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RESEARCH OF THE BACTERICIDAL PROPERTIES AND TOXICITY OF COMPOSITIONS FOR STONE FRUIT PRESERVATION

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Abstract. Damage of stone fruit during storage begins with the development of mycelial fungi on their surface that destroy the shell of a fruit and its anatomical integrity. Therefore, developing new tools for processing stone fruits on the basis of components harmless to people is a topical task of the modern agricultural, phytochemical, and biological industries. Nine compositions from extracts of medicinal plants and 2% of chitosan have been developed. The raw materials used to obtain extracts were: aloe leaves, camomile inflorescences, spruce bark (in the ratios 4:3:2, 5:4:3, 3:1:2, samples 1, 2, 3, respectively); eucalyptus leaves, basil herbs, thyme herbs (in the ratios 1:2:1, 2:4:3, 2:5:2, samples 4, 5, 6, respectively); lemon balm leaves, sage leaves, verbena grass (in the ratios 3:2:1, 4:3:2, 3:1:1, samples 7, 8, 9, respectively). All the compositions have been tested for fungicidal properties against *Monilinia laxa* and for antimicrobial activity by the sanitary-bacteriological method, and for toxicity by bacteriological methods (the method of direct inoculation on blood agar and the method of diffusion into agar). In all the samples studied, inhibited growth of the culture of the agent causing stone fruit moniliosis has been detected. All nine compositions have revealed antimicrobial action against *Bacillus cereus* ATCC 107-02, *Escherichia coli* ATCC-25922, and *Candida albicans* ATCC-885-653, with the best results in samples 1, 2, 3, 4, 6, 9. In the study of toxicity by direct inoculation on blood agar, samples 1, 2, 6 caused hemolysis of erythrocytes only in the area of application of the sample. Other samples did not show hemolytic activity. The study has shown that samples 3, 4, 9 are safe for humans, they demonstrate fungicidal properties and antimicrobial action against pathogens of stone fruits, which makes it possible to use them as components of chitosan-based film-forming compositions during storage.

Key words: extract, composition, medicinal herbs, hemolysis, antimicrobial activity.

Introduction. Formulation of the problem

Damage of stone fruits during storage begins with the development of mycelial fungi on their surface that destroy shell of a fruit and its anatomical integrity. The most common pathogens are fungi of the *Archmycetes* genus, fungi of the *Ascomycetes* genus and multicellular fungi of the *Fungi imperfecti* genus. Yeast fungi most often infect fruits and cause them to turn sour. In addition, fruits rich in peptides and organic acids can form bacterial rot. Various bacteria can cause this process, most often bacteria of the *Pectobacterium*, *Pseudomonas* and *Bacillus* genera, which cause darkening, destruction of the structure and softening of the fruit, and acetic acid strains cause acidification [1].

The main percentage of yield losses of cherries and apricots is due to fungal spoilage (Fig. 1) during storage. The development and implementation of new effective non-toxic means for the treatment of stone fruits can be effective in protecting the crop from pests.

Analysis of recent research and publications

O. Rosca-Casian, M. Parvu, L. Vlase and M. Tamas [2] proved high antifungal activity of aloe extracts against pathogens of the *Botrytis, Fusarium, Heterosporium* and *Penicillium* genera with a minimum fungicidal concentration of about 80–100 µl/ml. The scientists Y. Saks and R. Barkai-Golan [3] proved that the extract is able at a dose of 1 µl/l to destroy spores of *Penicillium digitatum, Penicillium expansum, Botrytis cinerea* and *Alternaria alternata*, and at concentrations of 100–105 µl/l is almost 95% efficient.

