Проведені дослідження ставили за мету наукове обґрунтування впливу елементів післязбирального доробки на збереженість часнику озимого.

Тривале зберігання часнику від урожаю до урожаю є необхідною умовою безперервного забезпечення населення часником. Виникає необхідність проведення післязбиральної доробки часнику озимого, спрямованої на зменшення втрат та подовження тривалості зберігання. Важливим ланцюгом в цьому є післязбиральний період (досушування). Підсушений часник має підвищену стійкість проти ураження мікроорганізмами та менше втрачає масу під час зберігання. Застосування біопрепаратів під час післязбиральної доробки дозволяє зменшити втрати часнику озимого від мікробіологічних хвороб при зберіганні.

Теоретично обґрунтовано та експериментально підтверджено, що природні втрати за весь період досушування часнику обрізного становили 15,9 % у сорту Дюшеста 21,8 у сорту Мереф'янський білий. Така сама закономірність спостерігалась при досушуванні часнику з стеблом, втрати маси були 38,7 та 49,0 % відповідно. У структурі втрат часнику більшу частину становили втрати маси непросушених цибулин від 11,09 до 14,4 % залежно від сорту. Втрати від ураження хворобами коливаються від 5,28 до 12, 15 % і мають сильний кореляційний зв'язок r=0,98.

Вихід товарної продукції після шести місяців зберігання залежить від вологості шийки цибулин. У просушеного до вологості шийки 25±1 % вихід товарної продукції становив 76,33 % у Мереф'янський білий та 78,59 % Мереф'янський рожевий (Дюшес). Часник просушенийдо вологості шийки 14±1 % збільшував вихід товарної продукції до 82,98–80,1 5 %, не просушений зменшував до 72,25–63,45 % відповідно.

Обробка цибулин часнику сорту Мереф'янський рожевий (Дюшес) перед зберіганням Гліокладіном 2 % підвищила вихід товарної продукції на 10,1 %, сорту Мереф'янський на 10,2 %. Обробка Фітоспорином 2 % збільшила вихід товарної продукції на 10 і 9,5 %

Ключові слова: часник, післязбиральна доробка, досушування цибулин,біопрепарати, втрата маси, тривалість зберігання

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PRESERVATION OF WINTER GARLIC DEPENDING ON THE ELEMENTS OF POSTHARVEST TREATMENT

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1. Introduction

Garlic, which possesses high nutritional and medicinal properties, is very important among vegetable crops.

Almost 10 million tons of garlic are grown annually. The largest world producers are China, Korea, India, the USA, Spain, Egypt, and Turkey. Garlic is one of the most used plants in many parts of India, Pakistan, and Bangladesh, it is popular in the French, Spanish, Portuguese, and South Asian cuisines. The United Nations Organization for Food and Agriculture (FAO) claims that now garlic is one of five products, the demand for which is steadily increasing by almost eight percent annually. At the same time, the world prices for it also grow [1].

Garlic bulbs are sold in the fresh or processed form with receiving dry powder or oil. The bulb is the most used part, but sometimes one also uses the cut leaves. Garlic is used not only to add some curry taste but also in drinks and spicy desserts. It is used in a fresh and processed form as a seasoning to various dishes, in sausage and meat production, as well as for pickles and canned vegetables. Garlic oil is used as a flavoring [2]. The plant of life is the ordinary garlic, known for thousands of years as the best natural cures. There are more than 200 unique components in this amazing plant [3, 4].

Despite the unique properties of garlic, the norms of its consumption (per capita) in Ukraine do not correspond to the physiological norms and are 0.6 kg per year, while as a result of national traditions and culinary processing, it is consumed in the world from 14 to 17 kg per capita annually [5].

Long-term storage of garlic from harvest to harvest is a prerequisite for the continuous supply of the population with garlic. However, violation of the storage conditions or the storage of the garlic that is insufficiently dry after harvesting increases the weight loss due to the damage by microbiological diseases and reduces the storage duration. During storage, garlic is affected by gray neck rot, fusaria wilt, bacteriosis and two types of stem nematodes. Diseases of garlic bulbs are caused by fungi *Botrytric allii Munu*, *Fusarium sp.,* bacteria *Erwinia carotovora subsp. Carotovora Bergey* et al., *Burkholderia cepacia ex Burkholder Yabuuchi* et al., *Pseudomonas syringae PV. Porri*, nematodes *Dytilenchus dipsaci, Dytilenchus Allii* [6].

