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DETERMINING THE EFFECT OF TREATING TABLE BEET WITH BIOPREPARATIONS BEFORE STORAGE ON ITS PRESERVATION

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The study reported here aimed to explore the preservation of table beet depending on its treatment with bio preparations before storage in order to prolong its shelf life.

The effect of aqueous solutions of the biopreparations Phytosporine and Gamair in concentrations of 0.2 %, 0.3 %, and 0.5 % on the intensity of quality loss by beetroots during storage was investigated.

It was found that the treatment with the bio preparations reduced the total weight loss by the roots Zepo F1 by 7.9–10.3 %, Carillon F1 – by 6.8–7.7 %. The daily weight loss by untreated beetroots due to the damage induced by microorganisms ranged from 0.08±0.01 % at a storage temperature of 1±1 °C to 0.1±0.01 % at a storage temperature of 15±1 °C, respectively.

The sugar content in beetroots non-treated with bio preparations decreases during storage by 21.6–25.0 %. Treating beetroots with a 0.3 % solution of Phytosporine reduces sugar losses over 150 days at a storage temperature of 1±1 °C by 3.7–6.5 %; with a 0.3 % Gamair solution – by 8.8–12.8 %.

The loss of vitamin C ranged from 39.4 % to 41.2 % relative to the initial content in the control. The treatment with Phytosporine reduced the loss of vitamin C to 17.4 % in Zepo F1, and 25.4 % – in Carillon F1; with Gamair – to 28.0 and 29.3 %, respectively. At a storage temperature of 15±1 °C, the content of vitamin C decreased by 1.5–1.8 times over 90 days.

It was established that the preservation of table beet depends on the shape of a root. At a storage temperature of 1±1 °C, the weight loss by cylindrical beetroots is 5.1 %, rounded shape – 5.4 %. The yield of marketable products ranges from 74.2 to 82.9 % for the Carillon F1 hybrid, and for Zepo F1 of a round shape – 73.3–80.5 % depending on the storage temperature.

The technique of treating table beet before storage with bio preparations allows using Phytosporine and Gamair for post-harvest treatment of vegetable raw materials. When devising new, low-cost, environmentally friendly, and affordable technologies, this is an important tool

Keywords: table beet, storage, biopreparations, preservation, components of chemical composition, damage by microorganisms

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1. Introduction

Table beet occupies one of the leading positions among vegetables for its taste and medicinal properties. Its roots are stored for a long time and used for various types of processing. Owing to the original set of nutrients and food components, they are necessary food for people of all ages. It is a valuable product for baby and diet food as it contains easily digestible polypeptides, essential amino acids, vitamins, many minerals, dietary fiber [1].

Losses of grown beetroots at the stages of sorting, transportation, and storage are large; that significantly reduces the profitability of processing, trade, and catering enterprises. At the same time, the use of conventional storing technologies in compliance with standard storage conditions (relative air humidity and temperature) does not always provide for a sufficiently low amount of losses. Moreover, during transportation, sale in a retail network, or processing at catering establishments, after long-term storage, the losses are quite significant. The losses are due to changes in temperature and relative humidity. Such beetroots are more prone to microbial spoilage.

Improving the technology of reducing the losses of beetroots at all stages of bringing them to the consumer is relevant.

Currently, in order to reduce losses during storage of plant raw materials, various technologies are used such as regulated gas environment, treatment with chemical reagents, biological preparations. The application of biological drugs can improve the efficiency of processing, take care of product quality preservation, increase the range of controlled phytopathogenic microorganisms, and reduce the risk of resistance development. This is an important tool in the development of new, low-cost, environmentally friendly, and affordable technologies.

Therefore, the use of antimicrobial drugs to prolong the period of consumption of fresh produce is relevant.

2. Literature review and problem statement

The application of the biopreparations Vitaplan, Extrasol, and Rizoplan extended the shelf life of apples, carrots, and potatoes [2, 3]. Meanwhile, the researchers note that biopreparations are an important factor that prevents the microbiological spoilage of fruits and vegetables by inhibiting the development of microorganisms. In their works, they emphasize the possibility of using these preparations on a wider range of fruits and vegetables. This allows the application of biological preparations when studying the longer shelf life of beetroots. Over the last ten years, biological plant protection means have become increasingly common in agriculture. The advantages of biological preparations include environmental friendliness (the substances produced by antagonist bacteria do not contaminate the soil and crops) and the specificity of action (high efficiency against certain types of phytopathogenic microorganisms). Biological preparations improve the field germination of seeds, the morphobiological characteristics of seedlings during germination, leaf formation, and the intensity of photosynthesis during seed development and maturation.

