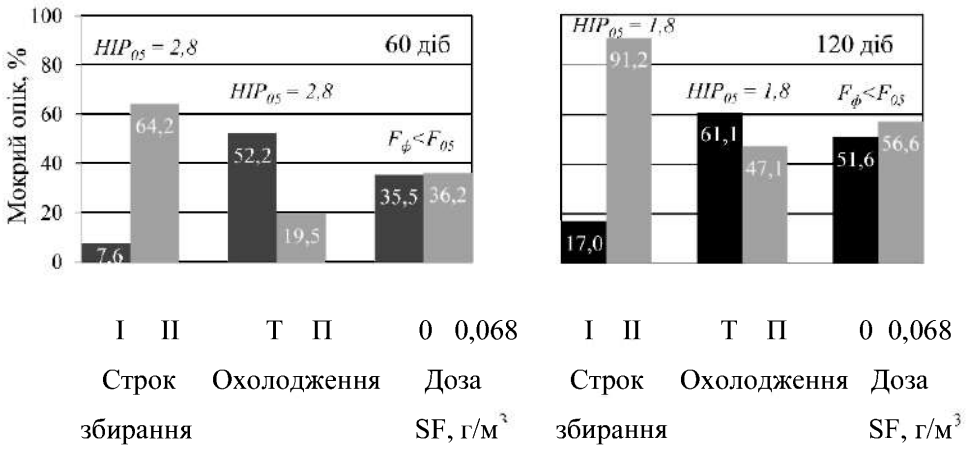

Рис. 1. **Усереднені дані впливу строку збирання, режиму охолодження та післязбиральної обробки 1-МЦП на втрати яблук сорту Хонейкріспвід мокрого опіку після 60 (зліва) і 120 (справа) діб зберігання (результати дисперсійного аналізу):** *строк збирання: I – масовий збір, II – на 7 діб пізніше; охолодження: Т – традиційне, П – повільне.*

повільним охолодженням на 1 °С за добу та зберіганням за температури 2±1 °С. Запізнення зі збором плодів і їх негайне охолодження до температури 5 °С спричинює масове ураження продукції низькотемпературним мокрим опіком. Післязбиральна обробка 1-МЦП стримує розвиток плодової гнилі для плодів масового збору врожаю, проте прояви мокрого опіку не обмежує і на природні втрати не впливає.

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RESPIRATION INTENSITY OF BLACK CURRANT FRUITS TREATED BY THE SUBSTANCES WITH ANTIMICROBIAL FUNCTION UNDER DIFFERENT STORAGE CONDITIONS

Abstract. *The study results of the process of respiration intensity of blackcurrant fruits treated by the substances with antimicrobial function while storing without cooling in terms of a refrigerator and modified gas environment were given. Keeping quality of fruits was combined with physiological-and-biochemical changes. It was determined that slowing down the*

process of fruits respiration occurred within the first 10–15 days (control variant) and 25–30 days (variants with treatment), after this its intensity increased gradually and reached climacteric rise on the 30th–35th day in fruits treated by solutions of sorbic acid and sodium benzoate with index growth to 10–29 %, and on the 35th–40th day in fruits treated with solution of citric acid and ethyl alcohol with index growth to 6–34 % depending on the variety and the year of research. Treatment of fruits by substances with antimicrobial function allowed prolonging occurrence of climacteric rise of respiration that helped to extend the duration of fruits storing.

It was defined that respiration intensity of fruits while their putting for storing lowered sharply with its further increase in control variants on the 35th day, when in the variants with treatment by substances with antimicrobial function – on the 65th day. In general, refrigeration storage of fruits in terms of MGE allowed extending the period of respiration process stabilization to 20 days in fruits without treatment (control variant) and to 50 days in variants with fruits treatment by substances with antimicrobial function which in turn slowed down the processes of fruits overripening.

