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Досліджено дію препаратів антимікробної дії – Байкал ЕМ-1, 0,5 %-ний розчин лимонної, 0,2 %-ний бензойної, 0,05 %-ний сорбінової кислот, 0,5:0,5 % розчин вітамінів С та Р (аскорутин) – на збереженість та якість капусти броколі. Встановлено, що препарати антимікробної дії сприяють подовженню строку зберігання капусти броколі на 5–20 діб залежно від гібриду. Обробка препаратами зменшує втрати за добу у 1,2–3,0 рази, забезпечує вихід тварної продукції 76,8–86,2 %.

Обробка капусти броколі препаратами антимікробної дії, особливо аскорутином, забезпечують вміст сухої речовини в 1,1–2,6 рази більше, ніж у контролі, сприяє зниженню інтенсивності витрачання сухих розчинних речовин та вітаміну С. У кінці зберігання вміст загального цукру та дисахаридів на рівні з контрольним варіантом, або перевищує його вміст відповідно в 1,2 та 1,5–2,0 рази. Більше у варіантах з кислотами та аскорутином. Вміст моносахаридів зберігається на початковому рівні. Втрати маси за рахунок випаровування води більше в 1,3–1,8 рази.

Байкал ЕМ-1 та аскорутин краще, ніж інші препарати стримують інтенсивність розвитку хвороботворних мікроорганізмів на 10–15 діб. Аскорутин забезпечує за тривалого зберігання менші на 0,8–2,2 % втрати маси від хвороб та фізіологічних розладів і на 4,1–7,6 % більший вихід товарної продукції. Більш активно пригнічує розвиток хвороботворних мікроорганізмів на капусті броколі аскорутин, лимонна, сорбінова та бензойна кислоти. Проте, від фізіологічних розладів під час зберігання препарати не захищають плоди. Спосіб оброблення капусти броколі препаратами антимікробної дії перед зберіганням дозволяє використання антисептиків – Байкал ЕМ-1, 0,5 %-ний розчин лимонної, 0,2 %-ний бензойної, 0,05 %-ний сорбінової кислот, 0,5:0,5 % розчин вітамінів С та Р (аскорутин) – для післязбиральної обробки овочевої сировини. У розробці нових, низьковитратних, екологічно чистих і доступних технологій це є важливим прийомом

Ключові слова: якість капусти броколі, антисептики, строк зберігання, компоненти хімічного складу, збереженість

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RESEARCH INTO PRESERVATION OF BROCCOLI DEPENDING ON THE TREATMENT WITH ANTIMICROBIC PREPARATIONS BEFORE STORAGE

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1. Introduction

Fresh vegetables have a limited storage period even under conditions of optimum temperature and humidity. The reasons are a large natural loss of weight and the loss due to diseases and physiological disorders. In addition, vegetables lose freshness and consistency. They also lose content of components of their chemical composition. Fresh fruits

and vegetables lose 20–25 % of their volume due to diseases even under optimal storage conditions [1]. It is necessary to perform post-harvest treatment of vegetables and fruits with chemicals to overcome losses and, as a consequence, to increase storage period. We can divide chemicals into groups by their action: antiseptics – they act against changes caused by a vital activity of microorganisms; antioxidants – they prevent chemical changes; emulsifiers-substances – they prevent physical changes [2].

There is a need to find new substances of natural origin under existing conditions of ecological deterioration, when various negative environmental factors affect the environment and the human body. Treatment with antiseptics increases the yield of commercial products and maximizes taste and nutritional and therapeutic properties of broccoli.

Given the above, the development of a technology for storing broccoli with the use of antimicrobial substances, which should be environmentally friendly and simple in implementation, is essential and relevant.

2. Literature review and problem statement

The aim of treatment of fruit and vegetable products by chemicals of various actions is increasing the retaining capacity and the yield of commercial products at the end of storage. Growers treated brussels sprouts with a benzimidazole solution for long-term preservation of good quality and green color, and then they stored it under light in a modified atmosphere, which contained 7 % of CO_2 and 14 % of O_2. They treated heads of cabbage, cauliflower, celery, broccoli and lettuce with aqueous solutions of N^6-benzylidene (an inhibitor of plant tissue senility, which reduces intensity of respiration) on a day before harvesting or before storage. Products remained untreated 1.5 times longer and contained more chlorophyll by 2–4 times [3]. Tissues lose important components of a chemical composition – sugars, organic acids, phenolic substances during respiration. The lower respiration intensity of fruits, the better is their quality and nutritional value. But there were no changes in components of a chemical composition in the above studies.

Growers treated tomatoes with solutions of boric acid, potassium permanganate and calcium chloride before storage in polyethylene bags. Their storage life increased in 3 times due to the reduction of natural losses. Treated fruits preserved a good consistency, acquired an attractive color and aroma and contained more vitamin C throughout the entire period [4]. The action of antiseptics consists in the fact that chemicals combine with proteins of membranes of microorganisms, and act on cells toxically, which causes their death. However, chemicals do not protect fruits from physiological disorders during storage.

Treatment of the inner part of plastic bags and packaging paper with essential oils of Siberian fir and cinnamon for storage of beet, cabbage, onions, potatoes, carrots and strawberries prevented development of fungal diseases of products [5, 6]. In addition, it is possible to use essential oils of oregano, thyme, ash, marjoram, lavender, rosemary, wormwood and mint of marsh against *Botrytis cintrea*, *Fusarium solani var.* [7]. Thyme essential oil and essential oil of savory maintained a bunch of table grapes clean from *Penicillium digitatum* and *Rhizopus stolonifer* for 60 days of storage [8]. Treatment with chitosan reduced a damage of gray rot of table sorts of grapes by 2 times [9] and increased the storage life of strawberry and lettuce [10]. Oil of Siberian fir, oils of oregano, thyme, ash tree, marjoram, lavender, rosemary, wormwood and marsh mint contain tannins, ascorbic acid, tocopherols, tannins, phenolcarboxylic acids, phytoncides, alkaloids and flavonoids. All of them have bactericidal properties; they suppress staphylococci and rod bacterium microorganisms.

