Scientific significance of using protective devices in pear storage in refrigerated warehouses (in the case of Uzbekistan)

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Abstract. In this article, a scientific study on the long-term storage of Santa Maria pears in refrigerated warehouses through using modern protective equipment, special bags and ethylene-absorbing absorbers, was conducted. Accordingly, the main factor influencing the long shelf life of pears was the natural loss during the storage. It was considered that calculation and analysis of effects inducing the natural loss were pivotal to improve the preservation of the fruit, maintain freshness and all useful elements of the fruit, and prolong the storage period. Ethylene absorber and Modified Atmosphere Packaging (MAP) packages were used in the initial research step, and collected pears were placed in the refrigerator at a temperature of 0-2°C in 8 different Options. Results showed that the higher natural loss in the fruit stored without employing any means (in option 1) was 5.45% equal to 193.9 gram, whereas the best result was in Option 7 used the MAP special plastic bag and two pieces of absorbers, and compared to the initial weight, 4099 grams, the natural loss in the fruit was 1.20% equal to 47.7 gram.

1. Introduction

Global population growth, climate changes, and water shortage are exacerbating problems, such as poverty, hunger, food security and decreased yield in agricultural production in some areas of the world [1, 2]. Nevertheless, it was stated that all sectors around the globe have rapidly been developing, including agricultural sector [3, 4, 5, 6, 7]. All parties and actors, who have vested interest in selling agricultural products, are trying to enter to the world market [8, 9]. For the developing countries like Uzbekistan, producing and storing the export-oriented fruits is one of the most pressing challenges in entering the world market. Use and implementation of special means and methods being used for storing fruits in the developed countries through experience exchange and cooperation will not only enhance experience but will also facilitate the exchange of scientific and practical knowledge of Uzbekistan with other countries [10]. Therefore, the state is issuing a number of decrees and measures on increase the export potential of
the country through the development of technologies for growing and storing fruits and vegetables. On 11th of December 2019, presidential decree, No. 4549, on “Further development of fruit, vegetable and viticulture, and additional measures towards creating a value chain in the field”. In that decree, the inadequacy of the scientific approach to the development of fruit, vegetable growing and viticulture, and the incomplete use of the existing potentials of the sector were emphasized [11].

It is known that one of the most grown and consumed fruits is pear. Pears are delivered to consumers in different ways depending on the growing season; early ripening varieties of pears are sent to the local market or export, medium ripening varieties to local markets and processing enterprises, and late ripening varieties mainly to warehouses [12]. As mentioned above, one of the ways to deliver the product to consumers is to deliver it by storing pears in warehouses. One of the unique advantages of the method is that during any seasons of the year, the population is provided with fresh pears towards satisfying the needs of the human body for vitamins and trace elements. Typically, pears are stored in a variety of ground and naturally cooled (uncontrolled) rooms, however, due to the development of technical capabilities in recent years, it was possible to maintain optimal modes, room temperature, and relative humidity at optimal levels. Consequently, natural loss and sharp decline in quality indicators, which were considered uncontrollable parameters of the normal storage, such as ethylene gas, can be decreased and even be eliminated [13, 14, 15]. In this case, question might be raised that what is ethylene gas? Why is it so important to control? Clearly, ethylene is a natural growth hormone that many fruits produce to some degree, and the main causative agent of fungal diseases such as gray and white rot and mold. Uncontrolled ethylene gas accelerates the ripening process during fruit storage. For instance, damages are darkening or loss of color of the fruit, dullness and rot of the fruit, additionally, fruits and vegetables become soft and lose their flavor, color and weight. In other words, ethylene gas produced by fruits leads to rapid destruction of fruits, rot, darkening, change in taste, loss of hardness, twisting of the upper part of the fruit and an increased natural loss in the fruit weight [10, 13, 16, 17]. Therefore, it is especially important to reduce the presence of ethylene during storage.

Evidently, pears are very delicate in terms of compositions and require considering a number of specific factors in preparing them for the storage. Preliminary research results showed that no scientific work has been done in Uzbekistan on the storage of pears in special warehouses and the solution to possible problems during the storage. Therefore, this research aimed at testing protective means, special packages and adsorbers that absorb ethylene gas released during the storage of pears.

2. Study Area

This research was conducted in collaboration with the department of fruit-grape of Scientific Research Institute of Horticulture, Viticulture and Winemaking named after academician Makhmud Mirzaev, scientists of Tashkent State Agrarian University, and “Save Fresh Asia” LLC, official representative office of “Arteria Inter Fresh LLC” of Russia in Uzbekistan. The research was carried out in the laboratory, therefore, there is not specific study area in this scientific work.