Keywords: *blackcurrant fruits, substances with antimicrobial function, storage, modified gas environment.*

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ІНТЕНСИВНІСТЬ ДИХАННЯ ПЛОДІВ ЧОРНОЇ СМОРОДИНИ, ОБРОБЛЕНИХ РЕЧОВИНАМИ АНТИМІКРОБНОЇ ДІЇ ЗА РІЗНИХ УМОВ ЗБЕРІГАННЯ

Анотація. *Викладені результати вивчення процесу інтенсивності дихання плодів чорної смородини оброблених речовинами антимікробної дії під час зберігання без охолодження, в умовах холодильника та модифікованого газового середовища.*

Встановлено, що гальмування процесу дихання плодів відбувалось протягом перших 10–15 діб (контроль) та 25–30 діб (варіанти з обробкою), після чого його інтенсивність поступово підвищувалась і досягала клімактеричного підйому на 30–35 добу в плодах оброблених розчинами сорбінової кислоти та бензоату натрію зі зростанням показника на 10–29 % та 35–40 добу – оброблених розчином лимонної кислоти та етиловим спиртом зі зростанням показника на 6– 34 %, в залежності від сорту та року досліджень. Обробка плодів речовинами антимікробної дії дозволила розтягнути в часі настання клімактеричного підйому дихання, що сприяло продовженню тривалості зберігання плодів.

Встановлено, що при закладанні на зберігання інтенсивність дихання плодів різко знижувалась з наступним її підвищенням в контрольних варіантах на 35 добу, тоді як у варіантах з обробкою їх речовинами антимікробної дії – на 65-ту добу. В цілому, холодильне зберігання плодів в умовах МГС дозволило подовжити період стабілізації процесу дихання до 20-ти діб у плодах без обробки (контроль) та 50-ти діб у варіантах з обробкою плодів речовинами антимікробної дії, що в свою чергу уповільнило процеси перезрівання плодів.

Ключові слова: *плоди чорної смородини, речовини антимікробної дії, зберігання, модифіковане газове середовище.*

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ИНТЕНСИВНОСТЬ ДЫХАНИЯ ПЛОДОВ ЧЕРНОЙ СМОРОДИНЫ, ОБРАБОТАННЫХ ВЕЩЕСТВАМИ АНТИМИКРОБНОГО ДЕЙСТВИЯ В РАЗЛИЧНЫХ УСЛОВИЯХ ХРАНЕНИЯ

Аннотация. *Изложенные результаты изучения процесса интенсивности дыхания плодов черной смородины обработанных веществами антимикробного действия при хранении без охлаждения, в условиях холодильника и модифицированной газовой среды (МГС).*

Установлено, что торможение процесса дыхания плодов происходило в течение первых 10–15 суток (контроль) и 25–30 суток (варианты с обработкой), после чего его интенсивность постепенно повышалась и достигала климактерического подъема на 30–35 сутки в плодах обработанных растворами сорбиновой кислоты и бензоата натрия с ростом показателя на 10–29 % и 35–40 сутки – обработанных раствором лимонной кислоты и этиловым спиртом с ростом показателя на 6–34 %, в зависимости от сорта и года исследований. Обработка плодов веществами антимикробного действия позволила растянуть во времени наступления климактерического подъема дыхания, способствовало продолжению продолжительности хранения плодов.

Установлено, что при закладке на хранение интенсивность дыхания плодов резко снижалась с последующим ее повышением в контрольных вариантах на 35 сутки, тогда как в вариантах с обработкой их веществами антимикробного действия – на 65-е сутки. В целом, холодильное хранение плодов в условиях МГС позволило продлить период стабилизации процесса дыхания до 20-ти суток в плодах без обработки (контроль) и 50-ти суток в вариантах с обработкой плодов веществами антимикробного действия, что в свою очередь замедлило процессы перезревания плодов.

Ключевые слова: *плоды черной смородины, вещества антимикробного действия, хранение, модифицированная газовая среда.*

Problem formulation. Complex processes of vital activity in fresh fruits and berries are not stopped at all stages of their storing – on the road, storehouses and other conditions. It is known that there are various processes occurred after fruits gathering – at first metabolic, thereafter metabolic and partly anabolic processes that to some extent is a continuation of the events that took place prior to fruits gathering. However, in general, physiology of gathered fruits is mainly physiology of their ripening, ageing and programmed death [1]. Fruits immunity to pathogenic agents and their ability for storing decrease in consequence of metabolism violation [2].

Skillful regulation of physiological processes forms the basis of methods and ways of fruits and berries storing aimed to reduce losses and save products quality [3].

Knowing the regularities that occur in storage facilities it is possible to use scientifically based systems of measures for providing quantitative and qualitative storage of products.

Complication of berry fruits storing is specified by physiological and physical-and-chemical properties. There

is a need to protect products from active influence of the factors of biotic environment and also to create conditions that prevent intensive metabolism in organism cells based on the nature of the products under storing [1, 4].