Bacteria *Bacillus amyloliquefaciens* and yeasts *Pichia guilliermondii*, *Candida guilliermondii*, *C. oleophila* and *Rhodosporidium paludigenum* protected tomatoes from gray rot before storage [11]. There is information on the treatment of potato tubers with isolates of *Bacillus spp* before storage, which made it possible to keep tubers clean from a rotten pathogen up to 8 months [12]. The use of *Aureobasidium pullulans* PL5 reduced loss of plums and peaches from brown rot, and apples – from blue and gray molds by 2 times [13].

We should note that the use of microbial preparations almost does not require changes in the technology of storage of vegetables. The main thing is to take into account their composition. Preparations in their composition are living microorganisms with biologically active products of their livelihood. Therefore, microbial preparations can lose their properties without observance of the obligatory conditions of their storage and application. Biological means do not eliminate harmful species completely; they only reduce harmfulness of microorganisms to an acceptable level. Researchers consider the biological method as a component of the control of harmful organisms.

Growers effectively used *Cryptococcus laurentii* and hay bacterium against *Rhizopus stolonifer*, gray and blue molds and wet rot at storage of peaches and nectarines [14]. Authors give information on treatment with *Kloeckera apiculata* yeast against *Penicillium expansum*, *Botrytis cinerea* and *Monilinia fructicola* [15]. Yeast of *Pichia caribbica* provided inhibition of expansion of wet rot and an increase in activity of peroxidase and catalase in fruit cells [16].

Paper [17] proposes extracts of plants such as *Borago officinalis, Orobanche crenata, Plantago coronopus, Plantago lanceolata, Sanguisorba minor, Silene vulgaris, Sonchus asper, Sonchus oleraceus* and *Taraxacum officinale* for post-harvest treatment of fruits and vegetables [17].

Cryptococcus laurentii and hayloaf effectively protected peaches and nectarines against *Rhizopus stolonifer*, gray and blue mold and wet rot during storage [18–20]. Authors of work [21] used *Kloeckera apiculata* yeast against *Penicillium expansum*, *Botrytis cinerea* and *Monilinia fructicola* [21]. Yeast of *Pichia caribbica* inhibited expansion of wet rot and increased activity of peroxidase and catalase in fruit cells in study [22]. Such treatment stimulates protective reactions of fruits, which extends their storage time by 20 %. It reduces losses caused by microbiological damage by 50 %. However, the disadvantage of the method is a significant increase in the cost of products.

Treatment freshly cut cabbage with a 1 % solution of citric acid kept its freshness for 22 days at a temperature of 0...5 °C and prevented its browning in a place of a cut [18]. Studies on different fruits confirmed effectiveness of a use of acetic acid, peracetic, salicylic, jasmine acids and methylazasmonate against rot and mold [19, 20]. Zucchini treated with solutions of polyamines, such as putrescine, spermidine and spermine for 12 days at a storage temperature of 0 °C had less weight loss than control ones, they preserved their color and firm consistence of a pulp [21]. Citric acid slows expansion of all microorganisms especially; it prevents development of bacteria by reducing of pH of cellular juice. It also exhibits

antioxidant action. There were no studies of the antimicrobial properties of such preparations for post-harvest treatment of broccoli before storage.

Treatment of cherries with a 10 % ethanol solution heated to 60 °C inhibited expansion of spores of *Penicillium expansum* and *Botrytis cinerea* during storage [22]. Strawberry losses caused by grey mold decreased at immersion in water at a temperature of 55 °C and 60 °C for 30 seconds [23]. Authors of work [24] submerged peaches and nectarines in water of a temperature of 48 °C before storage to control expansion of brown rot (*Monilinia laxa*). Peaches – for 12 minutes and nectarines – for 6 minutes. This reduced disease losses in 10 times and maintained the quality of fruits [24]. Immersion of peaches in water of 37 °C and their subsequent treatment with *Cryptococcus laurentii* reduced losses caused by blue mold and wet rot [25]. Sorbic acid and benzoic acids act against mold fungi and yeast and partly bacteria [4].

We can note that scientific information on the use of antimicrobial preparations for preservation and quality of broccoli is not sufficient. Because there are no studies on the subject. Treatment of fruit and vegetable products with antimicrobial preparations before storage has a number of disadvantages. Namely, it does not protect fruits from physiological disorders during storage. There are no changes in components of a chemical composition in the above studies carried out. Biological means do not eliminate microorganisms completely, they only reduce harm to an acceptable level. The disadvantage of the method is a significant increase in the cost of production.

Therefore, it is important to investigate an effect of antimicrobial preparations on weight loss, changes in components of a chemical composition of broccoli, microorganism affection and physiological disorders during storage.

3. The aim and objectives of the study

The aim of this study was to investigate an effect of antimicrobial preparations on preservation and quality of broccoli to determine duration of the storage life of broccoli in dependence on a preparation.

We solved the following tasks to achieve the objective:

– determination of natural mass loss during storage;

– study on affection of broccoli with diseases and physiological disorders;

– investigation of a change of components of a chemical composition during storage of broccoli;

– conduction of a comparative estimation of preservation of broccoli in dependence on a type of antimicrobial preparation.