Development of the elements of the winter garlic storage technology that are environmentally friendly and easy to implement is essential and relevant. Therefore, there arises a need for postharvest treatment of winter garlic, aimed at reducing the losses and extending the storage duration. An important link in this is the postharvest period (drying). Dried garlic has increased resistance to the damage by microorganisms and loses less weight during storage. Under existing conditions, when the ecology deteriorated and the human organism is exposed to various negative environmental factors, there is a need to search for new preparations of the natural origin to fight against microorganisms.

The use of biopreparations during postharvest treatment makes it possible to reduce the losses of winter garlic due to microbiological diseases during storage.

2. Literature review and problem statement

Significant losses of garlic and onions are caused by the damage by various pathogens. A complex of agrotechnical, preventive and chemical measures is conducted to reduce such losses. The spread of rot on bulbs is prevented by timely harvesting, high-quality drying, compliance with temperature and humidity storage conditions, and treatment with biopreparations.

Traditional sun-drying occurs by storing the product in direct sunlight. Sun drying is possible only in the areas where annual average weather makes it possible to dry the products immediately after harvesting. The main benefits of sun-drying are low capital and maintenance costs [7].

Sun-drying is the most used commercial method to dry biological products, and although there is plenty of information about drying, the process remains an art [8, 9]. Paper [10] described the experiments on drying winter garlic at the temperature of 45 °C within 8–12 hours and then drying by ventilated air at the temperature of 30 °C. Drying the bulbs increases the viscosity of cellular juice, the ratio of sugars is shifted towards sucrose and that of nitric substances – to proteins. However, this method of garlic drying involves the use of heated air, which is energy-consuming.

It is recommended to dry garlic in a field in the sun within 6–10 days [11]. During such a drying period, the weather conditions can change and adversely affect the state of garlic bulbs.

According to DSTU [8], before storage, garlic is dried for 10–12 days at the temperature of 20...25 °C, and the temperature is increased up to 35 °C 2–3 days before the end of drying. Drying under the field conditions is associated with the risk of getting sunburned, whereas drying in poorly ventilated storage sheds can lead to being affected by diseases [13].

Drying naturally involves drying the layers of laid out garlic under the ventilated canopies without direct sunlight. It is a long-lasting process that can take many days. When laying garlic in containers, exhaust ventilators are used in premises, the air is directed through the mass of garlic in boxes and garlic is dried up to the desired condition. The drying process can take up to 10 days.

Drying under conditions of increased humidity or in the damp climate can be carried out in forcibly ventilated chambers, where the air is forced and, if necessary, is heated by heaters. Supply and exhaust ventilation operates under constant control of the temperature to the desired degree of garlic drying [13].

The disadvantage of the use of heat generators or electric heaters to heat the air is a constant threat not to maintain the temperature and humidity conditions, possible overdrying or overheating of garlic, which immediately affects the product quality.

A more modern perspective method of garlic drying in the ventilated premises is the use of air dehumidifiers. In this way, the desired level of air humidity of the room is created and controlled. However, this method of drying is energy-consuming.

It is better to harvest garlic 5 days earlier than 5 days later. At early harvesting and maturation of bulbs under a canopy within 5–10 days, nutritious substances flow from leaves into bulbs. Their mass and density at the same time increases, forming 3–4 cover scales of good quality [14].

American farmers recommend drying garlic in high tunnels at a temperature of 110 °F up to the wax plaque on bulbs. However, it is necessary to additionally install a fan for uniform heating of bulbs and relative humidity of the air in the tunnels. In order to fight diseases during postharvest treatment, elevated temperatures and air humidity limitations are needed during bulb drying [15]. Not every manufacturer can use the system of high tunnels for drying garlic due to high energy costs.

An important role in the suppression of the development of garlic plant diseases is played by microorganisms of the genus *Pseudomonas sp.* and *Trichoderma sp.* [16]. Recently, the multifunctional ability of microorganisms *Trichoderma* and *Pseudomonas*, based on which the biological preparations Trichodermin, Gliocladine, Phytopsine were created, was proven.

Fungi of genus Trichoderma are characterized by the antibiotic (form antibiotics glioxin, viridin, alamecin) and antagonistic properties.

Microorganisms *Trichoderma* take part in the processes of ammonification and nitrification [17], help to increase the fungicide activity of the cell juice of plants. Fungi of the genus *Pseudomonas spma Trichodermas* activate redox processes and increase the adaptive processes of agricultural plants.

The fungal culture *Trichoderma harzianum VIZ–18* has a complex of metabolites and is a component of the preparation of Gliocladine, which affects the sulfur content in plants [18]. The analog of the preparation of Trichodermine is applied against the pathogens of verticilliosis of celery, eggplant, fusarial wilt fading of watermelons, brown patch of potato and to eliminate the damage by various types of rots [19].