The main biologically active microorganisms are some species of Trichoderma and *Pseudomonas*, *Bacillus subtilis, Bacillus amyloliquefaciens, Arbuscular mycorrhizas,* endophytes, yeast, and avirulent or hypervirulent strains of certain pathogens, lactobacilli [4]. But the effectiveness of their use is associated with the competition against the microflora that already inhabits the surface of produce. Such biological preparations as Gamair, Phytosporine, Alirin, Vitaplan, Pseudobacterin, Gliokladin, Lepidocid, Boverin, Baktofit, and others have become widely used. Therefore, the issue of selecting the most effective of them for a particular type of fruit and vegetable product remains open.

In work [5], data on the use of antimicrobial drugs of organic origin are reported. The researchers treated garlic bulbs before storage with the biological preparations Gliocladin (Russia, AgroBioTechnology LLC) and Phytosporine (Ukraine, BashIncom LLC). Gliocladin contains the fungal culture *Trichoderma harzianum,* strain VIZR-18; Phytosporin contains strains of the bacterium *Bacillus subtilis* 26 D. It was found that the treatment of garlic bulbs with these biological preparations contributed to the yield of marketable products after six months of storage at the level of 80–83 %. That is 10.2 % larger than in the version without treatment. However, the issue arises as to the effectiveness of these drugs on other vegetables whose food organs are in direct contact with the soil. For example, beetroots.

Pseudomonas syringae L-59-66 (trade name BioSave) is used to control post-harvest damage of maize cobs. This preparation reduces the growth of *Escherichia coli* O157:H7 on the wounded tissues of apples [6]. The application of this drug is promising on the roots, bulbs, and tubers of vegetable plants. For successful storage after their removal from the soil, they must undergo a treatment period, during which wound tissue is formed.

The effectiveness of biological control of *Botrytis cinerea* on tomatoes by the epiphytic yeast strains *Candida guilliermondii* 101 and US 7, and *Candida oleophila* I-182 was established [7]. However, the shortcoming of the cited work is the lack of research involving other vegetables because gray rot is one of the common diseases that spoil produce during storage.

A reduction of dry potato rot was noted, when treating with *Pseudomonas fluorescens,* by 35 %, and *Enterobacter cloacae,* by 26.5 %. A significant decrease in the degree of development of dry rot of potatoes was observed for all treatment techniques in comparison with the untreated control sample when inoculating with *Fusarium sambucinu* [8]. However, promising biological preparations that are based on highly active strains of bacteria of the genus *Pseudomonas,* remain poorly understood in agrocenoses and under storage conditions of beetroots. This is because these bacteria are a large group of microorganisms that have different physiological and biochemical properties.

A study involving carrot roots proved the effectiveness of the yeast drug Shemer™ to reduce the development of diseases during storage. The combined use of steam treatment followed by treatment with Shemer™ reduces the microbiological spoilage of carrots caused by the fungus *Thielaviopsis basicola* by 86 % compared with the control [9].

Studies with apples and peaches [10] have shown that the use of the strain *Pseudomonas graminis* CPA-7 prevents the growth of pathogenic microorganisms. An effective reduction in the number of *E. Coli* O157: H7, *Salmonella*, *L. monocytogenes,* and *Listeria innocua* on minimally treated apples and peaches under laboratory and industrial conditions was established. The color did not change, there was an increase in hardness; however, issues related to the combined use of *Pseudomonas graminis* CPA-7 with other methods such as storage at low temperatures and the use of controlled gaseous media remained unresolved.

Treatment of melon by *Pseudomonas graminis* CPA-7 resulted in a reduction of *Salmonella* and *L. monocytogenes* on sliced melon after 5 days of storage. In the treated and untreated samples, no significant differences were found in the content of soluble dry matter, titrated acidity, pH, and hardness of the sliced melon. Besides, the antioxidant properties and the content of vitamin C were preserved [11]. There is a question of expediency of storing a cut melon for 5 days.

Antagonistic properties of *Enterobacter cowanii* B-6-1 strains against tomato phytopathogens were established. Treatment with *Enterobacter cowanii* B-6-1 at a concentration of 1×105 CFU/ml reduced the infection with *Fusarium verticillioides, Alternaria tenuissima,* and *Botrýtis cinérea*. Experiments have shown that *Enterobacter cowanii* can effectively inhibit the appearance of *B. cinerea* after harvesting tomatoes. The effect of treatment with a culture-based fluid at a concentration of 1×109 CFU/ml reaches 95.24 %. *E. cowanii* has antagonistic potential against *B. cinerea* on harvested fruits and vegetables [12].

Bacteria *Bacillus amyloliquefaciens* and the yeasts *Pichia guilliermondii, Candida guilliermondii, C. Oleophila,* and *Rhodosporidium paludigenum* were used on them as biological protection of tomato fruits from gray rot before storage [13]. Potato tubers were treated with the isolates of *Bacillus spp.* before storage, which allowed maintaining the tubers clean from the causative agent of dry rot for up to 8 months [14].

An interesting technique to prepare potatoes for storage was proposed by the company Baker & Mackenzie (USA) [15]. According to that technology, potatoes are treated with a solution of hydrogen peroxide for subsequent storage. Such technology is environmentally friendly, it prevents damage and rot caused by pathogenic microorganisms. However, in the case of long-term storage, it is advisable to treat potatoes with the solution every few weeks. In addition, in the intervals between such treatment, potatoes must be maintained in a sterile environment and at excess humidity.