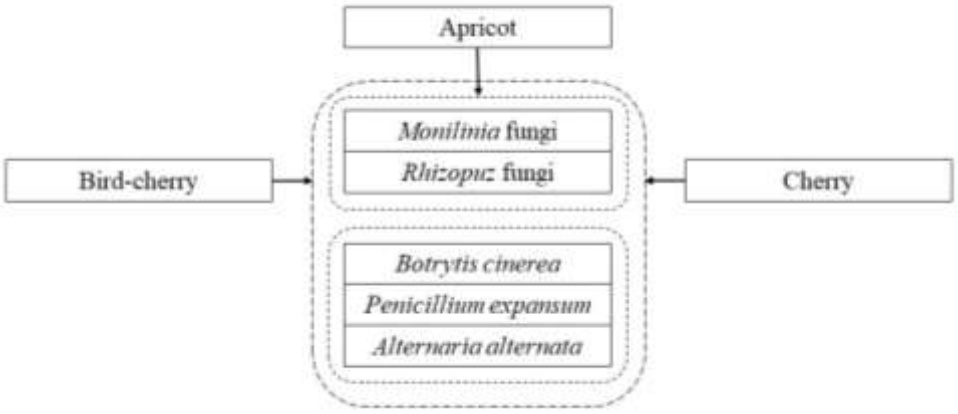


Fig. 1. The main pathogenic fungi that spoil the fruits of cherries and apricots

In the research made by G. Teodorescu, M. Sumedrea, F.C. Marin and F. Murariu [4] providing that 10% concentration in agar during short-term incubation, the combined extract of camomile inflorescence reduced the growth of fungi almost twice. Incubation under the influence of the extract for 7 days reduces the colonies size by almost 5.5 cm compared to the negative control, after 14 days – by 3 cm, and after 21 days – by 2 cm, indicating stable and long-term activity of camomile extract against *Monilinia spp.*

Alcoholic extract of spruce bark at a concentration of 20 mg/l per 100% inhibits the growth of mycelium of plant pathogens *Botrytis cinerea, Colletotrichum acutatum, Phytophthora cactorum* and *Mycosphaerella fragariae* [5].

Among fungal pathogens, aqueous extract of eucalyptus leaves was the most effective against *Geotrichum candidum* (MIC - 4.88 μg/ml) *and Aspergillus brasiliensis* (MIC – 2.44 μg/ml). Among bacterial pathogens, the extract showed the best performance against *Staphylococcus lugdunensis* at a minimum inhibitory concentration of 78 μg/ml [6].

Alcohol extract of eucalyptus leaves at a concentration of 15% inhibited the growth zone of the mycelium of *Alternaria alternata* by 0.5 cm. The authors recommend to use the extract in agriculture to control the pathogen [7].

Aqueous and alcoholic extracts of eucalyptus leaves are effective against fungi of the *Penicillium* genus. At a concentration of 80 mg/ml, the zone of growth inhibition of *Penicillium digitatum* was 15 mm for aqueous extract and 17 mm for alcoholic extract. The same study proved antimicrobial effect against *Staphylococcus aureus* and *Escherichia coli* [8].

At a concentration of 7 mg/ml, the extract of basil completely inhibits the growth of *Cladosporium cladosporioides* pathogen, and at a concentration of 15 mg/ml – inhibits the growth of mycelium of all model microorganisms [9].

The influence of thyme extracts with a high content of essential oil on spore formation was studied with the use of the forms of pathogens isolated from food: *Penicillium sp., Alternaria sp.* and *Aureobasidium sp*. The research was performed by the method of discs diffusion into agar. At a concentration of 8 mg/disc, the extract inhibited the germination of spores from 80% to 100% depending on the type of pathogen. After analysing the results, the authors recommend to use concentration of 4 mg/l, if the source content of spores in the infected environment or object is not very high [10].

The research of antifungal properties of the extracted essential oil of lemon balm indicate significant activity against *Cladosporium carrionii* (at a concentration of 512 μg/ml – complete inhibition of mycelial growth and germination of spores), *Botrytis cinerea* (at a dose of 2 μl/ml inhibited the growth of 80% pathogen at a dose of 160 μl per disc completely – mycelial growth) and *Penicillium expansum* (at a dose of 2 μl/ml and 160 μl per disc completely inhibited mycelial growth) [11].