The main and most accurate indicator of vital activity of fruits is the process of respiration. All metabolic transformations in fruits can be made only through constant and continuous inflow of energy that releases in the process of respiration. There is a deep connection between respiration and storage because any action increasing energy of fruit respiration stimulates ripening [5].

Analysis of recent researches and publications. Rapid cooling of fruits after their gathering leads to decreasing of their respiration intensity, reducing of organic matters decay, resulting longer period of retaining the flavor and nutritional properties by the products. Respiration intensity lessens 2–6 times less with rapid cooling of the fruits. Temperature below zero does not stop respiration process but slows down it greatly. However, different fruit types and varieties have individual characteristics in respiratory gas exchange [6].

Carbon dioxide has slowing effect on respiration intensity. Reducing the concentration of oxygen and increasing the content of carbon dioxide slows respiration intensity. In addition to that nutritional value is kept better because organic matters are less wasted and natural resistance to different diseases increases that helps to prolong storage period.

Existing methods of fresh fruits storing provide only partial or temporary suppression of vital activity of microflora that does not guarantee full saving of their quality [7, 8, 9, 10].

Use of chemical antiseptics in technological aspect has several positive peculiarities: use simplicity, quickness and high efficiency of microflora suppression by low doses that cause effectiveness of chemical application of antiseptics. Advantages of chemical antiseptics in hygienic terms are equally important because it is known which antiseptic and what quantity is used. Antioxidant substances can potentiate endogenous protective systems and increase fruits resistance while storing, so their use is of particular importance and there is a need to make research in this area.

The purpose of the research. To determine the impact of storage conditions of blackcurrant fruits and processing by substances with antimicrobial function on the intensity of their respiration.

Methods and conditions of the research. Research was carried out in the laboratory of the department of technology of storage and processing of fruit and vegetables of Uman National University of Horticulture. Blackcurrant fruits of such varieties as Mynai Shmyriov, Biloruska solodka and Bagira were used for research.

Fruits weighing about 4 kg of consumer degree of ripeness were gathered by bunches after dew drying into box-trays No. 5.2 (with paper in the bottom) in accordance with GOST 6829-89 "Fresh blackcurrant".

Fruits in netted containers were dipped for 25–30 seconds into substances solution with antimicrobial function with the temperature of 0...+ 1° C: 0,5 % solution of citric or sorbic acid, 0,7 % sodium benzoate or 95,5 % ethyl alcohol after a 10–12-hour cooling to the temperature of 0...+ 1° C in "KHR-12M" chamber. Fruits weighing about 4 kg were packed into box-trays No.5.2 after flowing down the remaining solution. At the same time we kept fruits without treatment (control variant). Pre-cooling was not conducted for the fruits that were kept without cooling. It was repeated three times.

Storage of blackcurrant fruits was conducted without cooling (temperature 16° C, relative humidity – 85 %), in "KHR-12M" refrigerator chamber (temperature 0...-1±0,5° C, relative humidity – about 85 %) and in terms of MGE – modified gas environment (temperature 0...-1±0,5° C, relative humidity of the environment – about 100 %). Fruits weighing 1 kg after treatment were packed into plastic containers and untreated fruits (control variant) were packed into bags of polyethylene with thickness of 50–55 microns for storing in MGE.

Respiration intensity in blackcurrant fruits was determined by a standard method at the moment of putting, in the course of and at the end of storing. Selection and preparation of samples for analysis were done according to "Methodological recommendations for storage of fruits, vegetables and grape" (Moscow, 1998).

Statistical processing of received results was performed by the method of disperse analysis by the scheme of multivariate research using application package "Statistica" [11].

Research results. Physiological state of fruits, variety, presence of damages, temperature and composition of gas environment referred to the factors affect respiration intensity the most significantly.

It was found that post-gathering treatment of blackcurrant fruits by substances with antimicrobial function influenced on the general physiological activity of fruits, primarily on respiration intensity. Received results (Fig. 1) indicated that the process slowed down considerably in the fruits with treatment.

