Preservation of the quality of Actinidia kolomikta berries using a modified atmosphere

O M Blinnikova¹, I M Novikova¹, A S Ilinsky², L G Eliseeva³ and D A Blinnikova⁴

¹Michurinsk State Agrarian University, 101, International st., Michurinsk, 393760, Russia
²I.V. Michurin Federal Research Centre, 30, Michurin st., Michurinsk, 393774, Russia
³Plekhanov Russian Economic University, 36, Stremyanny lane, Moscow, 117997, Russia
⁴Pirogov Russian National Research Medical University (RNRMU), Ostrovitianov st. 1, Moscow, 117997, Russia

E-mail: blinnikova@mgau.ru

Abstract. Actinidia berries are a unique natural source of ascorbic acid and many other important physiologically valuable nutrients, but they have a short shelf life. A modified atmosphere is of particular importance for preserving the quality of Actinidia berries during storage. The research was implemented in the laboratory of progressive technologies for storing fruits and vegetables of the research center of the Federal State Budgetary Educational Institution of Higher Education of the Michurinsky State Agrarian University on Actinidia berries of the Soroka variety. 600-700 g of freshly picked berries were placed in perforated plastic containers. The storage technology provided for the cooling of Actinidia to a temperature of + 0.5 °C, the installation of perforated plastic containers with berries in the Xtend package, and packaging. The packages had two mini-cranes each, designed to connect the gas-analyzer inlet pneumatic line and return the medium. Storage was carried out in a refrigerator at a constant temperature of + 0.5 °C and relative humidity of 90%. During the storage period, the concentration of oxygen, carbon dioxide, and ethylene in the bag was regularly measured, and the berries were examined, and their appearance was assessed. It was found that after three days of storage, the level of gas concentrations inside the package stabilized and over the next 28 days was in the range of 3.1-3.5% for carbon dioxide and 17.8-18.8% for oxygen. The intensity of ethylene release increased sharply on the 28th day of storage, which led to a significant decrease in the commercial quality of the berries. The studies have shown that to preserve the quality and extend the storage period of Actinidia berries, it is possible to recommend using a modified atmosphere, which ensures the preservation of the original quality of fresh berries. The optimal storage period is 24 days, with the yield of standard berries 94.4%, which is 2.3 times higher than the control. The duration of storage in a modified atmosphere is increased from 3 days to 24 days.

1. Introduction

The preservation of organoleptic and physicochemical indicators of fruit and berry raw materials is of key importance for the country's socio-economic development and the formation of an optimal physiological state of various groups of the population [1]. Functional food products play an important role in this process, with specific properties formed by the type and quality of raw materials.
Currently, the use for food purposes of various cultures that are not traditional for a particular region is gaining popularity, for example, Actinidia kolokmita. The berries of this plant are characterized by high taste and medicinal properties [2-7]. The berries of Actinidia kolokmit are juicy, tender, with strawberry, pineapple, or a specific Actinidia aroma. They taste like strawberries, watermelon, banana, apple, and most often pineapple, from sweet and sour to sweet, depending on the variety.

Actinidia berries are distinguished by a unique vitamin C content, ranging from 700 to 1300 mg/100g. Even the berries of a close "relative" – Chinese Actinidia (kiwi) – contain no more than 150-200 mg/100g of ascorbic acid. No wonder they are called "fruits of health" – 2-3 Actinidia berries are enough to satisfy a person's daily need for vitamin C.

Despite the unique chemical composition of Actinidia, their use in the production of functional food products is limited by the short storage period of the berries, which is 2-3 days. The use of a modified atmosphere is carried out using fundamentally new films that ensure maximum preservation of the quality of berry products. This method is necessary to increase the storage time of berries, reduce their respiration rate and reduce weight loss.

The effectiveness of using a modified atmosphere for storing berries is noted by many researchers [6-9]. The shelf life of strawberries using this technology reaches 12-18 days.

The bags are made for specific types of fruits and vegetables, considering the product's respiration rate, providing conditions that prevent the formation of condensation on the surface of the film and product.