Aqueous lemon balm extract at a concentration of 25 mg/ml was able to completely inhibit the growth of *Candida albicans,* and alcohol extract at a concentration of 100 μl/ml almost completely inhibited the growth of *Saccharomyces cerevisiae* pathogen. The minimal inhibitory concentration for the essential oil is 3.9 μg/ml for *Candida parapsilosis* and 1.9 μg/ml for *Candida glabrata*, which is better than itroconazole and fluconazole indicators. At a concentration of 5 mg/l, the essential oil has been shown to almost completely inhibit the growth of *Verticillium dahliae* and *Penicillium aurantiogriseum* mycelium [12-15].

In case of direct contact with *Rhizopus stolonifer* pathogen, lemon balm essential oil in the amount of 24 μl completely inhibits the growth of *Rhizopus stolonifer* mycelium even 7 days after incubation [16].

At a dose of 250 ppm, each of the components of verbena essential oil effectively inhibits the growth and development of *Botrytis cinerea, Penicillium italicum, Penicillium expansum, Phytophthora citrophthora* and *Rhizopus stolonifer* pathogens. The authors concluded that *Verbena officinalis* may be a promising raw material for the manufacture of effective harmless antifungal agents [17].

The essential oil of *Verbena officinalis* possesses antifungal properties against pathogenic fungi of the *Monilinia* genus. Thus, Hazem S. Elshafie *et al.* in their study showed that the essential oil (standardised by citral – 44.5%) at a concentration of 1000 ppm completely inhibited the growth and development of *Monilinia laxa, Monilinia fructigena, Monilinia fructicola* and reduced diameter of the lesion [19].

Synthetic agents (broad-spectrum contact fungicides) are commonly used to protect food raw materials, which have toxicological profile on a human body, can cause poisoning and damage health if consumers do not treat them properly. Thus, the development of new tools for stone fruits processing on the basis of plant components harmless to humans is a very important task of modern agricultural, phytochemical and biological industries.

The purpose of the research is to create film-forming compositions based on chitosan for the treatment of stone fruits and experimental investigation of toxicityand fungicidal properties. According to the purpose of the research, the following objectives were defined:

– to create nine types of film-forming composition with the addition of 2% of chitosan;

– to determine the fungicidal properties of the created compositions;

– to determine antimicrobial activity by the method of sanitary bacteriology;

– to analyse the toxicity of the compositions.

Research materials and methods

*Materials under examination***.** Based on the literature analysis of fungicidal properties of medicinal plant materials, nine extracts were created by maceration: crushed medicinal raw materials were mixed with aqueous-alcohol-glycerol solution (1:5). The flowers were not crushed, leaves and grass were crushed to 3-5 mm, spruce bark – 7 mm. The composition of water-alcohol-glycerol solution includes alcohol – 40%, glycerol – 10%, and water – 50%. The use of aqueous-alcoholic-glycerol solution as an extract provides long-term storage and storage of biologically active substances (BAS) in medicinal raw materials. Aqueous-alcoholic-glycerol extracts were infused for 7–10 days in a dark cool room. The prepared extracts were stored in a dark glass container with a tight-fitting lid and stored at 4-6°C for 3 weeks. The content of BAS in the extracts varies significantly depending on the chemical composition of medicinal and plant raw materials. The extracts with the following concentrations: aloe leaf extract – 5%, camomile inflorescence extract – 5%, spruce bark extract – 4.4%, eucalyptus leaf extract – 6.5%, basil herb extract – 5.2%, thyme herb extract – 5.5%, lemon balm leaf extract – 4.5%, sage leaf extract – 6%, verbena herb extract – 5.5% were used during the research.

Taking into account the species characteristics of pathogens and microbiological characteristics of cherries, sour cherries and apricots, developed three compositions of extracts for each type of fruit in the following ratios with their subsequent introduction into the technological form of the tool:

1. compositions of the extracts of aloe leaves, chamomile inflorescences and spruce bark in the ratios 4:3:2, 5:4:3, and 3:1:2, respectively (samples 1, 2, 3) with the addition of 2% of chitosan, for cherry;

2. compositions of the extracts of eucalyptus leaves, basil herbs, thyme herbs in the ratios 1:2:1, 2:4:3, and 2:5:2, respectively (samples 4, 5, 6) with the addition of 2% of chitosan, for sour cherry;

3. composition of the extracts of lemon balm leaves, sage leaves and verbena grass in the ratios 3:2:1, 4:3:2, and 3: 1: 1, respectively (samples 7, 8, 9) with the addition of 2% of chitosan, for apricot.