Thus, respiration intensity of non-treated fruits of Mynai Shmyriov variety (control variant) at the beginning of storage was 17,48 mg CO_2/kg·h, that 1,4–1,7 times higher than in treated fruits. Fruits treatment of Bagira variety reduced the intensity of their respiration 1,3–1,6 times less

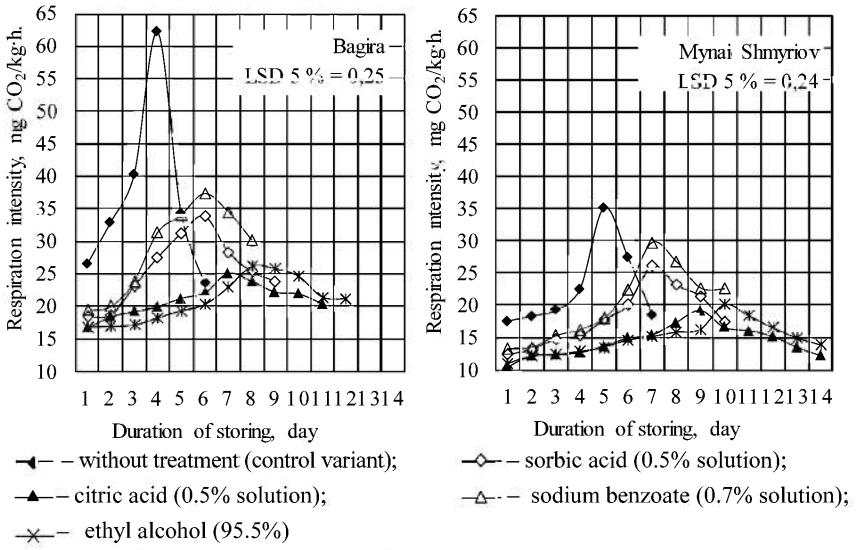

Fig. 1. **Respiration intensity of blackcurrant fruits during storage in the storehouse without artificial cooling while treatment by substances with antimicrobial function, 2003**

(control variant – 26,35 mg CO_2/kg·h).

It should be noted that features of the variety influenced significantly on respiration process. In particular, blackcurrant fruits of Bagira variety respired 1,5 times more intensive than fruits of Mynai Shmyriov variety regardless of the variant of the research.

Analyzing the values of respiration intensity of fruits in the variants of research, it was determined advantages of fruit treatment by solution of citric acid and ethyl alcohol that slowed down respiration intensity of fruits of Mynai Shmyriov variety to 38–41 % and index was 10,45 and 10.95 mg CO_2/kg·h respectively, fruits of Bagira variety – to 37 % and was 16,68 and 16,78 mg CO_2/kg·h. Fruit treatment by solutions of sorbic acid and sodium benzoate also slowed down respiration intensity of fruits (to 26–31 % on average by varieties), but slightly less than in previous variants.

Fruits respiration [12] in post-gathering period increased to the maximum level and after that decrease of its intensity was observed. Rise of respiration intensity of fruits coincided with activation of biosynthetic processes [13] that meant culmination of ripening processes, followed by their overripening, senility and dying off [14].

Thus, it is necessary to delay respiration increasing as long as possible to slow down ripening, which in turn will ensure retard of overripening processes.

General tendency to increasing respiration intensity regardless of the variant was observed during blackcurrant fruits storing. However, the shorter storage period was, the more intense the process grew.

After putting fruits for storage, their respiration intensity increased at first in the control variant reaching a maximum index on the 5th day in Mynai Shmyriov variety and on the 4th day in Bagira variety. After this the process stopped a little which probably meant the beginning of the period of fruits overripening.

The level of respiration intensity was much lower in treated fruits than in fruits of non-treated variants (control). In particular, slight increase of respiration intensity in fruits of blackcurrant of Mynai Shmyriov variety was registered the on the 7th day and in fruits of Bagira variety on the 6th day of storage by applying solutions of sorbic acid and sodium benzoate. Fruits treatment by ethyl alcohol and solution of citric acid helped to prolong the period of increasing of respiration intensity to 9–10 days for Mynai Shmyriov variety and to 7–8 days for Bagira variety. However, fruits respiration treated by substances with antimicrobial function was significantly lower than in control samples even in the period of maximum intensity.

It was defined by the research of respiration intensity study of blackcurrant fruits while refrigeration storing that the level of respiratory gas exchange in all variants considerably decreased from the first days of storage (Fig. 2) and combining refrigeration storing of fruits with treatment by substances with antimicrobial function significantly slowed down the process of respiration.

