Biotechnological methods used in the cultivation and storage of fruits

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Annotation. The article presents information on the biologization of technological processes in the cultivation and storage of fruits based on the use of biological preparations, microorganisms, and technological storage factors. The effectiveness of the natural biological growth regulator Gibbersib, obtained from microorganisms, is noted, which makes it possible to increase the yield, accelerate the ripening time and improve the chemical composition of apples. Due to the vital activity of microorganisms, the possibility of enhancing the color of fruits associated with an increase in the content of anthocyanins in the skin of apples has been established. Based on the use of chemical methods of influencing fruits during cultivation - Harvista ™ and storage - *SmartFresh* ™, regularities for controlling the rate of apple ripening in combination with optimization of technological parameters of storage in a controlled environment have been established at the cellular level

1 Introduction

Biotechnology is the purposeful production of products valuable for the national economy, in the process of which the biochemical activity of microorganisms, isolated cells or their components is used. Given this, it follows that the modeling of any biotechnological process or system during cultivation and storage is reduced to estimating the rate of biochemical processes in fruits, depending on one or more environmental parameters that ensure the flow of metabolic processes. [1-8].

Biologization of technological processes implies the most complete involvement of natural biological resources in production processes, increasing the biological potential of plants through the use of agricultural practices, biological preparations, technological storage factors [9-17].

Based on this, we have carried out work on testing several growth regulators in the cultivation and storage of apple fruits.

2 Materials and methods

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The objects of research were apple fruits grown in the conditions of the south of Russia.

In determining the quality indicators of fruits during cultivation and storage in apples, the following were defined: soluble solids according to GOST ISO 2173-2013; total sugars according to GOST 8756.13-87; titratable acids - according to GOST ISO 750-2013; vitamin C - iodometric method with potassium iodate; anthocyanins, vitamin P - in the modification of L.I. Vigorova; intensity of ethylene release - on the ICA-56 device; pulp hardness - with an FT-372 penetrometer with a plunger diameter of 10 mm. [16]; palatability - organoleptic evaluation [17].

3 Results and Discussion

In developing an algorithm for controlling the keeping quality of fruits in the system "growing - harvesting terms - post-harvest treatment - storage - sale", the features of the action of various biological growth regulators during the cultivation and storage of apple fruits, including those obtained using microorganisms has been studied.

The features of the action of the natural growth regulators Gibbersib, obtained from the fungus of the genus *Fusarium*, on the formation of the quality of fruits in the garden, providing the most complete involvement in the production processes of natural biological resources of plants, contributing to the improvement of the quality and keeping quality of fruits, have been established.

The use of the domestic natural biological growth regulator Gibbersib preparation based on gibberellic acids with a different set of them (A3, A4 and A7) allows us to conclude that it is effective with two (option 1) and three foliar treatments (option 2) in various phenological phases, which allows improve flowering and fruit set (by 4.4-6.5%), due to the rapid mobilization of nutrients that stimulate cell division and stretching; reduce June shedding by 3.4-5.4%, increase fruit weight by 2.6-2.8%, yield by 2.9-4.4 t/ha, accelerate ripening and improve the chemical composition of fruits in terms of sugar content and vitamin P, as well as to obtain a more attractive presentation of apples by reducing the impact of environmental stress factors during flowering and cell elongation, through the action of specific proteins involved in responses to environmental stress factors, which we observe when evaluating the development of rust on the skin of apples, arising from the action of low temperatures, heavy fogs, rain, drought during flowering or cell division (Figure 1, 2).