4. Materials and methods to study preservation of quality of broccoli and chemical and organoleptic parameters

We conducted the research with late ripening hybrids of broccoli (Ironman F_1, Agassi F_1, and Beaumont F_1). The method of growing was seedlings (we planted seedlings with 4–5 actual leaves). The method of placement of plants – a tape one with a scheme of placement (40+100)×50 cm. The registration area in the experiment with broccoli was 50 m^2, the repetition of the experiments was three times. The placement of options was systematic. The experiment was a one-factor experiment. We collected broccoli when heads acquired technical ripeness, size and density, which are characteristic for a certain hybrid. The diameter of a head of broccoli was not less than 4 cm according to the standard. We collected broccoli twice because it forms a second harvest on side heads after cutting of central heads. Ironman F_1 is a hybrid of broccoli for fresh processing and consumption. The color of heads is saturated blue-green, heads are highly dome-shaped, dense and heavy. Agassi F_1 is a universal hybrid of broccoli suitable for freezing and processing. Heads are of attractive light green color, it has very homogeneous inflorescences, they are medium-high and of high standard. Beaumont F_1 is a universal hybrid of broccoli. Head mass is up to 2.5 kg. Heads are of fine-grained structure, they are round, aligned and dark green. They have a very attractive appearance and a unique taste and they do not lose it. The hybrid is suitable for processing.

Paper [26] presents materials and methods for the study on preservation of the quality of broccoli and chemical and organoleptic parameters in more detail [26].

5. Results of study into preservation of broccoli

We established that the treatment of broccoli with antimicrobial preparations before storage with subsequent packaging in plastic bags contributed to their better preservation. On average, during the years of research (Fig. 1), natural mass losses in variants with the use of Baikal EM-1 preparation were: for Ironman F_1 hybrid – 4.5 % for 35 days of storage, for Agassi F_1 – 4.7 % for 30 days, for Beaumont F_1 – 3.4 % for 35 days; losses were slightly lower with the use of citric acid: 4.0 %, 4.3 % and 3.0 % for 35 days, respectively; with the use of sorbic acid: for Ironman F_1 – 2.4 % for 30 days of storage, for Agassi F_1 – 3.0 % for 25 days, for Beaumont F_1 – 2.2 % for 35 days.

With the use of benzoic acid, natural losses were: for Ironman F_1 – 3.0 % for 35 days, Agassi F_1 – 3.3 % for 25 days and for Beaumont F_1 – 2.4 % for 35 days of storage. Application of ascorutin contributed to prolonging the storage life of broccoli hybrids – Ironman F_1 and Beaumont F_1 up to 45 days, Agassi F_1 up to 40 days. The natural weight loss was 4.1, 3.5 and 4.6 %, respectively, during this period (Fig. 1).

The intensity of the affection of broccoli with diseases and physiological disorders during storage depends not only on weather conditions of the growing season, but also on the treatment of products with antimicrobial preparations before packaging. We established that the treatment of broccoli heads with antimicrobial preparations inhibited expansion of microorganisms and thus prolonged duration of its storage. The first signs of the affection and physiological disorders in Ironman F_1 hybrid heads treated with Baikal EM-1 and ascorutin preparations appeared 15 days later (on day 35) than in the control variant (Fig. 2). Losses were 11.9 % and 6.4 %, respectively.

At treatment with citric acid, we observed first injured heads on day 30 of storage – 9.8 %; with the use of sorbic acid and benzoic acid, we recorded the first signs of the affection as in the control version – on day 20. The losses were smaller by 1.1 and 1.9 times, respectively.

At further storage, we observed less rapid expansion of diseases and physiological disorders in the variants with Baikal EM-1 and ascorutin preparations: there were product losses of about 20 % on days 45 and 50 of storage, respectively.

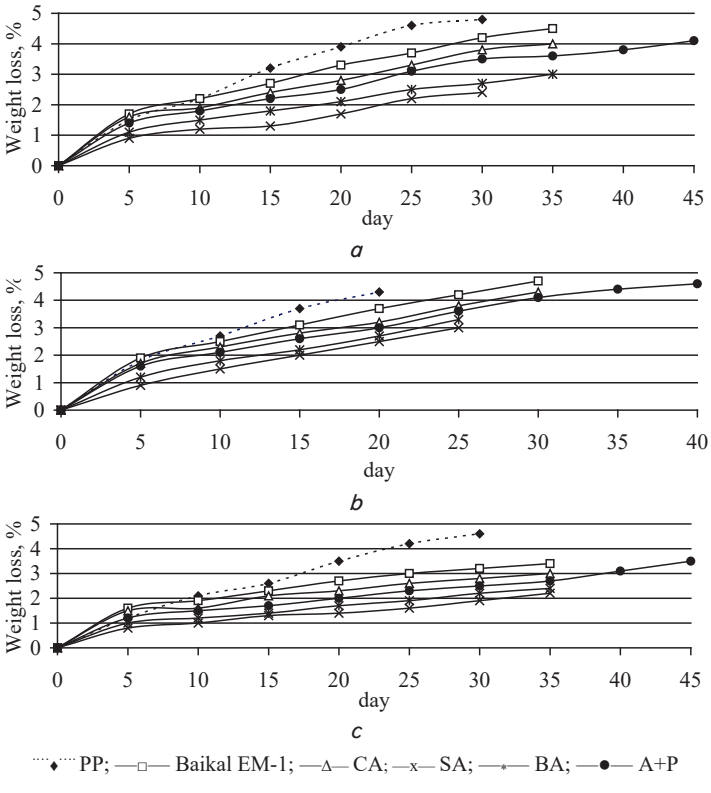

Fig. 1. Dynamics of natural mass loss of heads of broccoli hybrids in dependence on the treatment with preparations of antimicrobial action, %: *a* – Ironman F_1, *b* – Agassi F_1; *c* – Beaumont F_1

The variance analysis established that the effect of treatment of broccoli with antimicrobial preparations on total natural losses was 74.7 %.