Slowing down the respiration intensity in fruits of the control variant occurred during 15 days of storing of Mynai Shmyriov and Biloruska solodka varieties and during 10 days of Bagira variety storing. Moreover, the process retarded

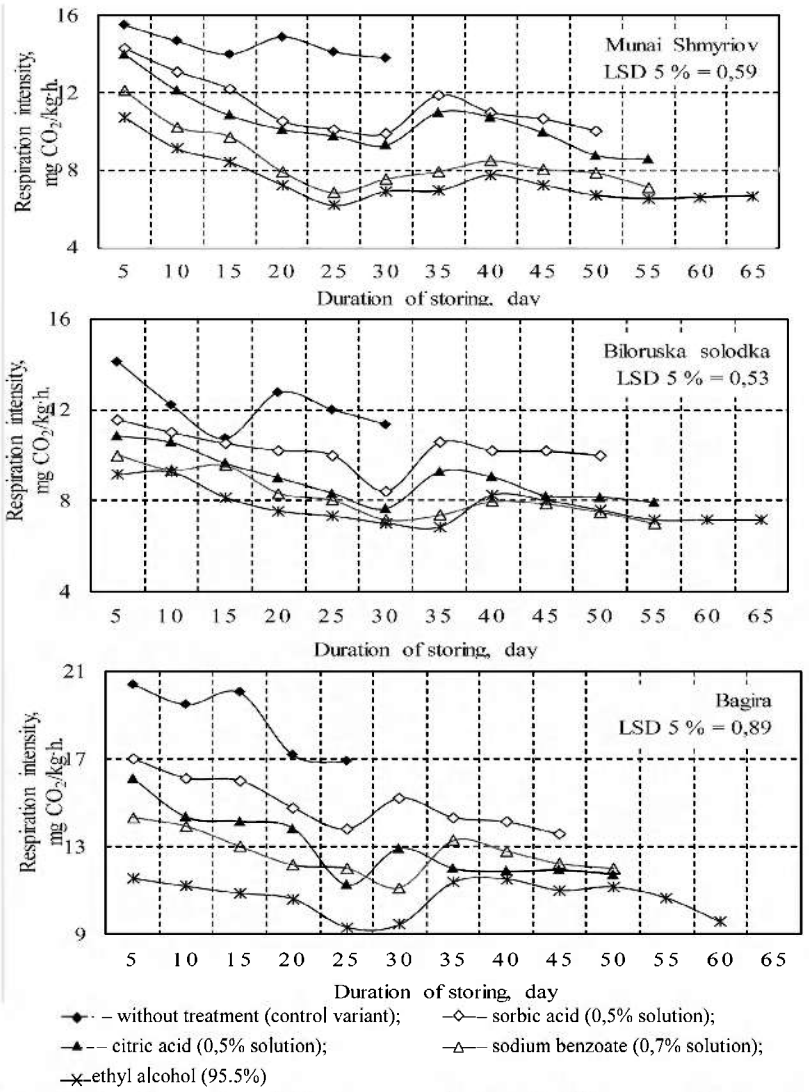

Fig. 2. **Change of respiration intensity of blackcurrant fruits of different varieties while storing in the refrigerator, on average for 2004–2006**

the most intensively in fruits of Biloruska solodka variety, in which its level decreased by 10–12 % every 5 days and by 4–8 % in fruits of Mynai Shmyriov and Bagira varieties for the same period. Further it was recorded increasing of respiration intensity: by 14,8 % in fruits of Biloruska solodka variety while this index grew only by 6 and 3 % in fruits of Mynai Shmyriov and Bagira varieties respectively. Sharp rise of respiration intensity coincided with preservation of consumer properties in fruits to this moment, and then the process of fruit ageing, senility and dying off began. The process of respiration intensity lowering occurred until the end of fruits storage after increasing of respiration intensity.

Physiological process in the research variants occurred in the same sequence but had certain features. Thus, the lowest respiration intensity had fruits treated by solution of citric acid and ethyl alcohol which obviously explained by better inhibitory ability of oxidative processes in fruits.

Slowing down the respiration intensity in products occurred during 30 days of storing of Mynai Shmyriov and Biloruska solodka varieties and during 25 days in fruits of Bagira variety. Then the process of respiration gradually grew and reached its maximum in fruits treated by solutions of sorbic acid and sodium benzoate of Mynai Shmyriov and Biloruska solodka varieties on the 35th day of storage and on the 30th day in fruits of Bagira variety. Respiration intensity of fruits treated by solutions of sorbic acid and sodium benzoate increased by 14 and 18 % for Mynai Shmyriov variety, by 20 and 29 % for Biloruska solodka variety and 12 and 10 % for Bagira variety respectively. Products treatment by solution of citric acid and ethyl alcohol intensified the maximum level for fruits of Mynai Shmyriov variety (increase was 15 and 6 % respectively) and Biloruska solodka variety (34 and 10 %) on the 40th day and for fruits of Bagira variety (18 %) on the 35th day. It was defined that fruits treatment by substances with antimicrobial function helped to slow growth of respiration intensity. This provided a delay of overripening processes and influenced greatly on the duration of storing. The next step was gradual lowering of respiration intensity of fruits with its stabilization by the end of storage.

