Honeysuckle storage in modified atmosphere

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Abstract. Honeysuckle is a natural source of the most important physiologically valuable nutrients but has a short period of storage. The experiments were carried out on variety Zymorodok. Freshly picked berries (600-700gr.) were placed in perforated plastic containers, cooled down to +0,5°C and stored in "Xtend" bags. The concentrations of oxygen, carbon dioxide and ethylene in the bags were regularly measured. The berries were also visually inspected. After 5 days of storage, the levels of concentrations of gases inside the packages stabilized and for the next 35 days were in the range of 1,2-2,1% for CO2 and - 19,2-18,8% for O2. The ethylene production was insignificant. The storage of cooled berries in MA significantly reduce berry losses induced by microbiological diseases (up to 2,2%) and better maintain the quality of honeysuckle (87,5% standard berries). Thus, using MA ("Xtend" bags), it is possible to prolong the period of storage of honeysuckle berries up to 28 days.

1. Introduction
Honeysuckle for the Central Chernozem Region is a non-traditional horticultural crop, the distinctive feature of which is the ability to accumulate a significant amount of biologically active substances and very early harvest time [1, 2, 3]. Among 250 species of the botanical genus Honeysuckle (Lonícera L.), only a few species belonging to the sub-section of blue honeysuckle (Caeruleae Rehd.) have tasty, edible fruits. Sweet and sour-sweet, without bitterness in taste, honeysuckle in wild form grows in Kamchatka and Magadan region, on the Kuril Islands, in Transbaikalia, in the South of Primorsky Krai. Edible, bitterish-sweet forms are found in the Altai and Sayan Mountains, in the Khabarovsk Territory and the north of Primorye. At present, honeysuckle is quite popular among horticultural berries [3]. Currently, over 80 honeysuckle varieties are registered in the State Breeding Register of the Russian Federation [4].

According to the Recommendations for rational norms of food consumption that meet modern requirements of a healthy diet (Order of the Ministry of Health of Russia from 19.08.2016 № 614) [5], the share of fruit should be 100 kg/year/person, including 7 kg of berries.) Honeysuckle is a strategically important crop, in high demand both in Russia and abroad due to high nutrient content and its super early harvesting time [4, 6]. Honeysuckle berries are a natural source of the most important biologically active substances but have a short period of storage [1, 7]. Researchers are working on the development of new methods of storing berries, fruits and vegetables, some of which
have been are used commercially – storage in controlled and modified atmospheres, optimization of temperature and humidity conditions, ozonization [8].

2. Material and methods
Modified atmosphere is quite promising for maintaining the quality of fruits and berries and increase their storage period. It is based on the modification of the atmosphere inside the polymeric packages (bags) due to the natural respiration of the produce. Initially, the product has to be cooled down to 1-60°C and subsequently put into a bag made out of a special plastic film [9]. In our experiments, the bags "Xtend" (XPlastic) of the Israeli company StePac were used. Due to the product respiration and different permeability of the film with respect to the main atmospheric gases, the concentration of oxygen reduces and concentration of carbon dioxide - increases. Such conditions reduce all metabolic processes of the produce and, as a result, prolong storage period and better maintain berry quality. Besides, the film ensures the reduction of excess moisture in the bag, which diminishes the development of fungal rot.

The effectiveness of the modified atmosphere (MA) for fruit storage was investigated by some researchers [10-18, 2, 19, 20]. Our experiments were carried out on honeysuckle variety "Zymorodok". It is a dessert variety, berries - about 1,1 gr., round-oval with a thickened tip, juicy, dark blue. The skin is quite thin; the taste is sweet, without bitterness, refreshing.

The experiments were carried out in the laboratory of progressive technologies of storage of fruits and vegetables of the Research centre of FSBEI HE Michurinsk State Agricultural University. Freshly harvested berries in the optimal state of maturity in perforated plastic containers were quickly delivered to the laboratory and cooled down in a refrigerated chamber for 3 hours to a temperature of +0.5°C. About 600-700 gr. of berries were placed into each perforated plastic container. Four containers were placed into each X-tend bag. The bags had two mini valves to connect the gas analyzer (in and out). The bags were stored in a refrigerating chamber together with the control at a temperature of +0.5°C and relative humidity of 90%. Each variant was in three replicas - about 2.5 kg in each [18, 21].

Concentrations of CO2 and O2 were regularly measured by Storex gas analyzer, (accuracy - 0.1%), and ethylene concentration – with ethylene gas analyzer ICA 56 (accuracy - 1 ppm) [18]. The quality of the berries was also examined.

3. Results and Discussion
The dynamics of oxygen and carbon dioxide concentrations in the X-tend package during storage are presented in Figure 1.

![Figure 1](image-url)

**Figure 1.** Concentrations of O2 and CO2 in the X-tend package during storage
The concentrations of gases inside the bags were stabilized in 5 days of storage and the next 35 days were in the range of 1.2-2.1% for CO2 and - 19.2-18.8% for O2. The ethylene production of honeysuckle berries during storage was deficient – 1.4-2.1 ppm (Figure 2).

Figure 2. Ethylene concentration during storage of honeysuckle berries (Zymorodok) in MA

Ethylene is a plant hormone that is synthesized by plants and at deficient concentrations regulates their growth, as well as activates the ripening of fruits. A wide range of effects of ethylene on plants has been discovered, including ripening and ageing of plants and activation of protective reactions [22].

According to literature, honeysuckle berries are not sensitive to ethylene, but a very high concentration of this gas can stimulate the intensive development of fungal pathogens. Our results showed that honeysuckle berries produce very little ethylene during storage.

The percentage of sound berries during storage in MA in comparison with control are presented in Figure 3, and the percentage of berries affected by pathogens – in Figure 4.

Figure 3. Percentage of sound berries (Zymorodok) during storage in MA and OA (control)
Figure 4. Percentage of berries (Zymorodok) effected by pathogens during storage in MA and OA (control)

The MA conditions better maintained the quality of honeysuckle berries during storage. Thus after 28 days of storage, the percentage of good berries in MA was 5.7 times higher than in control – 87.5% and 15.4%, respectively. During the storage of honeysuckle in MA significantly reduced the number of rotted berries, the weight/water loss in comparison with control was reduced by 1.5 folds (Figure 5).

Figure 5. Water loss of honeysuckle berries during storage in MA and OA (control) after 28 days, %

Thus, our experiments prove the perspective use of MA, "Xtend" packages as an example, to extend the storage of honeysuckle up to one month. The use of the modified atmosphere when stored at a temperature of +0.5°C significantly reduces berry losses caused by microbiological diseases and better maintains the quality of berries.

4. Conclusion
Honeysuckle Honeysuckle is very rich in the most important physiologically valuable nutrients and is of high demand in Russia and abroad. Unfortunately, its storage period is quite short.

To maintain the quality of honeysuckle Xtend bags were used - a modern package for storage and transportation of fruit and vegetable products. The basis of this technology is to create a modified atmosphere inside the polymeric packaging. Due to the respiration of honeysuckle berries and different permeability of the film with respect to the leading atmospheric gases, the concentration of oxygen in the package is reduced and the concentration of carbon dioxide – is increased. That slowdown all metabolic processes in berries and, as a result, extends storage period and better maintain quality.
The experiments were carried out on honeysuckle berries - variety Zymorodok. It was found that MA conditions better maintain the quality of honeysuckle berries during storage. Thus, after 28 days of storage, the percentage of good berries in MA was 5.7 times higher than in control - 87.5% and 15.4% respectively. The number of rotted berries was significantly reduced, and the water loss was decreased in 1.5 times.

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