The preparation of Haupsyn can inhibit an average of 92 % of fungal, 70 % of bacterial, and 15 % of viral diseases during the storage of onions. The action of *Pseudomonas aureofaciens* is caused by the property of tissue colonization and synthesis of antifungal compounds, as well as complex enzymatic activity [20, 21].

The agronomists pay attention to the use of living cultures of non-spore bacteria of genus a*ureafaciens*, the protective effect of which is caused by the colonization of the plant root system and the synthesis of various antifungal compounds.

Pre-treatment of tomato seeds and subsequent application of bacteria into the soil slows down or completely inhibits the growth of phytopathogenic fungi Fusarium culmorum and Botrytis cinerea. The antagonistic bacteria Pseudomonas aureofaciens 2006, introduced to the soil, promote its healing [18]. Bacteria of genus *Pseudomonas aureafaciens* are the components of the microbiological preparation of the complex action "Phytopsyn". This is the preparation of fungicide-insecticide action.

In many countries of the world, the research aimed at finding highly-active strains of microorganisms to create biological preparations on their basis is widely carried out. The use of these biopreparations increases productivity, prolongs the storage term and delays the damage of products by microbiological diseases.

At present, the effectiveness of biological preparations of Glyocladine and Phytosporine for the preservation of vegetables, including garlic, is studied insufficiently.

Biological preparations, created based on highly active strains of genus Pseudomonas, are some of the most promising. Strains of the genus Pseudomonas are the most studied groups of microorganisms for conducting the biological control of bacterial and fungal diseases of agricultural plants in the world. They have been insufficiently studied under storage conditions and in agrocenoses [22].

Thus, the problem of drying winter garlic remains challenging. There are no recommendations on which moisture content of the bulb neck garlic should be dried. The regulatory documents do not normalize natural losses of garlic, which would regulate them in the period from harvesting to storage. Currently, the influence of biological preparations on the preservation of vegetables, in particular, garlic, has not been sufficiently explored.

3. The aim and objectives of the study

The aim of this study is to substantiate the elements of the technology of postharvest treatment of winter garlic, which will make it possible to increase the quality of preservation and duration of garlic consumption. The working hypothesis is based on the assumption about the possibility of drying garlic to the neck moisture content of 14±1 % and the use of bacteria-antagonists of the genus Pseudomonas to improve the resistance of garlic bulbs during storage.

To accomplish the aim, the following tasks have been set:

– to determine the weight loss of winter garlic bulbs during drying;

– to determine the yield of marketable products of winter garlic after storage, depending on the moisture content of a bulb neck;

– to examine the effect of biopreparations on the yield of marketable products of winter garlic after storage.

4. Materials and methods to study the elements of the technology of postharvest treatment and storage of winter garlic

Field experiments were conducted at the research field in the eastern part of the left bank forest-steppe of Ukraine on the territory of Kharkiv region using drop irrigation. Laboratory experiments were carried out at the Department of optimization of technological systems named after T. P. Yevsiukov of Kharkiv National Technical University named after Petro Vasilenko (Ukraine).

Field experiments were conducted according to generally accepted techniques using the Merefians'kyi white variety and Merefians'kyi pink (Diushes) variety of winter garlic. Garlic was harvested in decade III of July when lower leaves got yellow. Garlic with stems and topped garlic with the trunk of 2.5 cm were laid for drying.

After drying, garlic was kept in the Polair refrigeration chamber (produced in Russia) at the temperature of −1...−3±0.5 °C and relative air humidity of 75–80 %.

The materials and methods of research into the garlic weight loss during storage are presented in more detail in paper [23].

5. Results of determining the yield of marketable product of garlic during postharvest treatment and storage

5. 1. Weight loss of garlic bulbs during drying and storage

At the beginning of drying winter garlic, for the first 5 days, the air temperature was from 18 to 29.5 °C at the relative air humidity of 72–80.5 %. For the next 5 days, the air temperature was 24.5...29.5 °C but the relative air humidity was lower and reached 69.5–78 %. The period from 11.08 to 15.08 is characterized by the lowest relative humidity and high temperature (Fig. 1).