The coating of the films includes low molecular water-soluble chitosan (MM 1–50 kDa, SD 75–95) manufacturer Shaanxi Jintai Biological Engineering Co., Ltd.

Description of the methods. To determine working concentrations of extracts and the choice of effective composition, fungicidal properties of herbal preparations were studied; microbiological investigations of test samples and biological standardisation of the components of the object of study were held.

1. Research of fungicidal properties [19].

Fungicidal properties of the drugs were studied apropos the *Monilinia laxa* fungus (Aderhold et Ruhland) Honey. The culture of the pathogen moniliosis was isolated from the affected cherry fruits.

Fungicidal properties of drugs apropos Monilinia laxa were studied on potato-glucose agar, which was poured into sterile Petri dishes. Sterile circles of filter paper were immersed in the drug until completely impregnated and placed in the centre of a Petri dish with a growth environment. The fungal cultures cut from agar in blocks of the same diameter (4 mm) were reinoculated. In the control, the filter discs were moistened with sterile water. Cultivated in a thermostat at a temperature of 24ºC until the growth of the culture of fungus to the circle of the filter disc in the control version.

2. Tests for antimicrobial activity were performed by the methods of sanitary bacteriology [20].

5% of sterile defibrinated blood (by volume) add to the sterile molten and cooled to 45–50°C base of agar medium, mix well and pour into cups. Cups with air bubbles or foam on the surface are not used. Blood used to prepare blood agar should not contain antibiotics or chemotherapeutic drugs. Defibrinated blood is prepared as follows: under sterile conditions, blood is collected with a syringe 18 (to prevent hemolysis caused by mechanical destruction) and immediately poured into a sterile flask with a layer of sterile glass beads (about 3 mm in diameter). The flask

is shaken in a horizontal surface for 10 minutes. Fibrin formed during the coagulation remains on the balls. The supernatant containing blood cells and serum is drained into sterile containers and stored in a refrigerator.

They are nncubated at 37°C for 24–48 hours. As a result of β-hemolysis, transparent colourless zones are formed around the colonies. Erythrocytes in these areas are completely lysed. As a result of α-hemolysis, a small halo is formed directly around the colonies, and it verges upon a zone of complete hemolysis, which spreads further into the environment.

3. Research of toxicity [21] using bacteriological methods.

Research of toxicity of the compositions was performed by bacteriological method – culture of 5% blood agar. To do this, holes were made in the surface of the blood agar, applying the heated edge of the test tube to its surface for a few seconds. In the centre of the well 0.05 ml of experimental compositions were added. The compounds hemolyse erythrocytes, and enlightenment of the blood environment occurs at the test site (erythrocyte lysis). One day after manufacture, samples of solutions were tested.

The method of diffusion into agar (method of wells) is based on the ability of drugs to penetrate into agar and detect hemolytic activity on 5% blood agar. To do this, metal cylinders were installed in Petri dishes (inner diameter (6.0±1.0) mm, high (10.0±1.0) mm. 15 ml of molten and cooled to 45–48°C meat peptone agar mixed with blood (5% blood agar) was poured around the cylinders. When agar in the plates solidified, the cylinders were carefully removed with sterile tweezers, 0.05 ml of test samples of solutions were added to the wells, and after culturing for 20 hours at t=30°C in thermostat the results were evaluated in accordance with the guidelines "Studying specific activity of antimicrobial drugs".