Due to the product's respiration and the different permeability of the film concerning the leading gases of the atmosphere, an environment with a reduced oxygen concentration and a slightly increased concentration of carbon dioxide is created in it. Such conditions ensure a slowdown in all metabolic processes and, consequently, an extension of the shelf life and better preservation of the quality of berries. In addition, the film ensures the removal of excess moisture, which reduces the likelihood of fungal rot development.

In order to establish the effectiveness of using a modified atmosphere to preserve the quality of honeysuckle berries as a unique raw material for the production of functional food, the Soroka variety was selected. According to the results of a comprehensive organoleptic assessment, the Soroka variety belongs to the highest quality category, characterized by a record content of ascorbic acid, antioxidants, and many other physiologically valuable nutrients [2, 10, 11].

2. Materials and methods

Actinidia berries were harvested in perforated plastic containers in the morning in the phase of consumer maturity. Then the berries were quickly delivered to the laboratory of intensive storage technologies of the Center for Collective Use of Michurinsky State Agrarian University. In the Center, the berries were cooled in a refrigerator for 3 hours to a temperature of + 0.5 ° C.

600-700 g of berries were placed in perforated plastic containers. Each bag contained four containers in one row. The packages had two mini-cranes each for connecting the gas-analyzer inlet pneumatic line and for returning the medium. Storage was carried out in a refrigerator at a constant temperature of + 0.5 ° C and relative humidity of 90%. In the same cell, there was also a control variant – storage in a normal atmosphere. Each variant of the experiment was in three replications – about 2.5 kg each.

During the storage period, the berries were regularly examined, their appearance was assessed, the presence and degree of damage by phytopathogens were determined, oxygen concentration, carbon dioxide, and ethylene inside the bag were measured.

The CO₂ and O₂ concentrations were measured with a Storex gas analyzer, the measurement error was 0.1%, and the ethylene concentration was measured with an ICA 56 ethylene gas analyzer. The measurement error was 1 ppm.

3. Results and Discussion

Figure 1 shows the dynamics of the concentration of O₂ and CO₂ during storage of Actinidia berries of the "Soroka" variety in "Xtend" packages for 38 days.
Figure 1. Concentrations of O$_2$ and CO$_2$ in the X-tend package during storage

Gas concentrations inside the bag stabilized on the third day of storage. Over the next 28 days, gas concentrations were in the range of 3.1-3.5% for CO$_2$ and 17.8-18.8% for O$_2$. By the end of storage, the concentration of CO$_2$ increased to 5.6%, the concentration of O$_2$ decreased to 16.9%.

Figure 2 shows the dynamics of ethylene accumulation during storage in a modified atmosphere of the berries of Actinidia kolomikta.

Figure 2. Ethylene concentration during storage of actinidia kolomikta (Soroka) in MA (modified atmosphere)

During the first 28 days of storage, Actinidia berries emitted a small amount of ethylene, namely 2.4-28.4 ppm. On the 31st day of storage, there was a sharp increase in ethylene concentration up to 180-183.3 ppm. Actinidia berries are susceptible to ethylene. An increase in ethylene concentration at the end of storage led to a decrease in the commercial quality of berries. The content of soft and overripe berries, as well as those affected by phytopathogens, has sharply increased (Figures 3-5). Figure 6 shows the loss of standard Actinidia berries when stored in a modified atmosphere.
Figure 3. Percentage of sound berries (Soroka) during storage in MA (modified atmosphere) and OA (control, normal atmosphere)

Figure 4. Percentage of non-standard berries (Soroka) during storage in MA (modified atmosphere) and OA (control, normal atmosphere)

Figure 5. Losses of standard Actinidia berries during storage in MA (modified atmosphere)
Figure 6. Losses of standard Actinidia berries during storage in OA (control, normal atmosphere)

The use of a modified atmosphere made it possible to preserve Actinidia berries’ commercial quality during storage. The content of standard berries on the 28th day of storage was 87.8%. While under the conditions of an ordinary, normal atmosphere, there was only 25.3% of them, i.e., 3.4 times less. The berries retained their appearance, firmness, and taste better. When stored in a modified atmosphere, the content of soft berries was significantly lower than the usual atmosphere – 8.6% and 65.4%, respectively, on the 24th day of storage.