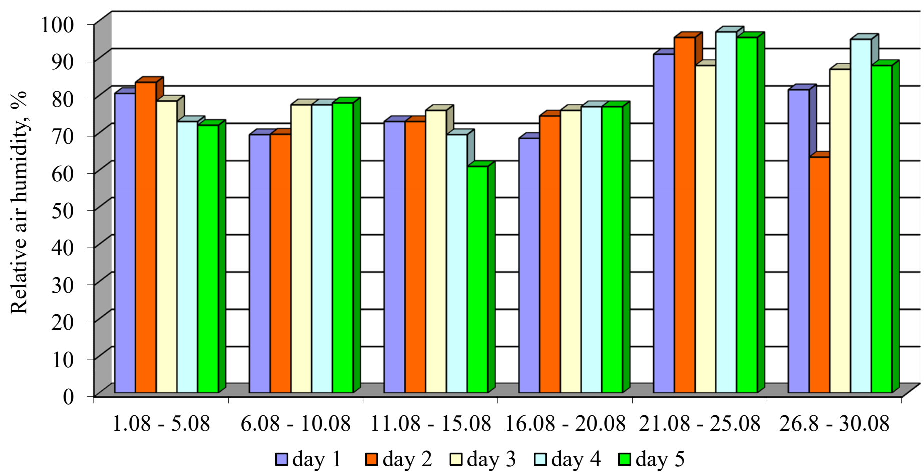
As a result of the research, it was found that natural losses for the entire period of drying the topped garlic were 15.9 % for the variety of Diushes and 21.8 % for the variety of Merefians'kyi white. The same regularity was observed during drying garlic with a stem, the weight losses were 38.7 and 49.0 %, respectively.

The tops of winter garlic lost the most weight in the first 10 days. Natural losses of the weight of topped winter garlic accounted for 17.6 % of Merefians'kyi white and for 12.9 % of Diushes varieties, of garlic with stem – 37.9 and 31.9 %, respectively. Within the next five days, weight losses slowed down up to 0.9 % for topped garlic and up to 1.1–2.2 % of untopped garlic.

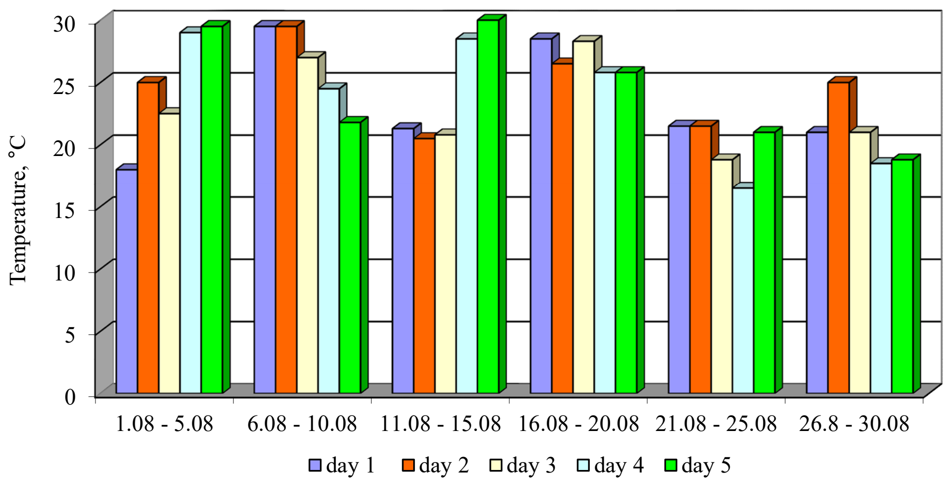
Daily weight loss decreased from 1.8–2.2 % to 0.06 % for topped garlic and from 4.5–5.5 % to 0.1–1.2 % of untopped garlic (Fig. 2).

When laying the samples of winter garlic with stems, the ratio of the garlic head weight to the stem weight was determined. At the beginning of drying, the weight of garlic heads amounted to 53 %, the weight of the stem – to 46 %, of other impurities – up to 1 %.

The yield of marketable product of winter garlic after storage involves qualitative changes as well, specifically, natural losses (at the expense of breathing and as a consequence of dry matter consumption) and the damage of microorganisms and bulb sprouting.



a



b

Fig. 1. Average temperature and humidity conditions during drying winter garlic by the years of studying: *a* — temperature, °C; *b* — relative air humidity, %