A series of studies into preserving the quality of strawberries [16, 17] showed that the use of the biological preparations Trichodermin, Planriz, and Phytocide during the storage of vegetables is an effective environmental alternative. Treating potato tubers with biological preparations helps reduce the loss of weight, starch, and dry matter by 1.2–1.5 times, which allows obtaining high-quality planting material and is cost-effective. Phytosporin is a microbiological preparation based on the most active endophytic bacterium *Bacillus subtilis* 26. The preparation is intended for protecting plants from a set of fungal and bacterial diseases. Phytosporin has a double effect. On the one hand, it is located in the intercellular space of plants and, as an endophytic bacterial culture, competitively inhibits the development of many pathogenic microorganisms inside plants. On the other hand, in the near-root soil environment, during the growing season, it inhibits the development of many pathogens, including root rot.

The effect of such microbiological preparations as Ampelomycin, Vermiculine, Trichodermin, Gaupsin, and Planriz on the preservation of potatoes during their long-term storage at refrigeration was studied. The duration of storage was 145 days. The study results showed that all preparations inhibited the development of microbiological processes and helped reduce the intensity of respiration, which led to a reduction in natural product losses and damage from spoilage.

Note that the use of microbial preparations requires almost no changes in the technology of vegetable storage. The main thing is to take into consideration their composition. In terms of composition, preparations are living microorganisms with biologically active products of their vital activity. Therefore, microbial drugs may lose their properties without the mandatory conditions of their storage and use. Biological agents are not intended to completely eradicate the harmful species but only to reduce the harmfulness of microorganisms to an acceptable level. The biological method is considered an integral part of pest control.

Therefore, when investigating the issue of using biological preparations on vegetable produce, no data was found on their use on the roots of beets in order to extend their shelf life. There is also no information on the use of biological preparations to preserve the quality of root crops and reduce losses during short-term storage at elevated temperatures. Given today's wide range of vegetable products, this is an unresolved issue, which is to preserve their quality over a long time, both under conditions of artificial cooling and without it.

3. The aim and objectives of the study

The study aims to determine the preservation of table beet depending on its treatment with biological preparations before storage, which could prolong the duration of their consumption.

To achieve this goal, the following tasks were solved:

– to determine the losses of weight by table beet during storage;

– to examine changes in some components of the chemical composition of table beet during storage (the overall content of sugar and vitamin C);

– to carry out a comparative assessment of the preservation condition of table beet depending on the type of a biological preparation.

4. Materials and methods to study the preservation condition of table beet quality

The study involved the hybrids of table beet Zepo F_1 and Carillon F_1 (manufactured by Bejo Zaden, The Netherlands). Zepo F_1 roots are round, they match in size, with a smooth surface. The inner part is homogeneous, of dark burgundy color, without pronounced white rings. The hybrid retains its marketable appearance over a long time and has good transportability. Zepo F_1 is a universal hybrid: it is intended for early harvest at the first sowing in early spring (late March-April-early May) and for long-term storage during the second sowing (late May-mid-July). The Carillon F_1 beetroots are intended for storing, processing, and using fresh. Roots are cylindrical, aligned, the internal structure is dark red without radial rings, the skin is smooth. A small root collar and a small leaf rosette give the perfect look for marketable products. A root's weight is 200–300 g.

The description of the technological process of table beetroot preparation for storage is shown in Fig. 1.

Samples of beetroots were treated with aqueous solutions of the biological preparations Phytosporine (Ukraine, OOO "NVP BashIncom") and Gamair (the country of origin is Russia). Phytosporine contains strains of the bacterium *Bacillus subtilis* 26 D., Gamair – (*Bacillusubtilis*, strain m-22 vizr) at a concentration of 0.2 %, 0.3 %, and 0.5 %.

The consumption rate of biological preparations is 2.5 s ml/kg of roots. The prepared roots were sprayed with the working solution and dried. Untreated roots were taken as control. The beetroots were stored at a temperature of 1±1 °C in a refrigerated storing facility at a temperature of 15±1 °C and relative humidity of 80±5 %. The beetroots were stored in nets weighing 5.0±0.1 kg. We determined the content of certain components of the chemical composition in the table beetroots according to acting state standards [18, 19].