Analyzing received data during researches of 2004–2006, it should be noted that the respiration intensity of fruits had a similar tendency every year. However, the lowest level of respiration intensity was recorded during research in 2005.

Respiration intensity of blackcurrant fruits treated by substances with antimicrobial function and kept in MGE lowered since the first days (Fig. 3). The process retarded abruptly after 15 days of storage.

Thus, respiration intensity in control variants in fruits of Mynai Shmyriov variety decreased by 15 % and was 10,7 mg CO_2/kg·h, to 27–30 % in fruits of Biloruska solodka and Bagira varieties and was 8,6 and 12,8 mg CO_2/kg·h respectively. Respiration intensity also decreased significantly in the variants with fruits treatment by substances with antimicrobial function. However, the most considerable decrease of index (to 40 %) was registered in the variant with fruits treatment by solution of citric acid. This index lowered by 7,4 and even by 4,4 mg CO_2/kg·h which was probably explained by the greatest inhibitory ability of the preparation on flow intensity of physiological processes of fruit. Lowering of respiration intensity occurred

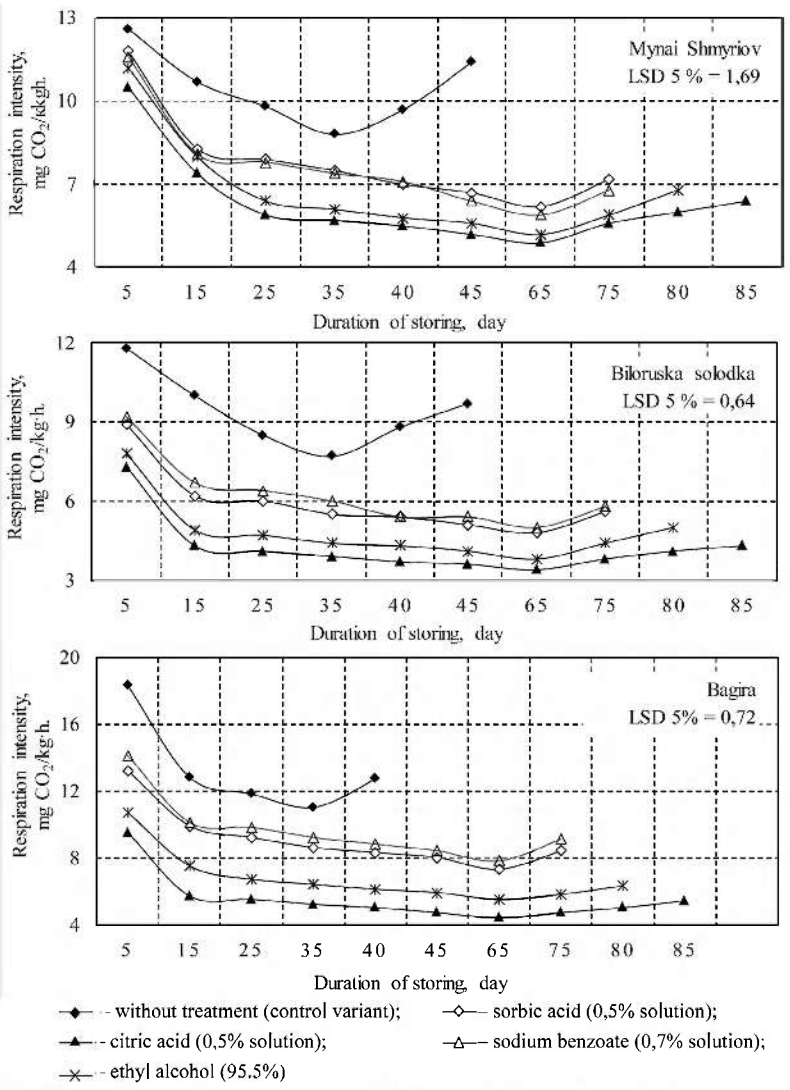

Fig. 3. **Respiration intensity of blackcurrant fruits while storing in the conditions of MGE, on average for 2004–2006**

at the level of 25–30 % in the variants of fruits treatment by other substances with antimicrobial function.