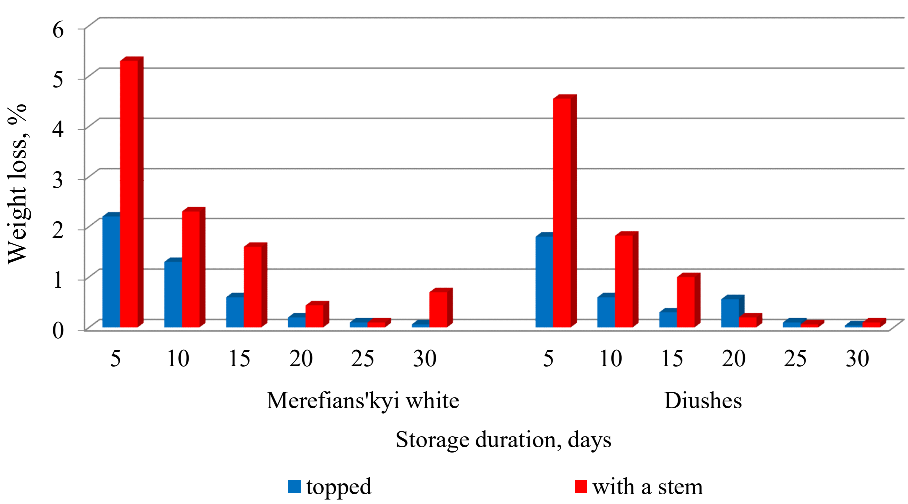


Fig. 2. Daily weight losses of winter garlic during drying, %

The preservation of garlic bulbs depends on the moisture content of the neck. Natural weight losses of the garlic dried up to the neck moisture content of 25±1 % after three months of storage ranged from 7.92 % for the Diushes variety to 11.67 % for the Merefians'kyi white variety. Drying up to the neck moisture content of 14±1 % reduced natural losses up to 5.79–6.97 %, respectively (Table 1). Losses due to diseases decreased by 1.4 times for the garlic variety of Diushes and by 3 times for the variety of Merefians'kyi white. Garlic drying reduced the bulb sprouting during storage from 6.85 to 4.90 % for the Diushes variety and from 7.82 to 5.76 % for the Merefians'kyi white variety.

In the structure of garlic losses, the weight losses of undried bulbs from 11.09 to 14.4 %, depending on the variety, made up most part (Fig. 3). This can be explained by the fact that a wet plant organism has intensive life processes, one of which is respiration. During respiration, dry substances are consumed and, as a result, the weight is lost. To identify the overall tendency of changes in bulb weight loss, depending on the neck moisture content, we performed a regression analysis. It makes it possible to estimate the degree of relations between variable features, to determine the mechanism of calculating the predicted value of a variable from several already known values. It was found that the weight loss of garlic bulbs, depending on the neck moisture content is described by the regression equation: $Y=-2.135x^2+6.385x+6.84$.

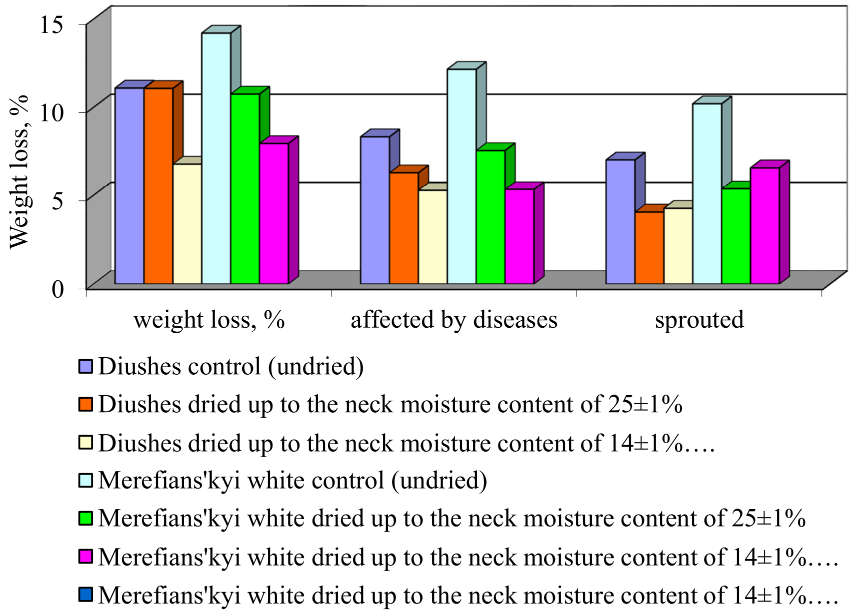


Fig. 3. Structure of garlic losses depending on the moisture content of the neck bulbs, %

Table 1

Preservation of garlic bulbs depending on the postharvest drying at the storage temperature of –1...– 3 °C