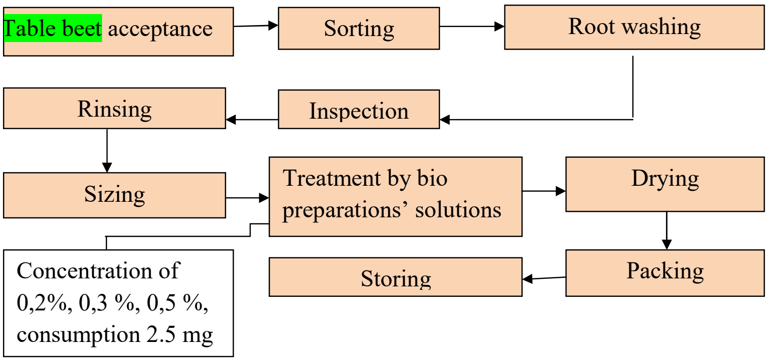

Fig. 1. Block chart of table beet preparation for storage

A sample was withdrawn from storage if the natural weight loss reached 10 % or larger and the produce showed signs of disease and physiological disorders. At the end of storing, the yield of standard products was determined. We identified the pathogens of microbiological diseases by the morphology of a pathogen under a microscope.

The working hypothesis assumes the possibility of using biological preparations in order to improve the stability of table beets during storage.

The data reported in this paper are the average value of three measurements. Statistical analysis was performed using Microsoft Excel 2007 (USA). Differences were considered statistically significant at the significance level $\alpha=0.05$.

5. Results of studying the preservation condition of table beetroot

5. 1. Determining the losses of table beetroot during storage.

It was found that at the surface of roots there are epiphytic microorganisms represented by bacteria, yeast, and mold fungi.

The largest number of bacteria of the genera *Bacillus* and *Clostridium*. species: *B. subtilis, B. mesentericus, B. megaterium*, and *B. mycoides*. Mold fungi at the surface of the roots are *Alternaria, Aspergillus, Clagosporium, Mucor, Rhizopus, Penicillium, Fusarium, Sclerotinia*, and *Botrytis*. Table beetroots are characterized by such diseases as brown rot (pathogen *Rhizoctonia solani*) and "storage rot" (complex of pathogens: *Botrytis cinerea, Phoma betae*, fungi of the genera *Fusarium, Penicillium, Aspergillus, Rhizopus*).

It was established that the effective concentration for the biological preparations Gamair and Phytosporine is a concentration of 0.3 %. Increasing the concentration to 0.5 % does not significantly affect the loss in root mass during storage (Table 1).

Therefore, for the treatment of table beetroots before storage, it is recommended to use an aqueous solution of the biological preparations Phytosporine and Gamair with a concentration of 0.3 %; solution temperature, 23...25 °C; preparation consumption, 2.5 ml per 1 kg of beetroots.

When storing root crops, there are weight losses due to respiration and partial evaporation of water (natural weight loss), the germination and the development of microorganisms. It is possible to reduce these losses by the post-harvest treatment of beetroots with biological preparations. It was established that the yield of marketable produce also depends on the storage temperature and the characteristics of the hybrid (Table 2).

It was found that when storing table beet of the hybrid Zepo F_1 at a temperature of 1±1 °C the total losses were 19.5 %. The treatment with biopreparations reduced the total loss of roots by 7.9–10 %. A similar pattern was observed for root crops of the hybrid Carillon F_1. Total losses decreased by 6.8–7.7 %.

Storage temperature significantly affected the losses by roots during storage. It was established that the daily weight loss, due to microorganisms, by the untreated roots ranged from 0.08±0.01 % at a storage temperature of 1±1 °C, to 0.1±0.01 % at a storage temperature of 15±1 °C. The treatment of beetroots with biological preparations reduced the weight loss caused by microorganisms to 0.04±0.01 % and 0.07±0.02 %, respectively.

Table 1

Weight loss by table beet Zepo F_1 depending on the treatment with biopreparations, % (60 days of storage)

Option	at a storage temperature of 15±1 °C		at a storage temperature of 1±1 °C	
	overall losses	due to microbiological spoilage	overall losses	due to microbiological spoilage
Untreated (k)	8.5±0.4	5.3±0.3	2.7 ±0.5	1.5±0.3
Treated by aqueous solution of Phytosporine of concentration, %:				
0.2	8.1±0.4	2.9±0.1	2.5±0.4	0.9±0.3
0.3	7.4±0.4	2.6±0.1	2.2±0.3	0.6±0.2
0.5	7.5±0.4	2.7±0.1	2.5±0.3	0.7±0.3
Treated by aqueous solution of Gamair of concentration, %:				
0.2	8.9±0.4	3.9±0.2	2.7±0.4	1.1±0.3
0.3	8.1±0.1	2.9±0.1	2.5±0.3	0.8±0.2
0.5	8.0±0.2	3.1±0.3	2.8±0.3	0.9±0.3

Table 2

Preservation of table beet depending on the treatment by biopreparations, characteristics of the hybrid, and storage temperature, %