During storage it was found that increasing of respiration intensity in fruits of control variants was recorded on the 35th day of storage, which grew by 10–17 % every five days by the end of storage. Moreover, decrease of respiration process was determined in fruits of Biloruska solodka variety.

Increasing of respiration intensity in fruits of variants with treatment by substances with antimicrobial function was defined on the 65th day of storage. However, respiration intensity grew by 8–10 % in the variants with treatment by solution of ethyl alcohol in the next 10 days of storage and it was 4,4–6,6 mg CO_2/kg·h on average, and the index rose by 8 % during further storage. Respiration intensity in fruits of the variants with treatment by solution of sorbic acid for the same period increased by 12–18 % and was 5,6–8,4 mg CO_2/kg·h, and with treatment by solution of sodium benzoate by 15 % regardless of the variety. Respiration intensity while fruits treatment by solution of citric acid increased by 10 % and was 3,6–5,3 mg CO_2/kg·h, and with further storage it grew by 15–17 % and to 8 % in Bagira variety.

Over the years on average, fruits of Biloruska solodka variety showed the lowest respiration intensity, which at the beginning of storage was 1,3–1,4 times lower than in fruits of Mynai Shmyriov and Bagira varieties. However, there was a sharp lowering in fruits of such variety during storage compared to other varieties and further there was process growth that was obviously specified by features of the variety.

It was found that respiration intensity of fruits kept in 2005 was the lowest; by 10–12 % less than in 2004 and by 15–20 % less than in 2006. This feature could be explained by fruits formation in that year under favorable conditions of vegetation that influenced on the course of respiration process.

Consequently, refrigeration storage of products in MGE positively affected their respiration intensity and it helped to prolong the stabilization period of respiration process to 20 days in fruits without treatment (control variant) and to 50 days in variants with fruits treatment by substances with antimicrobial function that in turn slowed down the processes of fruits overripening. Fruits of Biloruska solodka variety were characterized by the lowest respiration intensity which was 1,3–1,4 times lower than in fruits of Mynai Shmyriov and Bagira varieties.

Process of assimilates coming stopped after gathering of blackcurrant fruits, and a fruit got energy necessary to maintain metabolism by oxidation of accumulated organic matters. For this reason, during storage their content decreased with different intensity in individual varieties depending on treatment and storage conditions.

Conclusion. Treatment of blackcurrant fruits kept in a storehouse without artificial cooling by substances with antimicrobial function reduced respiration intensity of fruits compared with the control variant 1,2–1,7 times less depending on the preparation. However, respiration intensity lowered by 37–41 % while fruits treatment by 0,5 % solution of citric acid and ethyl alcohol, when using solutions of sorbic acid (0,5 %) and sodium benzoate (0,7 %) slowed down their respiration intensity almost three times (26–31 %). Herewith peak of respiration approached on 9^{th}–10^{th} day in fruits of Mynai Shmyriov variety and on 7^{th}–8^{th} day in fruits of Bagira variety.

Keeping quality of fruits was combined with physiological-and-biochemical changes. It was determined that slowing down the process of fruits respiration occurred within the first 10–15 days (control variant) and 25–30 days (variants with treatment), after this its intensity increased gradually and reached climacteric rise on the 30^{th}–35^{th} day in fruits treated by solutions of sorbic acid and sodium benzoate with index growth to 10–29 %, and on the 35^{th}–40^{th} day in fruits treated with solution of citric acid and ethyl alcohol with index growth to 6–34 % depending on the variety and the year of research. Treatment of fruits by substances with antimicrobial function allowed prolonging occurrence of climacteric rise of respiration that helped to extend the duration of fruits storing.

It was defined that respiration intensity of fruits while their putting for storing lowered sharply with its further increase in control variants on the 35^{th} day, when in the variants with treatment by substances with antimicrobial function – on the 65^{th} day. In general, refrigeration storage of fruits in terms of MGE allowed extending the period of respiration process stabilization to 20 days in fruits without treatment (control variant) and to 50 days in variants with fruits treatment by substances with antimicrobial function which in turn slowed down the processes of fruits over-ripening.

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