Research variants	Natural weight losses, %	Losses due to diseases, %	Germinated bulbs, %	Total losses, %	The yield of marketable products, %
After four months of storage					
Merefians'kyi pink (Diushes)					
Control (undried)	10.50	7.25	6.85	24.60	75.40
Dried to the neck moisture content of 25±1 %	7.95	6.65	5.75	20.35	79.65
Dried to the neck moisture content of 14±1 %	5.78	5.20	4.90	15.88	84.12
HIP_{05}	0.72				
Merefians'kyi white					
Control (undried)	12.39	8.93	7.82	29.14	70.86
Dried to the neck moisture content of 25±1 %	11.67	6.88	4.35	18.91	81.09
Dried to the neck moisture content of 14±1 %	6.98	2.89	5.76	19.62	80.38
HIP_{05}	0.86				
After six months of storage					
Merefians'kyi pink (Diushes)					
Control (undried)	11.09	8.33	7.02	27.25	72.75
Dried to the neck moisture content of 25±1 %	11.07	6.29	4.25	21.61	78.59
Dried to the neck moisture content of 14±1 %	6.78	5.28	4.06	17.02	82.98
HIP_{05}	0.80				
Merefians'kyi white					
Control	14.20	12.15	10.20	36.55	63.45
Dried to the neck moisture content of 25±1 %	10.75	7.55	5.77	23.67	76.33
Dried to the neck moisture content of 14±1 %	7.95	5.33	5.57	19.85	80.15
HIP_{05}	0.68				
Average for the varieties					
Control	13.05	10.24	8.61	31.9	68.10
Dried to the neck moisture content of 25±1 %	9.51	6.92	5.01	21.44	78.56
Dried to the neck moisture content of 14±1 %	7.34	5.31	4.75	18.4	81.60

The trend line was used to analyze (evaluate) the errors of regression analysis. The accuracy of the regression analysis is determined by the R^2 value. According to the obtained data R^2=0.753 for the rectilinear dependence of bulb weight loss on neck moisture content. The second-order curvilinear correlation dependence of bulb weight loss on the neck moisture content R^2=1.0 is more reliable.

It is established that varietal characteristics influence weight loss. Merefians'kyi pink (Diushes) lost from 6.78 to 11.09 %, depending on the neck moisture content, whereas Merefians'kyi white lost 7.95–14.2 %, respectively.

The losses from the damage by diseases range from 5.28 to 12, 15 % and have a strong correlation r=0.98.

5. 2. Influence of biopreparations on the yield of marketable product of winter garlic after storage

The weight of winter garlic bulbs after four months of storage decreased by 2.04–2.86 %, depending on the biopreparation, whereas the untreated bulbs lost up to 7.55–7.95 %. The percentage of garlic affected by diseases was 0.52–2.67 %, the percentage of germinated bulbs after four months of storage made up 1.23–2.41 %, depending on the varietal characteristics and the treatment with biopreparations. The treatment with 2 % phytosporine ensured the smallest losses due to the development of microorganisms and was 0.52–0.92 %. Sprouting during storage was mostly inhibited by the treatment of garlic with 2 % gliocladine (Table 2).

After six months of storage, these indicators increase. Losses due to diseases increase up to 5.33–8.33 % of untreated bulbs. The treatment with 2 % Phytosporine leads to 6.28–6.88 % and with 2 % Gliocladine – 2.29–2.89 %. Bulbs sprouting during storage ranges from 4.05–5.76 %. The yield of marketable products after six months of storage of untreated bulbs is 84.25–85.75 % depending on the varietal characteristics. The treatment of bulbs of garlic of the variety Merefians'kyi pink (Diushes) with 2 % Gliocladine before storage ensured the yield of marketable products of 82.59 %, the variety of Merefians'kyi white of 81.09 %. Treatment with 2 % Phytosporine ensured the yield of 81.98 and 80.38 %, respectively (Fig. 4).

It is known that in the process of storing plant products, there are natural biochemical processes in their tissue. Biochemical changes are related to oxidation-reduction processes, a change in respiration intensity, and intensification in peroxide oxidation processes. The consequence is the intensification of growth processes and weight losses of plant products. In addition, the listed processes also affect the quality of chemical indicators.

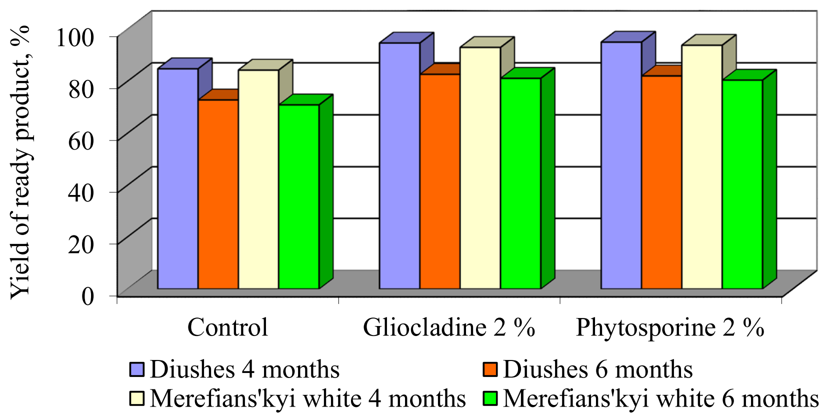


Fig. 4. Garlic preservation, depending on the treatment with biopreparations, %

Table 2

Preservation of winter garlic bulbs treated with biological preparations at a storage temperature of −1...−3 °C