Natural losses per day were significantly lower in the variants with the use of antimicrobial preparations than without such treatment (LSD_{05} = =0.01–0.02 %). Results fluctuated within 0.11–0.15 % for Agassi F_1, within 0.07–0.13 % for Ironman F_1, and results for Beaumont F_1 hybrid were somewhat smaller – within 0.05–0.10 %. The treatment with preparations reduced losses per day for Ironman F_1 by 1.2–2.1 times, for Agassi F_1 – by 1.3–1.9 times and for Beaumont F_1 – by 1.5–3.0 times depending on the preparation compared with the variants without treatment. The share of preparation effect was 58.0 %.

We found that losses of products due to diseases and physiological disorders depends by 11.7 % on the treatment with a preparation (factor A), by 3.7 % on characteristics of a hybrid (factor B) and by 27.7 % on the combined effect of these factors. These fluctuations range within 10.5–18.4 % for Ironman F_1, within 10.2–17.6 % for Agassi F_1, and from 10.5 to 18.4 % for Beaumont F_1 depending on the preparation (Table 1).

The yield of products at the end of storage fluctuated, on average, within 76.8–86.9 % for Ironman F_1 over the years of research, in dependence on a preparation, for Agassi F_1 – 78.5–87.6 %, and for Beaumont F_1 – from 78.5 to 88.2 %.

The use of ascorutin delayed expansion of pathogenic microorganisms for Agassi F_1 hybrid. The first signs of the affection appeared on them 15 days later (on 30th day) than in the control variant, and losses were 6.1 %.

The treatment with Baikal EM-1 and citric acid increased resistance to diseases. The first signs of damage appeared 10 days later (on day 25) than in the control variant and were 8.0 and 9.7 %, respectively.

With the use of sorbic and benzoic acids, diseases appeared 5 days later than in the control variant, and losses were 3.7 % and 3.4 %, respectively. This hybrid is unstable to disease during storage, so losses of products in the variants with the use of citric acid, sorbic acid and benzoic acid reach about 20 % or more after 5–10 days. Diseases on the heads treated with Baikal EM-1 and ascorutin developed less intensively.

The treatment of the heads of Beaumont F_1 hybrid with Baikal EM-1 and ascorutin increased the period of disease development for 10 days. The first signs of the affection appeared on day 35 and losses were 10.2 and 4.6 %, respectively. The treatment with citric acid delayed manifestation of diseases for 5 days.

The first losses appeared on day 30 and was 8.0 %. The first signs of a presence of diseases of products treated with sorbic acid and benzoic acid appeared on day 25, as well as in the control variant. The losses were 3.5 % and 2.7 %, respectively. Diseases of broccoli treated with ascorutin developed less intensively at further storage.

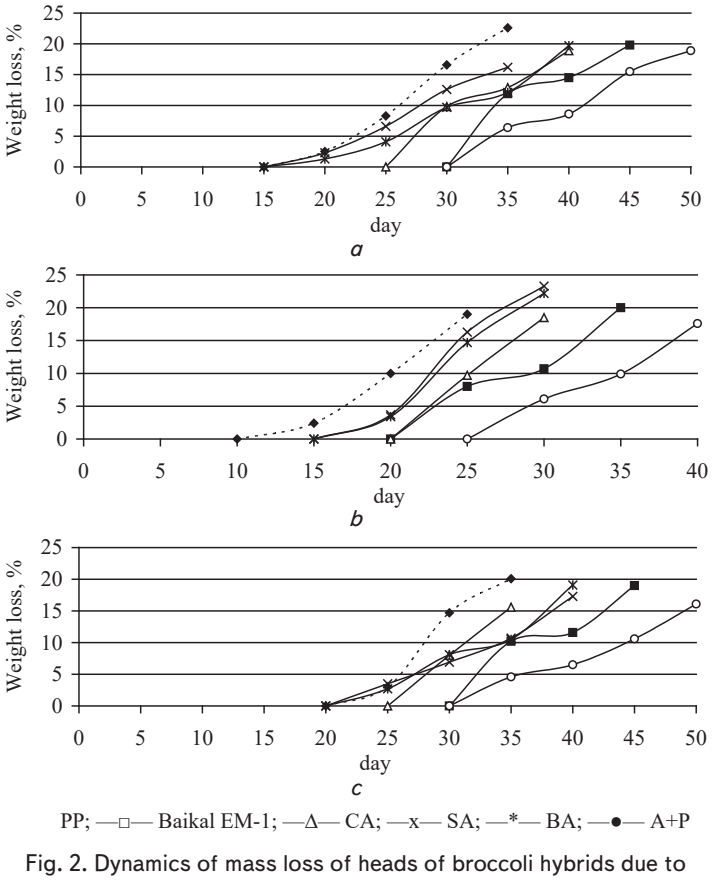

Fig. 2. Dynamics of mass loss of heads of broccoli hybrids due to diseases and physiological disorders in dependence on the treatment with antimicrobial preparations, %: *a* – Ironman F_1; *b* – Agassi F_1; *c* – Beaumont F_1

Table 1

Preservation of broccoli depending on the treatment with antimicrobial preparations (average over the years of studies)

