leading pathogens of wounds and burns. Reference and clinical strains of *A.baumannii* show the greatest susceptibility to samples with decamethoxin (№ 1-3 DCM), as well as to biomaterials Suprasorb® and Guanpolisept® based on polyhexanide. Biomaterials with decamethoxin №1, №2 and №3, Suprasorb®, Guanpolisept® and Bétadine® were determined to be the most effective against reference and clinical strains of *K.pneumoniae*. Reference and clinical strains of *P.aeruginosa* are most susceptible to biomaterials with decamethoxin №1, №2 and №3 and Bétadine®.

Conclusions. The developed biomaterials were not inferior to modern effective wound dressings based on cationic detergents and silver-containing wound dressings, they actively inhibited the growth of reference and clinical strains of *K.pneumoniae, A.baumannii, P.aeruginosa*, and were often the most active. The effectiveness of silver-containing wound dressings in vitro was inferior to the effectiveness of dressings with cationic detergents and iodophors.

Key words: antimicrobial biomaterials, *K.pneumoniae, A .baumannii, P.aeruginosa,* antiseptics.

ORCID and contributionship:
Denysko T. V.: https://orcid.org/0000-0002-2188-2001 ABCDEF

Corresponding author
Denysko Tetyana Valeriyivna
National Pirogov Memorial Medical University
Ukraine, 21018, Vinnytsia, 56 Pyrohova str.
Tel.: +380969358394
E-mail: tanya.denisko@gmail.com

A – Work concept and design, **B** – Data collection and analysis, **C** – Responsibility for statistical analysis, **D** – Writing the article, **E** – Critical review, **F** – Final approval of the article.

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Drehval O. A., Lesychna A. V., Drehval I. V., Sklyar T. V.

INFLUENCE OF CARBON AND NITROGEN SOURCES ON BIOMASS YIELD AND FUNGISTATIC ACTIVITY OF *TRICHODERMA VIRIDE* KMB-F-15

Oles Honchar Dnipro National University (Dnipro, Ukraine)
dregigor24@gmail.com

Micromycetes of the Trichoderma genus are the most common biological agents used in agriculture today to control plant mycoses. Using biological products allows us to produce environmentally friendly agricultural products and reduce the chemical burden on the environment. When choosing carbon and nitrogen sources as a basic base for developing the optimal composition of the nutrient medium for deep cultivation of microorganisms, it is necessary to consider their genus and strain characteristics.

In this study, we investigated the effect of carbon and nitrogen sources on the biomass accumulation and fungistatic activity of Trichoderma viride strain KMB-F-15, an antagonist of a wide range of phytopathogenic fungi. The fungistatic activity was determined by inhibition of growth of the phytopathogenic fungus Fusarium culmorum IMB-F-50716 when the filtrate of T. viride KMB-F-1 culture fluid was added to the dense medium. It was found that glycerol and green molasses at a concentration of 20 g/l resulted in the highest yield of dry biomass of T. viride KMB-F-15 (5.0 g/l and 4.9 g/l, respectively). The most favourable nitrogen sources for the fungus growth at a concentration of 5 g/l were yeast autolysate (dry biomass yield – 4.4 g/l) and ammonium chloride (3.3 g/l). The fungistatic activity of T. viride KMB-F-15, regardless of the carbon source, was high (94.7-100%). The manifestation of fungistatic activity was influenced by the source of nitrogen nutrition. The highest percentage of growth inhibition of the phytopathogen was observed when corn extract, yeast autolysate, L-glutamic acid, ammonium chloride or ammonium sulfate were used (88.5-100%).

Key words: *Trichoderma, submerged cultivation, accumulation of biomass, antagonistic properties, phytopathogenic fungi.*

Connection of publication with planned research works.

The article is a fragment of the research work of the Department of Microbiology, Virology and Biotechnology of Oles Honchar Dnipro National University: “Antagonistic and synergistic relationships in microbial associations” (state registration number 0122U001456).

Introduction.

Today, the chemical method prevails in protecting agricultural plants from pests. Compared to other pesticides, fungicides are considered less threatening to non-target organisms, but some are also banned as evidence of their negative impact on biota is accumulated [1]. In addition, the widespread use of fungicides creates se-