Option	Natural weight loss	Roots that are damaged by diseases	Roots that are withered, sprouted	Overall losses	Yield of marketable produce
at a storage temperature of 1±1 °C, (150 days)					
Zepo F_1					
Untreated (k)	5.4	12.3	1.8	19.5	80.5
Treated with Phytosporine	4.5	5.3	0.8	9.0	91.0
Treated with Gamair	4.7	6.1	0.8	11.6	88.4
Carillon F_1					
Untreated (k)	5.1	10.4	1.6	17.1	82.9
Treated with Phytosporine	6.4	4.2	0.6	9.4	90.6
Treated with Gamair	4.9	4.7	0.7	10.3	89.7
$LSD_{05\ factor\ A}$	0.66	0.43	0.06	0.83	1.3
$LSD_{05\ factor\ B}$	0.54	0.35	0.04	0.25	1.1
Power of factor *A* effect, %	73	58	53	31	87
factor *B*, %	6	8	6	8	5
Variance, %	12.8	47.6	11.8	27.6	21
at a storage temperature of 15±1 °C (90 days)					
Zepo F_1					
Untreated (k)	15.3	9.5	1.9	26.7	73.3
Treated with Phytosporine	14.5	6.5	1.2	22.2	77.8
Treated with Gamair	14.7	6.9	1.9	23.5	76.5
Carillon F_1					
Untreated (k)	15.0	9.2	1.6	25.8	74.2
Treated with Phytosporine	14.2	6.3	0.9	21.4	78.6
Treated with Gamair	14.5	6.7	1.0	22.2	77.8
$LSD_{05\ factor\ A}$	0.66	0.52	1.0	0.76	0.87
$LSD_{05\ factor\ B}$	0.54	0.42	0.81	0.44	0.71
Power of factor *A* effect, %	39	91	17	41	86
factor *B*, %	4	2	11	5	8
Variance, %	4.2	19.2	70.6	14.2	2.9

5. 2. Changes in the components of table beet chemical composition during storage

The taste, technological, consumer properties of beetroots depend on their sugar content. During storage, sugars are spent on physiological processes (mainly respiration). At the beginning of storage, the sugar content can increase due to the hydrolysis of starch, pectin, polyphenols, hemicellulose [20]. During subsequent storage, sugar content decreases. In beetroots, sugar is represented to a greater extent by sucrose, less – by monosaccharides (glucose and fructose). It was established that the sugar content after storage depends on the pre-treatment of roots with biological preparations and storage temperature (Fig. 2).

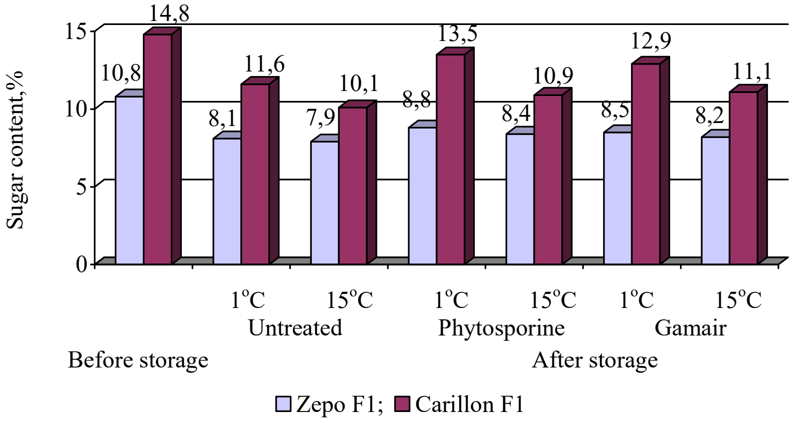

Fig. 2. Change in the sugar content of table beet depending on the treatment with biopreparations, storage temperature, %

When storing root crops at a storage temperature of 1±1 °C for 150 days, the loss of sugars significantly depended on the characteristics of the hybrid and the type of a biological preparation. The untreated roots lost from 21.6 % of sugar (hybrid Carillon F_1) to 25 % (hybrid Zepo F_1) relative to the initial content. The treatment with Phytosporin reduced sugar loss to 8.8 % and 18.5 %, respectively. The Gamair-involved root crop treatment reduced sugar loss to 12.8 and 21.3 %. Thus, the treatment of beetroots before storage with the biological preparation Phytosporine allows reducing sugar losses during storage at a temperature of 1±1 °C for 150 days by 3.7–6.5 %, with the biological preparation Gamair – 8.8–12.8 %.

In the plant raw materials, ascorbic acid is involved in redox reactions that inhibit the aging of cell membranes. Vitamin C is not stable during storage when exposed to ultraviolet rays, heavy metals, temperature. Inhibition of vital processes contributes to the greater stability of vitamin C [21].

It was found that the loss of vitamin C depends on the storage temperature, the characteristics of the hybrid, and the type of biological preparation (Fig. 3).