Variant		Storage period. days	Product losses. %			Product yield. %
			natural		due to diseases and physiological disorders	
			altogether	per day		
Ironman F_1	1. PP	30	4.8	0.16	16.6	78.6
	2. Baikal EM-1	35–50	3.9–4.5	0.11–0.13	12.9–17.3	76.8–82.6
	3. CA	30–40	3.4–5.0	0.10–0.13	12.5–15.6	80.7–84.0
	4. SA	30–35	2.2–2.9	0.07–0.09	10.5–18.4	79.4–86.9
	5. BA	30–40	2.4–3.7	0.08–0.09	13.1–16.3	80.0–83.8
	6. A+P	35–45	3.3–4.5	0.09–0.10	10.5–14.4	81.6–86.2
Agassi F_1	1. PP	20–25	3.8–5.6	0.19–0.23	16.7–18.1	77.7–78.1
	2. Baikal EM-1	25–40	3.7–6.1	0.15	15.4–16.7	78.5–80.8
	3. CA	25–35	3.4–3.9	0.14–0.15	12.8–16.4	78.6–83.3
	4. SA	20–25	2.1–3.3	0.11–0.13	11.1–17.6	79.1–86.8
	5. BA	20–25	2.2–3.5	0.11–0.14	10.2–15.1	81.4–87.6
	6. A+P	30–45	3.6–5.7	0.12–0.13	12.8–17.0	78.6–83.6
Beaumont F_1	1. PP	30	4.6	0.15	14.7	80.7
	2. Baikal EM-1	35–45	2.9–4.4	0.08–0.10	13.0–15.3	81.8–82.7
	3. CA	30–35	2.6–3.3	0.09–0.10	12.1–15.4	81.3–85.3
	4. SA	25–45	1.3–3.1	0.05–0.07	10.5–18.4	78.5–88.2
	5. BA	30–40	1.9–3.1	0.06–0.08	12.0–17.3	79.6–85.6
	6. A+P	45–50	3.2–4.3	0.07–0.09	11.8–14.1	82.7–84.8
$LSD_{05}A$		2	0.2–0.3	0.01	2.2–3.5	2.3–3.6
$LSD_{05}B$			0.1–0.2	0.01	1.6–2.5	1.6–2.5
$LSD_{05}AB$			0.3–0.5	0.01–0.02	3.9–6.0	3.9–6.2

Note: PP – storage of unprocessed cabbage. processing: CA – citric acid; SA – sorbic acid; BA – benzoic acid; A+P – ascorutinum

When studying the effects of antimicrobial preparations on the phytosanitary state of broccoli, we found that pathogenic microorganisms developed on untreated heads of broccoli more intensively at the beginning of storage: up to 20 %, they were affected to a high degree from day 30. The number of injured heads remained the same for all variants, but we did not find heads affected in a high degree among the variants with the use of Baikal EM-1, citric acid and ascorutin. Phytopathogenic organisms developed less intensively on washed with ordinary water heads and treated with sorbic acid and benzoic acid than on untreated ones – by 10 %.

We found no heads affected by diseases to a high degree in the middle of storage among the variants with the use of ascorutin. There were 10 % of the heads affected to a high degree in the variant with citric acid.

Diseases and disorders affected half of the heads to a high degree in all other cases. The total number of injured heads was 40 % in the middle of storage.

At the end of storage, the number of broccoli-headed affected with diseases was more than half, and in variants without treatment, with washed heads, it was 70 % with the application of Baikal EM-1 and citric acid. 30 % of them were affected by diseases to a high degree. The intensity of disease development in the variants with the use of sorbic, benzoic acid and ascorutin was less and it was 60 %. 20 % of the heads were affected to a high degree.

Treatment of broccoli with antimicrobial preparations before storage and package by 40 μm thick film contributed to preservation of components of the chemical composition. We established that the content of dry matter in broccoli was higher in the variants with the use of antimicrobial preparations than in the control one at the end of storage. Ironman F_1 hybrid with the use of Baikal EM-1 preparation and citric acid lost 1.3 times less dry matter in 35 days of storage than the control variant in 30 days, in average for the years of research. The losses were less by 2.5 times for 30 days at the use of sorbic acid; by 1.8 times for 35 days in the version with benzoic acid; by 1.5 times for 45 days with ascorutin than in the control variant.

Agassi F_1 hybrid lost 3.1 % of dry matter when using Baikal EM-1 in 30 days of storage, while in the control variant – 3.2 % in 20 days.

The losses were less by 1.1 times for 30 days of storage in the variant with treatment with citric acid. Treatment with sorbic and benzoic acids reduced the losses by 1.6 and 1.5 times, respectively, for 25 days. Application of ascorutin – reduced the losses of dry matter by 1.1 times than in the control version for 40 days of storage.

The loss of dry matter in Beaumont F_1 hybrid with the use of Baikal EM-1, citric, sorbic, and benzoic acids was less by 1.6–2.6 times for 35 days of storage than in the control variant for 30 days. The loss of dry matter was less than 1.8 times for 45 days of storage at application of ascorutin.

The variance analysis found that the treatment with antimicrobial preparations (LSD_{05}=2 days) influenced the storage life of broccoli significantly. It extended it depending on the hybrid to 50 days. We established that the application of antimicrobial preparations made possible to lose, on average, by 1.1–1.4 times less mass at the expense of dry matter over the years of research than in the control version. Depending on a preparation, these losses were 52.5–72.0 % for Ironman F_1, 56.3–73.1 % for Agassi F_1, and 50.9–69.2 % for Beaumont F_1 (Table 2).

The mass losses were significantly lower due to dry matter during 2011–2012 (LSD_{05}=10.7–16.3 %) with the use of Baikal EM-1 and ascorutin preparations. Due to the evaporation of moisture, on average, weight losses during the years of research were 28.0–47.5 % for Ironman F_1, 26.9–43.7 % for Agassi F_1, and 30.8–49.1 % for Beaumont F_1 depending on the preparation, which was larger than the control variant by 1.2–1.9 times (Table 2).