Results of the research and their discussion

Nine extracts were selected for the composition based on the literature analysis of fungicidal properties of medicinal and plant raw materials. Maceration was used for obtaining extracts from medicinal plants. Nine compositions from extracts of medicinal plant raw materials and 2% of chitosan were developed, namely compositions from extracts: aloe leaves, camomile inflorescences, spruce bark in the ratios 4:3:2, 5:4:3, 3:1:2 (samples 1, 2, 3), respectively; eucalyptus leaves, basil herbs, thyme herbs in the ratios 1:2:1, 2:4:3, 2:5:2 (samples 4, 5, 6), respectively; lemon balm leaves, sage leaves, verbena grass in the ratios 3:2:1, 4:3:2, 3:1:1 (samples 7, 8, 9), respectively.

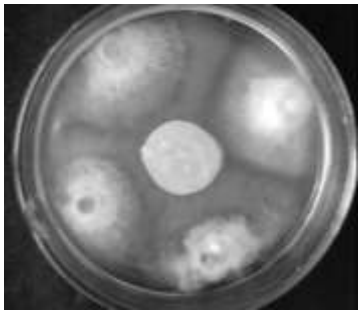
In the studied samples, inhibition of the growth of the culture of *Monilinia* pathogen of stone fruit was detected in comparison with the control. The growth of fungus of the *Penicillium* genus was observed on the filter discs immersed in the preparations, namely in samples 6, 7, 8 (Fig. 2.7, 2.8, 2.9). This is stipulated by the ingress of *Penicillium* into the studied samples and inability of these compositions to counteract this group of pathogens. Bacteria were not detected on discs with compositions 1, 2, 3, 4, 5, 9 (Fig. 2.2, 2.3, 2.4, 2.5, 2.6, 2.10). The control discs soaked in sterile water remained uninhabited by other objects.

When determining antimicrobial action by the method of sanitary bacteriology for comparison, control was taken without extracts. Control samples for *Bacillus cereus (B. cereus)* strains ATCC 107-02, *Escherichia coli (E. coli)* ATCC-25922 and *Candida albicans (C. albicans)* ATCC-885-653 did not demonstrate growth retardation of reference strains. The test compositions demonstrated antimicrobial action apropos all reference strains (Table 2).

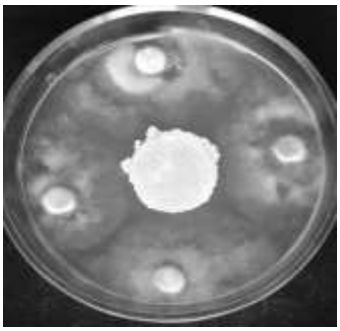
The best indicators of the zone of growth retardation of reference strains in samples 1, 2, 3, 4, 6, 9 and are relative to *B. cereus* 27.2–29.7 mm (±0,9), *E. coli* 25.8–29.0 mm (±0,85), *C. albicans* 25.0–28.0 mm (±0,9). These samples can be referred to bactericidal compositions that inhibit the growth of reference strains recommended for testing according to the data of the Pharmacopoeia of Ukraine, namely apropos *Bacillus cereus* ATCC 107-02, *Escherichia coli* ATCC-25922 and *Candida albicans* ATCC-885-653.

Research of toxicity were checked one day after the manufacture of compositions. Out of nine samples examined by direct inoculating on blood agar, no sample showed hemolytic activity against erythrocytes, and samples 1, 2, 6 caused hemolysis of erythrocytes only in the area of the sample application. Thus, it should be recognised that samples 1, 2, and 6 cannot be classified as safe, because their chronic use, or their overdose can cause anemia, kidney disease, severe poisoning [22].

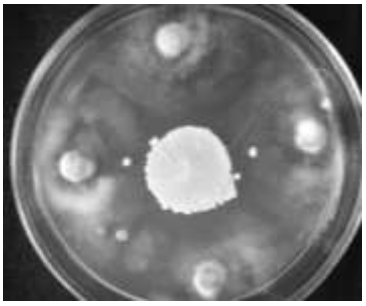
Toxicity research was carried out by the method of agar diffusion (Fig. 3), based on the ability of drugs to penetrate the agar layer and demonstrate hemolytic activity on 5% blood agar. To do this, cylinders were installed in Petri dishes (inner diameter – (6.0±0.1) mm, height – (10±1) mm). 15 ml of melted and cooled to 45–48°C meat-peptone agar mixed with blood (5% blood agar) was poured around the cylinders. After cooling agar, the cylinders were removed with sterile tweezers and 0.05 ml of test samples were added to the prepared wells. Evaluation of the results was performed in 20 hours of thermostatting at t=(30±1)°C. None of the samples under research demonstrated hemolytic activity against erythrocytes.