Research variants	Natural weight losses, %	Losses due to diseases, %	Sprouted bulbs, %	Total losses, %	The yield of ready products, %
After four months of storage					
Merefians'kyi pink (Diushes)					
Control	7.55	5.33	2.37	15.25	84.75
Gliocladine 2 %	2.04	2.07	1.23	5.34	94.66
Phytosporine 2 %	2.26	0.52	2.21	4.99	95.01
HIP_{05}	1.07				
Merefians'kyi white					
Control	7.95	5.33	2.57	15.85	84.25
Gliocladine 2 %	2.64	2.67	1.73	7.04	92.96
Phytosporine 2 %	2.86	0.92	2.41	6.19	93.81
HIP_{05}	0.78				
After six months of storage					
Merefians'kyi pink (Diushes)					
Control	11.09	8.33	7.02	27.25	72.75
Gliocladine 2 %	11.07	2.29	4.05	17.41	82.59
Phytosporine 2 %	6.48	6.28	5.26	18.02	81.98
HIP_{05}	0.86				
Merefians'kyi white					
Control	12.39	8.93	7.82	29.14	70.86
Gliocladine 2 %	11.67	2.89	4.35	18.91	81.09
Phytosporine 2 %	6.98	6.88	5.76	19.62	80.38
HIP_{05}	0.80	–	–	–	–

6. Discussion of results of the study of weight losses of garlic bulbs during storage depending on drying and treatment with biopreparations

The important biological feature of garlic is the ability to transfer to the state of dormancy. The deep physiological state of dormancy in garlic is short-lasting. The dormancy duration of bulbs depends on the moisture content of the neck. There is a clear functional relationship between the state of dormancy and resistance to pathogenic microflora. These results are proved by the results of papers [24, 25]. In particular, the heap of garlic usually has the moisture content of 60–70 %, it should be dried up to the moisture content of the outer scales of bulbs of not more than 14 %. At the air temperature of 45 °C, mites and nematodes die, the bulb neck becomes thinner and denser. Air temperature during drying bulbs should not be less than 30...35 °C at the humidity of 50–60 %. In an overdried bulb with the moisture content of upper scales of 8 %, the water starts to flow out of cloves and the volume of cloves decreases. The dry scales envelop the bud clove not tightly. Microorganisms easily penetrate cloves. As a result, cloves fall out of the bottom, the yield of marketable products is reduced. Therefore, it is not desirable to dry garlic to the moisture content of scales of 8 %. This method of drying can be applied if dryers are available, it is economically beneficial for large batches of garlic. There are some recommendations to dry garlic after harvesting to the state when bulbs are easily cut off from the stem. In this case, the moisture content of the bulb neck is not determined. Such recommendations are subjective in nature. It was established that the yield of marketable product of winter garlic after six months of storage depends on the moisture content of the neck (Table 1). At the moisture content of the bulb neck of 25±1 %, the yield of marketable products is increased by 5.8–12.8 %. Drying bulbs up to the moisture content of the neck of 14±1 % increases the yield of marketable products by 10.2–16.7 % depending on the varietal characteristics of garlic. During drying, free water is evaporated. The lower the moisture content of the neck, the lower the amount of free water. Bulbs with a well twisted dried neck are characterized by a longer period of dormancy.

The results of the study show that the growth and development of buds depend on the moisture content of the neck. After six months of storing garlic, the necks dried up to 14±1 % had the smallest amount of germinated bulbs of 4.75 %. The control variant had 8.61 % of germinated bulbs. At the bulb sprouting, plastic and physiologically active substances flow out to the growth cones. The bulk of storing tissues (garlic cloves) lose their value in terms of nutrition and marketing. Phytopathogenic microflora loses its stability. It was established that the moisture content of the bulb necks (factor *A*) by 94.9 % influences the yield of marketable products, the degree of influence of the specificity of variety (factor *B*) was 3.2 %, the joint action of these two factors was 0.7 %, other factors influenced by 1.2 %. Natural weight losses during the garlic storage were substantially smaller (HIP_{05}=0.68–0.80 %) compared with the control (Table 1). This makes it possible to say that the results received in this work are proved.