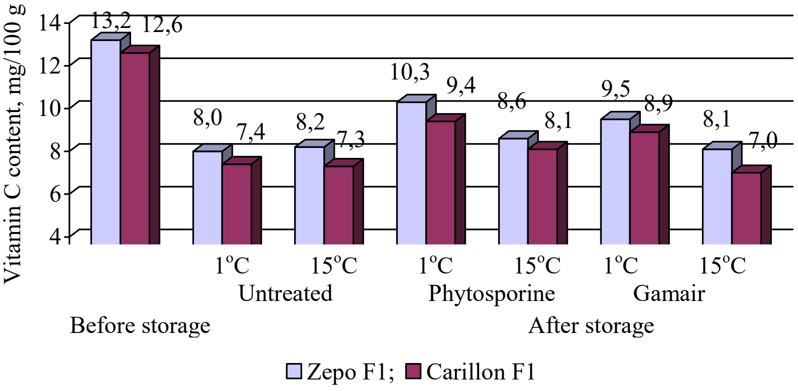

Fig. 3. Change in the vitamin C content in table beet depending on the treatment with bio preparations, storage temperature, mg/100 g

When storing beetroots at a storage temperature of 1±1 °C for 150 days, the loss of vitamin C ranged from 39.4 to 41.2 % relative to the initial content in the control. The treatment with Phytosporine reduced a vitamin C loss by 17.4 % in Zepo F_1 hybrid, and 25.4 % in Carillon F_1 hybrid. The treatment of beetroots with Gamair reduced vitamin C loss by 28.0 and 29.3 %, respectively.

The increase in temperature during storage intensifies the redox processes in stored produce. That leads to a more active consumption of vitamin C, which is a natural antioxidant. Intensive redox processes also reduce the duration of produce storage. Thus, at a temperature of 15±1 °C, the content of vitamin C in beetroots during 90 days of storage was 1.5–1.8 times less than before storage.

5. 3. Comparative evaluation of the preservation condition of table beet depending on the type of biological preparation and the characteristics of the hybrid

The taste and shelf life of table beet depend not only on the variety but also on the shape of their roots. Varieties with a flat shape ripen early, their preservation is satisfactory, the flesh is mostly purple-red with more or less pronounced white rings, the taste is good, the dry matter content is 8–11 %.

Varieties with a rounded and convex-flat shape, represented by Bordeaux and flat Nosivskyi, ripen a little later than the flat ones, they have good taste, contain 10–12 % of dry matter, and are well preserved. Beetroot varieties with a conical shape ripen late, are very well preserved, contain much fiber, and have a fibrous juicy flesh, so their quality is low, dry matter is 12–16 % in roots [1].

It was established that the preservation of table beetroots depends on the shape of the root. The hybrid Carillon F_1 roots have a cylindrical shape. The sugar content is 14.8 %. The Zepo F_1 hybrid is round, sugar content is 10.8 % (Fig. 4–8).

During storage, sugars are lost. The intensity of losses depends on the characteristics of the hybrid, namely the shape of the root. In the hybrid Carillon F_1, sugar loss is 21.6 % of the initial content. The Zepo F_1 hybrid reduces sugar content by 25.0 %. Natural weight loss correlates with sugar loss. At a storage temperature of 1±1 °C, the loss by roots with a cylindrical shape is 5.1 %, round shape – 5.4 %. A similar pattern is observed with the number of roots affected by microorganisms. During storage, the loss of beetroots due to the damage from microorganisms is 10.4 in the hybrid Carillon F_1, and 12.3 % – in the hybrid Zepo F_1. At a storage temperature of 15±1 °C, the losses increase in proportion to the shape of the root. The yield of marketable produce ranges from 74.2 to 82.9 % in the hybrid Carillon F_1, in the hybrid Zepo F_1 of a round shape is 73.3–80.5 % depending on the storage temperature (Table 2).

When beetroots are stored, there is a fusarium rot (Fig. 4). The symptoms of the disease are characterized by the appearance of a fluffy mycelium of the white, pink, or reddish color at the surface of the affected roots. At increased temperatures, the disease develops rapidly. The causative agents of the disease are fungi from the genus *Fusarium Link*.

a *b*

Fig. 4. Beetroots affected by fusarium wilt; *a* – Zepo F1; *b* – Carillon F1

Black rot (Alternaria) affects roots on all sides. Initially, depressed spots are formed, which are deepening, the tissue becomes black (Fig. 5).

Grey mold of beet is the most dangerous during root storage. Depending on the species composition of pathogens, there forms at the surface of the affected root a plaque of white, pink, gray, brown, green, and other colors. The affected tissue also has a different color and texture (Fig. 6).

a *b*

Fig. 5. Beetroots affected by black rot: *a* – Zepo F_1; *b* – Carillon F_1

a *b*

Fig. 6. Beetroots affected by Grey mold: *a* – Zepo F_1; *b* – Carillon F_1

Root can be wet and dry. The development of Kahatna rot on roots leads to the loss of the marketable appearance by produce and a significant deterioration or complete unsuitability for any use. The disease is caused by the fungi *Botrytis cinerea Pers., Penicillium spp., Fusarium spp.* The composition of microorganisms that cause the disease depends on storage conditions. *B. cinerea* develops only in the conditions of high humidity, which are created in the research. Most pathogens are semi-parasites and saprotrophs that develop on dead or weakened tissue. Studies established that Kahatna rot is manifested on beetroots that underwent mechanical damage (obtained during harvesting or transportation), or lost turgor (faded).