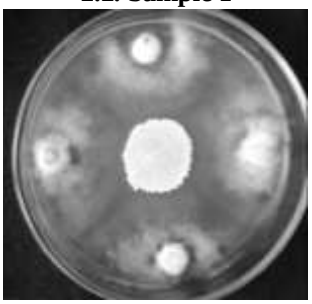
2.1. Control *Monilinia laxa*



2.2. Sample 1



Sample 2



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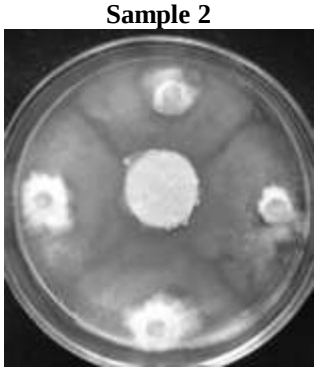

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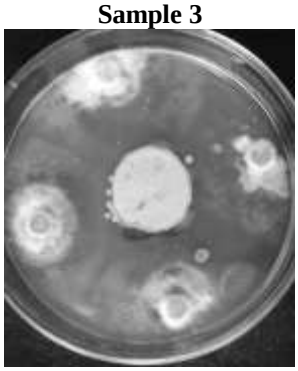

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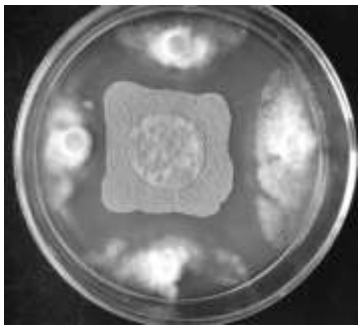

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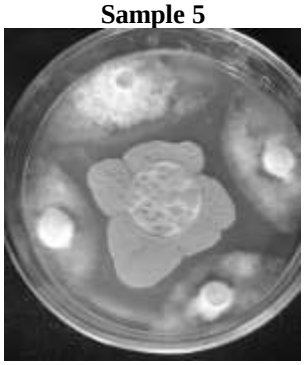
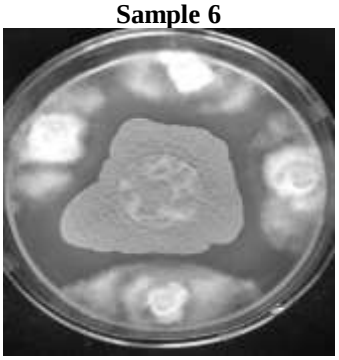
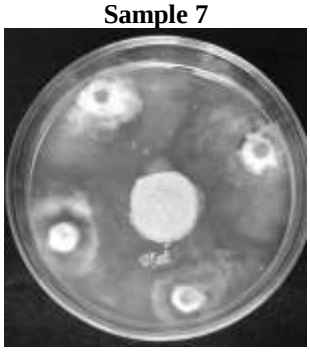