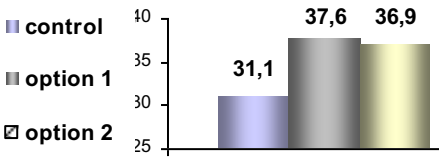

Fig. 1. The set of apple fruits as a result of treatment with *Gibbersib*

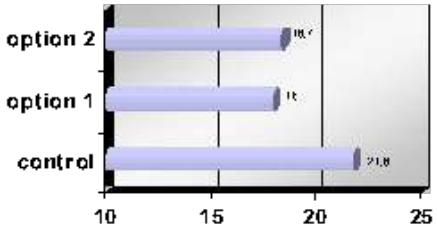

Fig. 2. Shedding of apple fruits as a result treatment with *Gibbersib* (variety Golden Delicious)

Due to the vital activity of microorganisms and the use of the internal biological potential of microorganisms (Trichoderma), which are part of the new biological product being

developed with a different combination of minerals, the issues of improving the quality indicators of fruits associated with an increase in the color of the skin of apples by increasing the rate of anthocyanins synthesis were purposefully solved. New experimental data have been obtained on the use of biological growth regulators on apples (varieties Idared, Fuji) in foliar treatments with different combinations of minerals enriched with calcium (preparation 1) and sulfur (preparation 2), which make it possible to purposefully form the quality of fruits during cultivation in order to better assimilate calcium (by 22-26%) , providing a reduction in losses from bitter pitting and an increase in the antioxidant activity of fruits, which enhances the resistance of fruits to the development of physiological diseases during storage. Due to the vital activity of microorganisms (Trichoderma), which are part of the preparation, affecting the skin of apples, the synthesis of anthocyanins is increased almost twice in comparison with the control, which enhances the color of the fruit without causing them to overripe (Figure 3).

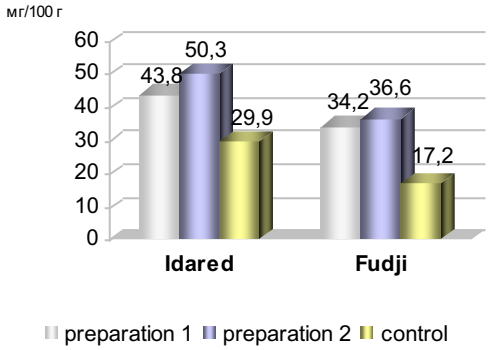

Fig. 3. The content of anthocyanins in apple fruits as a result of treatment with biostimulants

To control the rate of fruit ripening during cultivation, the use of a biotechnological preparation based on foliar treatment with a suspension of cyclic hydrocarbons - Harvista™, provides control over the quality of fruits during the ripening period, reducing the rate of biochemical processes, which ensures better formation of taste, aroma, hardness apples during cultivation and storage.

The patterns of control at the cellular level of the rate of ripening of apples during cultivation (Modi variety) were established on the basis of a decrease in the intensity of ethylene release by fruits (by 6.8 times) after spraying 10 days before the ripening of fruit-bearing plantations with a drug whose active ingredient is 1-methylcyclopropene on a paraffin basis. Reducing the intensity of ethylene release by fruits provides an extension of the period of accumulation of the stock of nutrients in the form of starch, which is necessary for fruit storage (Figure 4).

Control

Treatment

Fig. 4. Changes in the starch content in apples, taking into account the variants of experience, Modi variety

By regulating the rate of biochemical reactions of cell components, 1-MCP allows you to postpone the timing of starch hydrolysis and slow down the rate of its transition into sugars, which at the cellular level allows you to control the rate of ripening and overripening of fruits on a tree, maintain high hardness of fruit pulp. By acting on the stalk of apples, the drug contributes to a better retention of fruits on the tree, provides a decrease in the shedding of apples (by 4-5 times) for the entire period of extending the fruit picking period (by 30 days), while increasing the additional time for acquiring a more intense color, increasing weight fruits, the "harvest window" of fruits is expanding, losses from vitreousness are reduced, as was observed this year with heavy rainfall during the harvest period.

Considering that during the storage of fruits, modeling of any technological process, which is reduced to assessing the rate of biochemical processes, depending on one or more environmental parameters, is a **biotechnological** process, we studied the features of preserving the commercial qualities of apples that underwent post-harvest treatment with an ethylene inhibitor - *SmartFresh*^{TM} preparation with taking into account varietal characteristics.

Given that fruits are characterized by an increased metabolism, which causes increased sensitivity to environmental conditions, the regulation of the rate of biochemical processes in apples, taking into account varietal characteristics, allows you to set the optimal storage mode that ensures maximum preservation of fruit quality.