The appearance of table beet depends on the shape of the root and their treatment with biological preparations before storage. The roots of the Carillon F_1 hybrid of cylindrical shape, treated before storage with biological preparations, are whole, clean, not faded, not affected by diseases, without excess external moisture, typical of the botanical variety (Fig. 7). The roots of the Zepo F_1 hybrid, unlike the roots of the Carillon F_1 hybrid, show signs of slight wilting, which does not affect the marketable quality.

a *b*

Fig. 7. The appearance of beetroots, treated with biological preparations before storage, at the end of storage: *a* – Zepo F_1; *b* – Carillon F_1

In the control, there are wilted roots with signs of wrinkles (Fig. 8).

a *b*

Fig. 8. The appearance of roots at the end of storage – control: *a* – Zepo F_1; *b* – Carillon F_1

At the end of storage of the control, single roots were affected by diseases. Tissues that lose turgor are easily damaged by phytopathogenic microflora. The tail part of the root withers faster, hence the spread of diseases.

6. Discussion of results of studying the effect of biopreparations on the preservation quality of table beet

All roots, except radishes, are biennial crops. Their common biological feature is the ability to be at rest at a low temperature, which is not deep in the roots but forced.

Beetroots lose their disease resistance when they wither. Preventing root wilting is one of the main technological conditions for proper harvesting and storage.

The treatment of beetroots before storage with biological preparations reduced the number of wilted roots and those affected by microorganisms (Table 2). When storing beetroots at a temperature of 1±1 °C, in the control the number of wilted roots was 1.6–1.8 %, affected by microorganisms – 10.4–12.3 %. The treatment of beetroots with Phytosporine reduced the number of wilted roots by 0.6–0.8 %, the number of beetroots affected by microorganisms – by 4.2–5.3 %, depending on the hybrid. The results from a two-factor analysis of variance of beetroots damaged by microorganisms, depending on the treatment with biopreparations and the characteristics of the hybrid, indicate that the difference between the experimental variants and control (a 5 % significance level) is significant ($LSD_{05\text{ factor A}}=0.43$; $LSD_{05\text{ factor B}}=0.35$). The strength of the treatment effect exerted on roots by biological preparations on the damage due to microorganisms is 58 %, the features of the hybrid – 8 %. The number of wilted roots depends by 53 % on the treatment with biological preparations, and by 6 % on the features of the hybrid. A storage temperature of 15±1 °C increases the number of wilted fruits and those affected by microorganisms. Therefore, the treatment of beetroots with biological preparations before storage can reduce losses and prolong the duration of storage. Similar results were obtained when treating table grapes with the lactic acid *bacteria Lactobacillus delbrueckii* subsp. *Bulgaricus* strain F17 and *Leuconostoc lactis* strain H52 significantly inhibited the development of mold and yeast on berries. That allowed the organoleptic characteristics of grapes to be preserved without a loss for 20 days at a temperature of 8 °C. Sliced apples and lettuce, treated with

Lactobacillus plantarum and *Lactobacillus casei*, maintained their organoleptic characteristics at 8 °C for 16 days. The treatment of lychee with *Lactobacillus plantarum* ensured the preservation of mass and organoleptic characteristics for 21 days at a temperature of 8 °C [22]. Lactic acid bacteria during their life activities emit carboxylic and fatty acids, ethanol, carbon dioxide, hydrogen peroxide, and other substances that have a bactericidal effect [23]. The use of *Aureobasidium pullulans* PL5 halved the loss of plums and peaches from brown rot, and apples – from blue and gray molds [25].

Potato tubers were treated by the isolates of *Bacillus spp.* before storage, which made it possible to maintain the tubers clean from the causative agent of dry rot for up to 8 months [24]. The use of *Aureobasidium pullulans* PL5 halved the loss of plums and peaches due to brown rot; apples – due to blue and gray mold [25].

The treatment with biopreparations significantly reduced the natural loss of roots during storage (Table 2). ($LSD_{0.5\ \text{factor A}}=0.66$, $LSD_{0.5\ \text{factor B}}=0.54$). Our analysis of variance showed that the treatment with biological preparations affects the natural weight loss of roots during storage at a temperature of 1±1 °C by 73 %; increasing the storage temperature to 15±1 °C reduces the impact to 39 %.

The yield of standard fruit products after storage by conventional technologies is at the level of 80.5–82.9 % (Table 2). The analysis of variance has revealed that the treatment with bio preparations (factor A) affects the yield of marketable products by 31.0 %; the degree of influence of the hybrid (factor B) was 8.0 %; the combined effect of these two factors is 5.7 %; other factors affected by 55.3 %.

Similar results were obtained in the study of the biological preparations Gaupsin and Planriz. The highest shelf life after 90 days of storage was observed in root crops, Bordeaux variety, treated with the biological preparations Gaupsin and Planriz, 92.9 % and 86.0 %, respectively, which is 9.9–3.0 % higher than that of control. It was found that when treating table beet with Gaupsin (during the growing season and before storage), after 180 days of storage the number of roots affected by diseases was 10.6 % less compared to control [26].