Sample 7



Sample 8

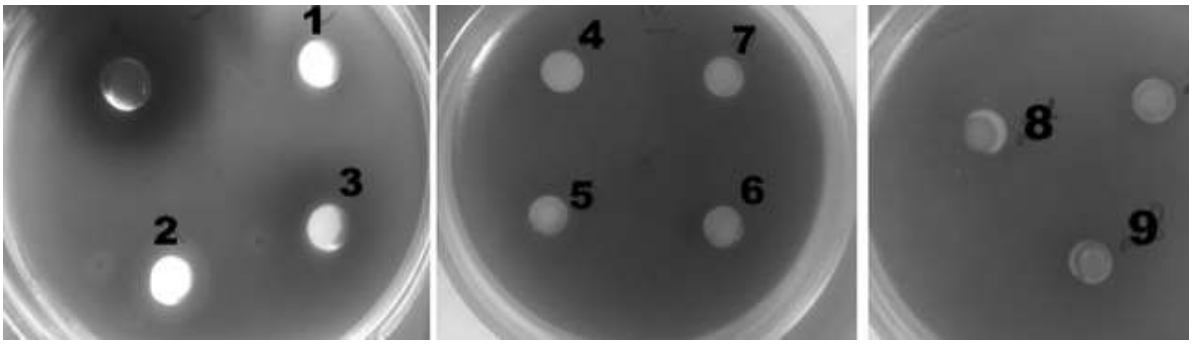


Sample 9

Fig. 2. Fungicidal properties apropos *Monilinia laxa*:

Table 2 – Antimicrobial action of the extract compositions

No	Compositions of extracts	Diameter of zones of growth retardation of reference strains, mm		
		B. cereus ATCC 107-02	*E. coli* ATCC-9027	*C. albicans* ATCC-25922
1	aloe leaves, camomile inflorescences and spruce bark in a ratio of 4:3:2	28.5±0.34	25.8±0.85	27.4±0.25
2	aloe leaves, camomile inflorescences and spruce bark in a ratio of 5:4:3	27.8±0.43	27.5±0.84	28.0±0.6
3	aloe leaves, camomile inflorescences and spruce bark in a ratio of 3:1:2	27.2±0.23	27.8±0.53	26.9±0.17
4	eucalyptus leaves, basil and thyme in a ratio of 1:2:1	27.5±0.5	28.2±0.4	27.3±0.25
5	eucalyptus leaves, basil and thyme in a ratio of 2:4:3	26.5±0.9	18.4±0.9	19.0±0.46
6	eucalyptus leaves, basil and thyme in a ratio of 2:5:2	28.0±0.9	29.0±0.14	27.8±0.6
7	lemon balm leaves, sage leaves and verbena herb in a ratio of 3:2:1	22.8±0.84	17.5±0.18	25.0±0.9
8	lemon balm leaves, sage leaves and verbena herb in a ratio of 4:3:2	27.2±0.36	18.8±0.2	21.6±0.87
9	lemon balm leaves, sage leaves and verbena herb in a ratio of 3:1:1	29.7±0.3	26.5±0.15	27.0±0.24



a) Samples 1, 2, 3 **b) Samples 4, 5, 6, 7** **c) Samples 8, 9**

Fig. 3. Research on pathogenic potential
(a – Samples 1, 2, 3; b – Samples 4, 5, 6, 7; c – Samples 8, 9)

Conclusion

Nine extracts of medicinal and herbal raw materials were selected for creating compositions for the main literature analysis. To obtain extracts from medicinal plants, the method of maceration or tincture was used (raw material was ground and placed together with the extractant in a closed vessel and infused at 15-20°C for 7 days). Nine compositions from extracts of medicinal plant raw materials and 2% of chitosan were developed, namely compositions from extracts: aloe leaves, camomile inflorescences, spruce bark in the ratios 4:3:2, 5:4:3, 3:1:2 (samples 1, 2, 3) respectively; eucalyptus leaves, basil herbs, thyme herbs in the ratios 1:2:1, 2:4:3, 2:5:2 (samples 4, 5, 6), respectively; lemon balm leaves, sage leaves, verbena grass in the ratios 3:2:1, 4:3:2, 3:1:1 (samples 7, 8, 9), respectively.

All samples were tested for fungicidal properties against the *Monilinia laxa* culture, and recorded its growth inhibition. However, on the filter discs immersed in the drugs, the growth of fungus of the *Penicillium* genus was found in samples 6, 7, 8. This is stipulated by the inclusion of *Penicillium* into the studied samples and inability of these compositions to counteract this group of pathogens.