Preparations of antimicrobial action inhibited losses of dry soluble substances in broccoli due to reducing of intensity of respiration. In average, during the years of research, the treatment with preparations inhibited losses of dry soluble substances in Ironman F_1 hybrid by 1.2–1.7 times, in Agassi F_1 – by 1.2–1.9 times, in Beaumont F_1 by 1.1–1.5 times compared to the variant without treatment.

Table 2

Structure of natural losses of mass of broccoli during storage depending on the treatment with antimicrobial preparations

Variant		Storage period, days	Weight losses, %		
			total	due to dry matter losses	due to moisture evaporation
Ironman F_1	1. PP	30	4.8	76.4	23.6
	2. Baikal EM-1	35–50	3.9–6.0	56.3–63.8	36.2–43.7
	3. AC	30–40	3.4–5.0	63.7–72.0	28.0–36.3
	4. SA	30–35	2.2–2.9	60.6–65.4	34.6–39.4
	5. BA	30–40	2.4–3.7	62.2–69.2	30.8–37.8
	6. A+P	35–45	3.3–4.5	52.5–60.6	39.4–47.5
Agassi F_1	1. PP	20–25	3.8–5.6	74.5–81.0	19.0–25.5
	2. Baikal EM-1	25–40	3.7–6.1	58.5–68.9	31.1–41.5
	3. AC	25–35	3.4–5.1	65.7–73.1	26.9–34.3
	4. SA	20–25	2.1–3.3	62.8–70.0	30.0–37.2
	5. BC	20–25	2.2–3.5	63.4–70.7	29.3–36.6
	6. A+P	30–45	3.6–5.7	56.3–65.3	34.7–43.7
Beaumont F_1	1. PP	30	4.6	73.9	26.1
	2. Baikal EM-1	35–45	2.9–4.4	53.7–61.1	38.9–46.3
	3. AC	30–35	2.6–3.3	62.8–69.2	30.8–37.2
	4. SA	25–45	1.3–3.1	56.7–64.1	35.9–43.3
	5. BA	30–40	1.9–3.1	60.2–67.3	32.7–39.8
	6. A+P	45–50	3.2–4.3	50.9–58.0	42.0–49.1
$LSD_{05}A$		2	0.2–0.3	6.2–12.6	6.2–12.6
$LSD_{05}B$			0.1–0.2	4.4–8.9	4.4–8.9
$LSD_{05}AB$			0.3–0.5	10.7–21.8	10.7–21.8

The content of total sugar in broccoli in the middle of storage (10–25 days) over the years of research was higher in the variants with the use of antimicrobial preparations.

The content of total sugar was significantly higher (LSD_{05} = 0.3 %) in the variants with the use of citric acid, benzoic acid, sorbic acid and ascorutin.

On average, over the years of research (Table 3), in the variants with preparations, the content of total sugars in the middle of storage decreased by 0.3–0.6 % for Ironman F_1, by 0.4–0.6 % – for Agassi F_1, by 0.2–0.5 % – for Beaumont F_1, depending on the preparation. The content of monosaccharides was almost unchanged from the initial one, it was also higher in the variants with application of preparations and varied in the range of 1.7–2.1 % depending on the hybrid, it was significantly higher (LSD_{05} = 0.2 %) in the variants with the use of sorbic acid.

The content of disaccharides decreased by 0.4–0.6 % in the variants with antimicrobial preparations compared with the initial one in the middle of storage. This content exceeded the control index and fluctuated within 0.6–1.0 % depending on the hybrid and the preparation. Ironman F_1 had significantly higher content (LSD_{05} = 0.2 %) of disaccharides with the use of acids and ascorutin and in Agassi F_1 with the use of benzoic acid.

At the end of storage, the content of total sugars (Table 3) decreased by 0.6–1.1 % compared with the initial one for Ironman F_1, by 0.5–0.9 % for Agassi F_1, by 0.5–0.8 % for Beaumont F_1, depending on the preparation. Its content ranged within 2.3–2.8 % for Ironman F_1, within 2.3–2.7 % for Agassi F_1, within 2.0–2.3 % for Beaumont F_1 depending on the preparation. The content of total sugar was significantly higher (LSD_{05} = 0.2 %) in Ironman F_1 and Beaumont F_1 hybrids in the variants with acids and ascorutin, in Agassi F_1 – with sorbic and benzoic acids.

The content of total sugar varied within 2.3–2.8 % for Ironman F_1, within 2.3–2.7 % for Agassi F_1, within 2.0–2.3 % for Beaumont F_1 depending on the preparation. It was significantly higher (LSD_{05} = 0.2 %) in Ironman F_1 and Beaumont F_1 hybrids in the variants with acids and ascorutin, in Agassi F_1 – with sorbic and benzoic acids.

The content of monosaccharides in broccoli was mainly at the initial level at the end of storage. However, the amount of monosaccharides decreased compared with the initial level by 0.2 % in Ironman F_1 and Beaumont F_1 in the variants with Baikal EM-1 and ascorutin. On average, over the years of research, monosaccharide content was within1.6–2.0 % depending on the hybrid and the preparation.