Further storage of berries in a normal atmosphere contributed to the defeat of overripe Actinidia berries by phytopathogens. The berries passed from the category "non-standard" to "affected by phytopathogens." The conditions of the modified atmosphere restrained the microbiological damage to the berries. So, the content of affected berries in a modified atmosphere on the 28th day of storage was 2.5%, in a normal atmosphere – 34%. The natural loss in the mass of Actinidia berries during storage in a modified atmosphere is reduced by 1.4 times compared to the normal atmosphere – 4.2% and 3.0%, respectively.

4. Conclusion

Actinidia berries are a unique natural source of the most important physiologically valuable nutrients. However, they have a short shelf life.

We used modern packaging that is widely used worldwide for storing and transporting fruit and vegetable products, Xtend bags, for preserving the quality of Actinidia berries. The basis of the technology under consideration for preserving the quality of berries is to create a modified atmosphere inside the polymer packaging and maintain it until the stored product is consumed. Due to the respiration of Actinidia berries and the different permeability of the film to the leading gases of the atmosphere, an environment with a reduced oxygen concentration and a slightly increased carbon dioxide concentration was created in the package. This process slowed down all metabolic processes and, consequently, extended shelf life and better preservation of the quality of berries. The studies were carried out on Actinidia berries of the "Soroka" variety.

The storage technology provided for the cooling of Actinidia to a temperature of + 0.5 °C, the installation of perforated plastic containers with berries in the Xtend package, and packaging. The packages had two mini-crane units for connecting the gas-analyzer inlet pneumatic line and returning the medium. Storage was carried out in a refrigerating chamber at a constant temperature of + 0.5 °C and relative humidity of 90%.

The performed studies of the effectiveness of using a modified atmosphere to preserve the quality of Actinidia berries of the Soroka variety have shown the prospects of this storage method, which makes it possible to preserve the commercial quality of berries and the valuable nutrient composition for 24
days. The use of a modified atmosphere makes it possible to increase the period of consumption of fresh Actinidia berries and their use in the production of functional food products.

References
[1] Ivanova E S, Rodionovich Y V, Ivanova E P, Konovalov V V and Nikitin D V 2020 Research of methods of processing post-spirit drinking enterprises of the central-black-earth district IOP Conference Series: Earth and Environmental Science 422(1) 012112
[2] Blinnikova O M 2016 The need to use the berries of actinidia kolomikta in the production of functional food Nutritional issues 2(85) 181-182
[3] Arťes F 2000 Modified atmosphere packaging of pomegranate Food Sci. 65 1112-1116
[4] Caleb O J, Opara U L and Witthuhn C R 2012 Modified atmosphere packaging of pomegranate fruit and arils: a review Food Bioprocess Technol. 5 15-30
[5] Candir E, Ozdemir A E, Kamiloglu O, Soylu E M, Dilbaz R and Ustun D 2012 Modified atmosphere packaging and ethanol vapor to control decay of «Red Globe» table grapes during storage Postharvest Biology and Technology 63 98-106
[6] Ozkaya O, Dündar O, Camerata Scovazzo G and Volpe G 2009 Evaluation of quality parameters of strawberry fruits in modified atmosphere packaging during storage African Journal of Biotechnology 8 (5) 789-793
[7] Selcuk N and Erkan M 2014 Changes in antioxidant activity and postharvest quality of sweet pomegranates cv. Hicrannar under modified atmosphere packaging Postharvest Biology and Technology 92 29-36
[8] Selcuk N 2015 The effects of modified and palliflex controlled atmosphere storage on postharvest quality and composition of «İstanbul» medlar fruit Postharvest Biology and Technology 99 9-19
[9] Waghmare R B and Annapure U S 2013 Combined effect of chemical treatment and/or modified atmosphere packaging (MAP) on quality of fresh-cut papaya Postharvest Biology and Technology 85 147–153
[10] Zhang M, Meng X, Bhandari B, Fang Z and Chen H.2014 Recent application of modified atmosphere packaging (MAP) in fresh and fresh-cut foods Food Reviews International 31(2) 172-193
[11] Blinnikova O M, Ilinksky A S, Novikova I M and Eliseeva L G 2021 Honeysuckle storage in modified atmosphere IOP Conference Series: Earth and Environmental Science 640(2) 022069