The compositions have been tested for antimicrobial action regarding *Bacillus cereus* ATCC 107-02, *Escherichia coli* ATCC-25922 and *Candida albicans* ATCC-885-653. All nine compositions demonstrated antimicrobial action, but the best indicators of the zone of growth retardation of reference strains are in samples 1, 2, 3, 4, 6, 9, and they are relative to *B. cereus* 27.2–29.7 mm (±0,9), *E. coli* 25.8–29.0 mm (±0,85), *C. albicans* 25.0–28.0 mm (±0,9). These samples can be referred to bactericidal compositions that inhibit the growth of reference strains recommended for testing according to the data of Pharmacopoeia of Ukraine, namely against *Bacillus cereus* ATCC 107-02, *Escherichia coli* ATCC-25922 and *Candida albicans* ATCC-885-653.

Results of the research of toxicity were checked one day after the manufacture of the studied compositions. Out of nine samples tested by the method of direct inoculating on blood agar, none demonstrated hemolytic activity regarding

erythrocytes, and samples 1, 2, 6 caused hemolysis of erythrocytes only in the area of the sample application. Thus, it should be recognised that samples 1, 2 and 6 cannot be classified as safe, because their chronic use, or their overdose can cause anemia, kidney disease, severe poisoning by infectious agents (hemolytic streptococcus, malaria, toxoplasmosis, candidiasis, viral hepatitis B and C).

Based on the research, samples 3, 4, 9 are safe for people, they demonstrated fungicidal properties and antimicrobial action against pathogens in stone fruits, which makes it possible to use them as components of film-forming compositions based on chitosan, during storage.

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ДОСЛІДЖЕННЯ БАКТЕРИЦИДНИХ ВЛАСТИВОСТЕЙ ТА ТОКСИЧНОСТІ КОМПОЗИЦІЙ ДЛЯ ЗБЕРІГАННЯ КІСТОЧКОВИХ ПЛОДІВ

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Анотація. Псування кісточкових плодів під час зберігання починається з розвитку на їхній поверхні міцеліальних грибів, що руйнують оболонку плоду та анатомічну цілісність. Тому, розробка нових засобів для обробки кісточкових плодів на основі нешкідливих для людини компонентів є актуальним завданням сучасної аграрної, фітохімічної та біологічної галузей. Розроблено дев'ять композицій з екстрактів лікарсько-рослинної сировини та 2% хітозана, а саме композиції з екстрактів: листя алое, суцвіття ромашки, кори ялини у співвідношеннях 4:3:2, 5:4:3, 3:1:2

(зразки № 1, 2, 3) відповідно; листя евкаліпту, трави базиліку, трави чебрецю у співвідношеннях 1:2:1, 2:4:3, 2:5:2 (зразки № 4, 5, 6) відповідно; листя меліси, листя шавлії, трави вербени у співвідношеннях 3:2:1, 4:3:2, 3:1:1 (зразки № 7, 8, 9) відповідно. Всі композиції досліджували на фунгіцидні властивості відносно *Monilinia laxa*, антимікробна активність методом санітарної бактеріології і токсичності з використанням бактеріологічних методів (метод прямого посіву на кров'яний агар та метод дифузії в агар). У всіх досліджених зразках зафіксовано пригнічення росту культури збудника моніліозу кісточкових культур. Всі дев'ять композицій виявили антимікробна дію відносно *Bacillus cereus* ATCC 107-02, *Escherichia coli* ATCC-25922 та *Candida albicans* ATCC-885-653, найкращі показники у зразках № 1, 2, 3, 4, 6, 9. При дослідженні токсичності методом прямого посіву на кров'яний агар зразки № 1, 2, 6 спричинили гемоліз еритроцитів тільки в зоні нанесення зразка, інші зразки не проявили гемолітичну активність. На основі дослідження зразки № 3, 4, 9 являються безпечними для людини, вони проявили фунгіцидні властивості та антимікробну дію проти збудників кісточкових плодів, що дає можливість використовувати їх як складові плівкоутворюючі композиції на основі хітозану, у процесі зберігання.

Ключові слова: екстракт, композиція, лікарські трави, гемоліз, антимікробна активність.

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