Table 3

Dynamics of sugar contents in broccoli depending on the treatment with antimicrobial preparations, % (average for 2011–2013)

Variant		In the middle			At the end of storage		
		Total	Monosaccharides	Disaccharides	Total	Monosaccharides	Disaccharides
Ironman F_1	1. PP	2.7	1.9	0.7	2.3	1.6	0.6
	2. Baikal EM-1	2.8	1.9	0.8	2.3	1.7	0.6
	3. CA	2.9	1.9	0.9	2.5	1.7	0.8
	4. SA	3.1	2.1	1.0	2.8	2.0	0.8
	5. BA	3.0	2.0	0.9	2.7	1.8	0.9
	6. A+P	2.9	2.0	0.9	2.5	1.7	0.7
Agassi F_1	1. PP	2.5	1.8	0.6	2.3	1.7	0.5
	2. Baikal EM-1	2.6	1.9	0.7	2.3	1.7	0.5
	3. CA	2.6	1.9	0.7	2.4	1.7	0.7
	4. SA	2.8	2.1	0.7	2.7	2.0	0.7
	5. BA	2.8	2.0	0.8	2.6	1.8	0.8
	6. A+P	2.7	2.0	0.7	2.4	1.7	0.7
Beaumont F_1	1. PP	2.2	1.7	0.5	1.9	1.6	0.3
	2. Baikal EM-1	2.3	1.7	0.6	2.0	1.6	0.4
	3. CA	2.4	1.8	0.6	2.2	1.7	0.5
	4. SA	2.6	2.0	0.6	2.3	1.8	0.5
	5. BA	2.5	1.9	0.6	2.3	1.7	0.6
	6. A+P	2.4	1.8	0.6	2.1	1.6	0.5
$LSD_{05}A$		0,2	0.1	0.1	0.1	0.1	0.1
$LSD_{05}B$		0,1	0.1	0.1	0.1	0.1	0.1
$LSD_{05}AB$		0,3	0.2	0.2	0.2	0.2	0.2

The content (LSD_{05}=0.2 %) was significantly higher in the variants with sorbic and benzoic acids in Ironman F_1 and with the use of sorbic acid in Agassi F_1 and Beaumont F_1. The number of disaccharides decreased in the variants with the use of antimicrobial preparations by 0.5–0.8 % compared with the beginning of storage in Ironman F_1 and Agassi F_1 and by 0.4–0.5 % in Beaumont F_1 depending on the preparation. This number was greater than the number in the control variant and it was in the range of 0.6–0.9 % for Ironman F_1, 0.5–0.8 % – for Agassi F_1, 0.4–0.6 % – for Beaumont F_1. The variants with the use of citric acid, benzoic acid and sorbic acid had significantly higher (LSD_{05}=0.2 %) content of disaccharides (Table 3).

The content of vitamin C increased in broccoli after the treatment with antimicrobial preparations during the first 15 days of storage, as in the control variants. On average, over the years of research in the first 15 days, the content of vitamin C increased by 24.0–28.3 % in Ironman F_1 at the beginning of storage, by 25.7–29.9 % in Agassi F_1, and by 25.8–29.7 % in Beaumont F_1 depending on the preparation. The content of vitamin C was significantly higher (LSD_{05}=1.1–2.7 mg/100 g) in the variants with the use of citric acid, sorbic acid, benzoic acid and ascorutin. At the end of storage, vitamin C content decreased to 22.4 % in Ironman F_1, to 15.5 % in Beaumont F_1 and to 25.6 % in Agassi F_1 depending on the preparation.

6. Discussion of results of studying the preservation of broccoli depending on the type of an antimicrobial preparation

A decrease in the quality of broccoli during storage is a consequence of complex physiological, biochemical, physical-chemical and microbiological processes accompanied by destruction of organic compounds because of simultaneous occurrence of reactions of hydrolysis, oxidation and polymerization.

Varietal characteristics, chemical composition and a ratio of components of fruit systems, humidity, hydrogen index of the environment, activity of enzymes, and a degree of variance determine direction and intensity of negative processes. A degree of variance provides access of oxygen to cellular organelles by rapid damage and active development of microorganisms, and presence of natural substances that have bactericidal and bacteriostatic effects inhibits the development of microorganisms. In addition, the intensive process of transpiration significantly influences the course of negative processes at storage under traditional technologies.

For this reason, the yield of standard vegetable production is at the level of 76.8–88.2 % after storage using traditional technologies (Table 1). The variance analysis determined that the treatment with preparations (factor A) affects the yield of commercial products by 19.0 %, the degree of influence of hybrid features (factor B) was 5.7 %, the combined effect of these two factors made up 25.7 %, an influence of other factors was 49.7 %. We found that the treatment with preparations (factor A) affects the yield of commercial products by 19.0 %, the degree of influence of hybrid features (factor B) was 5.7 %, the combined effect of these two factors was 25.7 %, influence of other factors was 49.7 %. The natural losses of broccoli heads during storage were significantly lower (LSD_{05}=0.2 %) compared to the control variant.

Active forms of oxygen generated by activation of oxidative stress damage biological membranes, imbalance post-harvest metabolism of fruits and vegetables, increase intensity of respiration and accelerate processes of overripening and aging. Exogenous treatment with substances, which have high antimicrobial and antioxidant properties, provides neutralization of active forms of oxygen, induction of an endogenous system of protection of fruits and prolongation of its action. In view of this, the use of antiseptics for post-harvest processing of vegetable raw materials is an important technique in terms of the development of new, low-cost and affordable technologies for its storage.