Post-harvest treatment of apples with *SmartFresh* ^{TM} makes it possible to slow down the process of overripening of fruits by blocking ethylene receptors and controlling its activity, which also leads to a decrease in the intensity of fruit respiration. A decrease in the concentration of ethylene in the environment of the storage chamber ensures a slowdown in the intensity of respiration of the fruits, the rate of consumption of the supply of nutrients in the form of starch, sugars, acids, and, ultimately, a better preservation of the original qualities of the fruits (Figure 5).

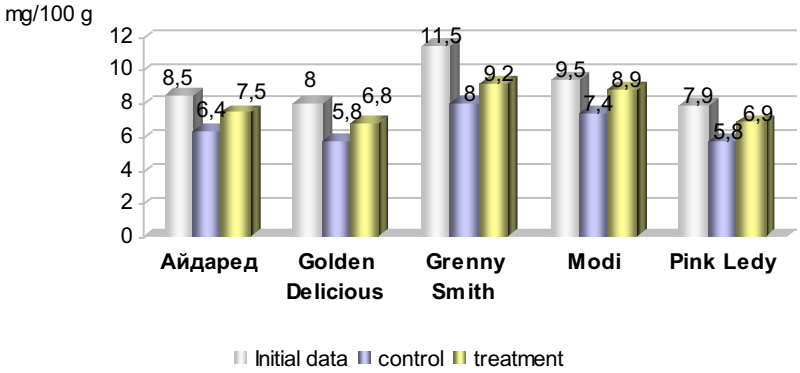

Fig. 5. Apple fruit firmness after 5 months of storage, taking into account post-harvest treatment with *SmartFresh* ™ and varietal characteristics

The use of a biotechnological method - storage in an environment with a low content of oxygen and a high content of carbon dioxide, allows you to control the intensity of respiration of fruits, reducing the consumption of nutrients during storage. For the main assortment of apples growing in the south of Russia, optimal storage parameters have been developed both in a normal environment and when stored in a controlled environment with different concentrations of carbon dioxide and oxygen - 1.5% O^2 and 1.5% CO^2 (Golden Delicious, Modi , Gold pink, Fuji); 1.5% O^2 and 1.3% CO^2 (Granny Smith, Renet Simirenko), where the information obtained is used to develop a scale of changing criterion indicators of the quality of fruits during storage, which allows, based on the speed of biochemical processes, to establish the optimal timing of the sale of fruits, and also predict the development of physiological diseases.

The combination of several technological parameters during the storage of fruits (the joint action of the *SmartFresh*™ preparation, aimed at controlling the rate of ethylene release, as well as the composition of the atmosphere in the storage chamber - reduced oxygen content and increased carbon dioxide, which reduces the respiration rate of fruits), which allows to achieve the maximum effect of maintaining the original quality fruits, in which the yield of commercial varieties amounted to 95-98%.

Monitoring of changes in the quality indicators of fruits, associated with the speed of biochemical processes, makes it possible to predict the shelf life of fruits, and the established digital parameters for reducing the initial biochemical quality indicators make it possible to develop a methodology for determining the effectiveness of the implementation of algorithms for managing the keeping quality of fruits.

Thus, biologization of technological processes based on the use of biological preparations of different directions of action, optimization of technological storage parameters related to storage temperature, composition of the environment in terms of oxygen, carbon dioxide, provides the most complete control over the rate of biochemical processes, allowing maximum preservation of the original quality of fruits, laid down for long-term storage.

4 Conclusion

Study of a natural biological growth regulator based on gibberellic acids, preparations containing microorganisms enriched with calcium (preparation 1) and sulfur (preparation 2), as well as a suspension of cyclic hydrocarbon based on 1-methylcyclopropene-preparation Harvista ™ for foliar treatments in the garden and *SmartFresh*™ in the

refrigerator - allow to most fully involve the biological resources of plants in production processes, as well as control the rate of biochemical processes in fruits, both during the cultivation and during a long-term storage. The combination of one or more technological storage parameters that allow to control the rate of biochemical processes in fruits, which refers to biotechnological processes, also permits to maximize the original quality of fruits and extend the time of their implementation.

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