3. Methods

For the initial research work, the pear variety, Santa-Maria, which was introduced in the late summer, was selected. Santa-Maria pear ripens between late July and early August. Ethylene absorber (Figure 1) and Modified Atmosphere Packaging (MAP) packages were used in the initial research step, and collected pears were placed in the refrigerator at a temperature of 0-2°C in 8 different options described below:

An average of 3.5-4 kg (20 pieces) of fruit was placed in each box where certain Option used. The results of the initial analysis, such as fruit hardness, weight, sugar content, dry matter content and acidity were obtained, and the internal temperature of the fruits was measured. When the internal temperature dropped to 1-2°C, the plastic bags were tightly closed.
Figure 1. Special packages absorbers ethylene gas (Ethylene absorber)

**Option #1:** Control - the fruit itself was folded into a box and placed in the refrigerator without any means. The purpose was to compare the effects of the means used during fruit storage in the remaining Option.

**Option #2:** Simple plastic bag in which pears were placed in boxes.

**Option #3:** Simple plastic bag + one ethylene absorber. In this case, the pears were placed in boxes with one ethylene absorber that absorbs ethylene gas emitted from the fruit.

**Option #4:** Simple plastic bag + two ethylene absorbers. Pear fruits were placed in boxes with two pieces of ethylene absorbers that absorbs the gas.

**Option #5:** MAP special plastic bag, in which pears were placed using the MAP that help to keep the fruit fresh.

**Option #6:** MAP special plastic bag + one ethylene absorber. In this case, the pears were placed in boxes using the MAP special plastic bag and one piece of ethylene absorber.

**Option #7:** MAP special plastic bag + two ethylene absorbers. The pear fruits were placed in boxes using the MAP special plastic bag and 2 pieces of ethylene absorbers that absorbs ethylene gas and keep the fruit fresh.

**Option #8** MAP special plastic bag + two ethylene absorber + rotten fruit. In this option, pears were placed in boxes using the MAP special plastic bag, two ethylene and 3 pieces of rotten fruit.

It is known that rotten fruits negatively influence the rest of healthy fruits and result in shortened lifespan. Consequently, healthy fruit are turned rotten ones in Business as Usual (BAU) case, therefore, it was intended to use combination as MAP special plastic bag + two ethylene absorber + rotten fruit towards testing their impact degree on lifespan of the pears (Figure 2).
4. Results and Discussion
It is stated that in the first days of storage, the fruits get rid of the circulating water, so the moisture in them quickly evaporates. Evaporation decreases for some time, but as the fruit ripens, evaporation increases. It is mentioned that air temperature and relative humidity in the fruit storage influence the smoothness of fruit evaporation, and during transportation and storage fruit get sweating due to water content in the fruit itself and other factors. It is necessary to increase humidity and decrease temperature in the warehouse towards stopping evaporation process, and keeping the fruit fresh. However, experiments presented that one of the main indicators of fruit storage is ethylene gas. Among fruits, pears are the second most abundant in terms of ethylene gas production and ethylene sensitivity (Table 1). Due to ethylene gas, rot occurs faster in pears than other fruits, such as apple, so that pears are stored in short whereas apples can even be stored in long-term.

| #  | Type of fruit | Ethylene sensitivity level | Ethylene production rate | Reaction to ethylene |
|----|---------------|----------------------------|--------------------------|----------------------|
| 1  | Apple         | High                       | Very high                | Become soft          |
| 2  | Pear          | High                       | High                     | Start rotting        |
| 3  | Quince        | High                       | Low                      | Start rotting        |

4.1 Natural loss of the fruits
Weight of the fruit in each Option was gradually measured to calculate natural loss in the fruit. In this research, the fruits were controlled at different time, and the overall results of the natural loss in the fruit stored for 70 days were depicted in Table 2. International standard stated that when the natural decrease of pears exceeds 10% the fruits are stopped storing and released for consumption. However, in this case, the condition of the fruit needs to meet the consumption requirements, such as hardness, full of flavor, color and weight.