Rutin shows high antioxidant activity among other natural antioxidants of phenolic nature that we can use to prolong preservation. It binds free radicals and inhibits a process of the chain reaction of formation of new aggressive radicals. Rutin is an effective inhibitor of peroxide lipid oxidation. An important mechanism of rutin action in biological systems is chelation of metal ions of variable valency. The role of the main synergist of rutin belongs to ascorbic acid (AA). The antioxidant properties of AA are due to the ability to intercept active forms of oxygen (AFO). An important function of AA is restoration of oxidized forms of other low molecular weight antioxidants, and in the first place, phenolic substances. Studies showed that ascorutin inhibits the intensity of development of pathogenic microorganisms better than other preparations. The first signs of damage appeared 10–15 days later. Ascorutin provided 0.8–2.2 % less weight loss caused by disease and physiological disorders at a long storage, and a 4.1–7.6 % higher yield of commercial products.

Substances of antiseptic effect affect development of pathogens of microbiological diseases. They penetrate the cells of bacteria, yeast and mold fungi; they change a structure of the protoplasm and violate metabolic processes in microorganisms, which leads to inhibition of their development and death. As a result, duration of broccoli storage lengthens and losses due to microbiological damage decrease.

A nature and a degree of action of antimicrobial preparations depend on a nature of a substance, its concentration, an amount and a composition of a surface microflora. However, the treatment of vegetables by antiseptics does not slow down the evaporation of water during storage. It is possible to solve the problem by treatment with a coating, which creates a film, in a composition with antiseptics. Such coating makes possible to create a moisture-retaining and gas-permeable film on a surface of a product for each specimen separately. The consequence is the inhibition of biochemical and reducing of expenditure of substances for metabolic processes.

7. Conclusions

1. The natural losses per day were significantly lower in the variants with the use of antimicrobial preparations than in the variant without treatment (LSD_{05}=0.01–0.02 %). The natural losses fluctuated within – 0.11–0.15 % for Agassi F_1, within 0.07–0.13 % for Ironman F_1, and they were somewhat smaller for the Beaumont F_1 hybrid – within 0.05–0.10 %. The treatment with preparations reduced the losses per day by 1.2–2.1 times for Ironman F_1, by 1.3–1.9 times for Agassi F_1 and by 1.5–3.0 times for Beaumont F_1 depending on the preparation compared with the variants without treatment. The share of the influence of preparations made up 58.0 %.

2. Baikal EM-1 and ascorutin inhibit the intensity of development of pathogenic microorganisms better than other preparations. The first signs of the affection appeared 10–15 days later. Ascorutin provided 0.8–2.2 % less of

weight loss due to diseases and physiological disorders at a long storage, and a 4.1–7.6 % higher yield of commercial products. Ascorutin, citric acid, sorbic acid and benzoic acid inhibited the development of pathogenic microorganisms in broccoli more actively.

3. The treatment of broccoli with antimicrobial preparations, with ascorutin especially, provided a dry matter content in the amount of 1.1–2.6 times greater than in the control variant. It contributed to a decrease in intensity of consumption of dry soluble substances and vitamin C. At the end of storage, the content of total sugars and disaccharides was equal to the level of the control variant, or exceeded its content by 1.2 and 1.5–2.0 times, respectively. The variants with acids and ascorutin had more of them. The content of monosaccharides was at the initial level. The losses of mass due to evaporation of water were larger by 1.3–1.8 times.

4. Preparations of antimicrobial action contributed to lengthening of the storage life of broccoli for 5–20 days depending on the hybrid. The application of Baikal EM-1 and ascorutin contributed to prolonging the storage life for 40–50 and 45–50 days, and the yield of commercial products was 76.8–80.8 and 78.6–86.2 %, respectively.

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У результаті проведених експериментальних досліджень встановлено, що для поліпшення консистенції при зберіганні кисломолочних напоїв, необхідно забезпечити зв'язування вільної вологи за рахунок застосування натуральних стабілізаторів, загущувачів та речовин, що виконують аналогічну функцію. Серед багатьох апробованих інгредієнтів цієї групи речовин, відібрано для впровадження та надано перевагу використанню стабілізуючих систем на основі природних складових рослинного та тваринного походження. Аналіз інформаційних джерел показує відсутність даних про використання пшеничних висівок у технологіях кисломолочних напоїв. Тому виникає об'єктивна необхідність створення нових видів кисломолочних напоїв, а саме кефірів з використанням пшеничних висівок. Споживання таких функціональних продуктів гарантує усунення недостатнього харчування, поповнення організму необхідними компонентами.

Вивчено вплив пшеничних висівок на якісні показники кисломолочного напою. Встановлено, що кисломолочний напій з пшеничними висівками з мчж 2,5 % за фізико-хімічними показниками відповідає вимогам діючого стандарту ДСТУ 4417:2005. Кефір. Технічні умови. При дослідженні органолептичних показників напою із використанням пшеничних висівок встановлено його чистий кисломолочний смак і запах. В напої з пшеничними висівками зростала загальна сума амінокислот – на 15,08 %, в тому числі незамінних – на 10,57 замінних – на 18,24 %, Виявлені зміни в амінокислотному складі напою з пшеничними висівками вказують на те, що використання пшеничних висівок при виготовленні кисломолочних напоїв дозволяє підвищити їх харчову та біологічну цінність білкової складової.

Додавання пшеничних висівок не тільки корегує харчову та біологічну цінність кисломолочного продукту, а й дозволяє підвищити його якісні характеристики за рахунок зв'язування вільгої вологи впродовж зберігання

Ключові слова: кисломолочні напої, добавки, пшеничні висівки, амінокислоти, органолептичні показники, фізико-хімічні показники

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INFLUENCE OF WHEAT BRAN ON QUALITY INDICATORS OF A SOUR MILK BEVERAGE

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1. Introduction

Modern severe environmental conditions create the urgent need to improve the structure of nutrition of the population by increasing biological and nutritional value of products and expanding their assortment [1]. Development of healthy eating became important for the development and enhancement of the structure of the food market [2]. That