As the main losses of vegetable products are caused by the development of phytopathogenic microflora, one of the most effective ways to suppress the pathogens of infectious diseases in the vegetable is the use of biopreparations. Currently, microbial biopreparations have become a component of organic agricultural technologies. The use of preparations of Trichodermine, Planris, and Phytocyde during the storage of vegetables is an effective environmental alternative. Penetrating the cells of bacteria, yeasts, and mold fungi, they alter the structure of the protoplasm and violate the processes of metabolism in microorganisms, which leads to inhibition of their development and death. It was found that the treatment of garlic bulbs with 2 % Gliocladine decreased the damage by 3.1–3.6 times, depending on varietal characteristics. The active substance is fungus Trichoderma harzianum VIZR-18. It inhibits the development of pathogenic microorganisms, the life processes of which are able to ruin most of the crop. The method of action of the fungi is that they penetrate the sclerotium of the pathogenic fungus, and then gradually dissolve its cells from the inside. Similar results were obtained when processing potato bulbs with biopreparations. The weight loss decreased by 1.2–1.5 times, the content of starch and dry substances decreased. This makes it possible to get high-quality planting material and is economically profitable [19, 26]. Treatment with 1 % Trichodermine solution reduces the development of fungal and bacterial rot by 1.6 times compared with untreated variants [27, 28].

To a lesser extent, the development of microorganisms is affected by the treatment with Phytosporine. After six months of storage, the loss from the damage by microorganisms of garlic bulbs treated with 2 % Phytosporine decreased by 1.3 times. Phytosporine action is based on the fact that useful bacteria actively destroy disease pathogens, enveloping plants with live protective cocoon even when there are not any external manifestations of a disease yet. The variance analysis revealed that the treatment with biopreparations (factor *A*) influences the yield of the marketable products of garlic by 50.4 %, the degree of the influence of varietal characteristics (factor *B*) was 30.7 %, the joint effect of these two factors was 8.7 %, other factors influenced by 10.2 %.

The ratios of weight losses of untreated garlic and the garlic treated with biopreparations during storage were non-uniform. At the beginning of the storage, they ranged from 2.7–3.2 % depending on the type of a preparation. After six months of storage, they made up 1.1–1.8 (Table 2). A decrease in weight losses occurs due to the transition of bulbs to the state of dormancy. The results of research into the treatment of fruit and vegetable products with *Aureobasidium Pullulans* prove the obtained results. The weight loss of a peach fruit treated with *Aureobasidium pullulans* after 21 days of storage was 7.6 %, whereas that of untreated peach was 9.6 %. The weight loss occurred ununiformly. After 3 days of storage, the weight losses of the untreated fruit were 1.1 times higher than those of the peach treated with the biopreparation. By the end of the storage term, they increased by 1.5 times [29].

We note that the use of microbial biopreparations requires almost no changes in the vegetable storage technology. The main thing is to take into consideration their composition. By composition, the preparations are living microorganisms with biologically active products of their vital activity. That is why microbial preparations can lose their properties without adherence to the mandatory conditions of their storage and application. Biological preparations are intended not for the complete extermination of a harmful species, but rather for decreasing the harm caused by microorganisms to the acceptable level. The biological method is considered as a part of the fight against harmful organisms. It can be noted that there is not enough scientific information about postharvest drying of bulbs, the application of biological preparations of antimicrobial action on preservation and the quality of garlic. It is explained by the fact that such studies have not been conducted. The shortcomings of the study include the lack of results of changes in the chemical composition of garlic during postharvest treatment and storage. That is why it is essential to investigate the influence of drying of bulbs and biopreparations of antimicrobial action on the change of the chemical composition of winter garlic. Treatment of vegetable with biopreparations does not inhibit water evaporation during storage. It is possible to solve the problem by the treatment with the film-forming coating in the composition with biopreparations. This coating makes it possible to create a moisture-retaining and gas-permeable film on the product surface separately for each product sample. As a consequence, it will inhibit biochemical processes and reduce the consumption of substances for metabolic processes.

6. Conclusions

1. Natural losses for the entire period of drying of topped garlic accounted for 15.9 % in the Diushes variety and 21.8 % in the variety of Merefians'kyi white. For garlic with the stem, the weight losses were 38.7 and 49.0 %, respectively. In the structure of garlic losses, the weight losses of undried bulbs were from 11.09 to 14.4 %, depending on the variety. Losses from the damage by diseases range from 5.28 to 12, 15 % and have a strong correlation r=0.98.

2. For the garlic dried up to the neck moisture content of 25±1 %, the yield of marketable products after six months of storage was 76.33 % for the variety of Merefians'kyi white and 78.59 % for Merefians'kyi pink (Diushes). The garlic dried up to the neck moisture content of 14±1 % increased the yield of the marketable products up to 82.98–80.15 %, the undried garlic decreased it up to 72.25–63.45 %, respectively.

3. The treatment of the bulbs of garlic variety Merefians'kyi pink (Diushes) with 2 % Glyocladine before storage ensured the yield of the marketable product of 82.59 %, of the variety Merefians'kyi white of 81.09 %. The treatment of 2 % Phytosporine increases the yield of marketable products by 81.98 and 80.38 %, respectively.

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