The suitability of roots for storage or certain types of processing significantly depends on the content of basic biochemical parameters. The level of dry matter, sugars, and vitamin C is especially important.

It was found that beetroots consumed sugars and vitamin C differently (Fig. 2, 3). The most economical consumption of sugars during the storage period was demonstrated by the hybrid Carillon F_1 beetroots. The loss over seven–five months of storage at 1±1 °C was 21.6 % of the initial content. The treatment with biological preparations reduced sugar loss by 8.8–12.8 depending on the type of preparation. To a greater extent, the losses of vitamin C were observed in the control variant – 39.3–41.2 %, the treatment with bio preparations contributed to a decrease by 21.9–25.0 % depending on the biological preparation.

Similar studies were performed with Planriz: this preparation was used to treat apples before laying them to be stored. There was a decrease in the intensity of redox reactions, the stabilization in carbon exchange. A reduction in the overall absolute losses was observed; the shelf life of fruits was prolonged. Throughout the entire storing period, the amount of sucrose in the treated apples increased, while that in the control decreased. At the initial stage, sugar accumulated both from sucrose and renewable sugars. The results from analyzing the examined products confirm the antifungal activity of the preparation Planriz [27].

This study reports the results from the post-harvest treatment of beetroots with biological preparations. The use of these preparations to prolong the storage period and maintain the quality of beetroot produce has demonstrated a positive effect. The reliability of our results has been confirmed by statistical analysis.

However, this study focuses on two preparations that contain the strains of the bacterium *Bacillus subtilis* 26 D. and *Bacillussubtilis*, strain m-22 vizr. In further studies, it will be important to study other preparations that contain the fungal culture *Trichoderma harzianum* strain VIZR-18 and *Pseudomonasfluorescence*. To protect plants from a wide range of fungal and bacterial diseases, there is the promising preparation Trichodermin, which is produced on the basis of the fungus *Trichodermalignorum*. The fungus inhibits the development of phytopathogens by direct parasitism, competition for the substrate, the release of enzymes, antibiotics (gliotoxin, viridine), and other biologically active substances [28]. It was found that the best ability to inhibit microbiological and physiological processes was demonstrated by the biological preparation Planriz, which is based on the microorganisms from the genus *Pseudomonasfluorescence*. Further research is relevant. This is due to the fact that growing organic products is gaining popularity. These products are also laid to be stored; to extend their storage duration, the use of organic preparations with an antimicrobial effect is implied. A promising area is to search for measures to improve the effectiveness of the application of biological preparations. As well as to study their influence on a change in the content of macro- and microelements in vegetable produce during storage.

7. Conclusions

1. It was established that when storing table beet of the hybrid Zepo F_1 at a temperature of 1±1 °C the total losses were 19.5 %. The treatment with biological preparations reduced the overall root losses by 7.9–10.3 %. A similar pattern was observed for beetroots of the hybrid Carillon F_1. The total losses decreased by 6.8–7.7 %. Storage temperature significantly affected the loss of roots when storing them. It was found that the daily weight loss due to microorganisms by the untreated roots ranged from 0.08±0.01 % at a storage temperature of 1±1 °C to 0.1±0.01 % at a storage temperature of 15±1 °C. The treatment of beetroots with biological preparations reduced their weight loss due to microorganisms by 0.04±0.01 % and 0.07±0.02 %, respectively.

2. Treating beetroots before storage with the biological preparation Phytosporine makes it possible to reduce sugar loss when stored at a temperature of 1±1 °C for 150 days by 3.7–6.5 %, with the preparation Gamair – by 8.8–12.8 %. A vitamin C loss ranged from 39.4 % to 41.2 % relative to the initial content in the control. The treatment with Phytosporine reduced a vitamin C loss to 17.4 % in Zepo F_1 hybrid and 25.4 % in Carillon F_1 hybrid; with Gamair – to 28.0 and 29.3 %, respectively. Elevated storage temperature accelerates the oxidation of vitamin C and reduces the duration of storage. When storing beetroots at a tempera-

ture of 15±1 °C for 60 days, the loss of vitamin C increased by 2.2–3.8 times.

3. It has been established that the preservation of table beet depends on the shape of the root. In the hybrid Carillon F_1 of a cylindrical shape, sugar loss is 21.6 % of the initial content. The Zepo F_1 round-shaped hybrid reduces sugar content by 25.0 %. Natural weight loss correlates to sugar loss. At a storage temperature of 1±1 °C, the loss of beetroots of a cylindrical shape is 5.1 %, round shape – 5.4 %. The yield of marketable produce ranges from 74.2 to 82.9 in the hybrid Carillon F_1, in the hybrid Zepo F_1 of a round shape – 73.3–80.5 % depending on the storage temperature.

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