Figure 2. Placement of pears based on the proposed variants
Table 2 represented that the higher natural loss in the fruit stored without employing any means was 5.45% equal to 193.9 gram, and the fruit got soften and overripe, consequently, the fruit did not meet the consumption requirement. Similar result was seen in the second option, simple plastic bag, accordingly, natural loss in the fruit was 5.02%. The natural loss in the rest of Options was distinguished between 1.20-3.30%. However, the research outputs showed that the best result was in Option 7 used the MAP special plastic bag and two pieces of absorbers, and compared to the initial weight, 4099 grams, the natural loss in the fruit was 1.20% equal to 47.7 gram.

All in all, the storage of the pears was stopped due to increased natural loss, and the natural loss was much lower in the other Options than the control one. Because fruits were stored in plastic bags, the rate of water leakage from the fruits was decreased. In this research two types of plastic bags, simple and the MAP were used, accordingly, the natural loss of the pears in simple plastic bag was less than the natural loss in the MAP special plastic bag. However, the pears in simple plastic bag started rotting, so that the storage was stopped. The natural loss of the pears in the MAP special bag was higher than the rest, but the storage was continued as the condition of the fruit was well preserved.

Table 2. Results of an average natural loss of Santa Maria pear stored for 70 days

| #  | Options                                                  | Initial total weight (gr) | Stored period (days) | Natural loss | Total weight (gr) | Decreased total weight (gr) | %     |
|----|----------------------------------------------------------|----------------------------|----------------------|--------------|-------------------|-----------------------------|-------|
| 1  | Control                                                 | 3,808                      | 70                   |              | 3,571             | 193.9                       | 5.45  |
| 2  | Simple plastic bag                                      | 3,316                      | 70                   |              | 3,291             | 165.2                       | 5.02  |
| 3  | Simple plastic bag + one ethylene absorber              | 4,044                      | 70                   |              | 3,993             | 130.1                       | 3.26  |
| 4  | Simple plastic bag + two ethylene absorbers             | 3,486                      | 70                   |              | 3,455             | 109.9                       | 3.18  |
| 5  | Modified Atmosphere packaging (MAP) special plastic bag | 3,594                      | 70                   |              | 3,472             | 114.5                       | 3.30  |
| 6  | Modified Atmosphere packaging (MAP) special plastic bag + one ethylene absorber | 3,350 | 70 | | 3,239 | 74.8 | 2.31 |
| 7  | Modified Atmosphere packaging (MAP) special plastic bag + two ethylene absorbers | 4,099 | 70 | | 3,982 | 47.7 | 1.20 |
| 8  | MAP special plastic bag + two ethylene absorber + three rotten fruit | 3,682 | 70 | | 3,613 | 67.7 | 1.87 |

4.2 Sweating conditions inside packages
It is stated that after harvest, the respiration process in the fruit continues. The storing fruits at low temperatures was intended to slow down the process in the fruit, such the natural loss, and prolong the lifespan of the fruit. In this research, cases of sweating in packages were observed during fruit storage, and
they especially were detected in simple plastic bag. Sweating has even occurred in Options with ethylene absorber packages that absorb ethylene gas. However, no sweating was observed in the products in the box used MAP special package and the adsorbers (Figure 3).

![Simple plastic bag + two ethylene](image1)
![MAP special plastic bag + two ethylene](image2)

**Figure 3.** Sweating conditions in the packages

Analysis of changes in the condition and appearance of fruits storage showed that the best results were identified in Option 7, MAP special plastic bag + two absorbers. Accordingly, the color of the fruit was turned to yellowish, and hardness of the fruit was well preserved. Noteworthy, no cases of rot in the fruit were observed, and bands and other organoleptic indicators were found to retain their initial state (Figure 4).

![Before](image3)
![After](image4)

**Figure 4.** Condition of the fruits stored in MAP special plastic bag + two absorbers
5. Conclusion

It was found that the preservation of pear fruits depends primarily on the characteristics of the variety, and mainly medium and late ripening varieties were well preserved. The research carried out on medium varieties of pears, and Option 7, MAP special plastic bag + two absorbers, showed good performance in term of keeping natural condition of the pears, such as hardness, freshness, and all elements. The storage of the pears was stopped due to increased natural loss, and the natural loss was much lower in the other Options than the control one. The natural loss of the pears in simple plastic bag was less than the natural loss in the MAP special plastic bag. However, the pears in simple plastic bag started rotting, so that the storage was stopped. The natural loss of the pears in the MAP special bag was higher than the rest, but the storage was continued as the condition of the fruit was well preserved. Overall, it can be said that Option 7 can be used for storing pears due to its good performance found during this research. For further research, the same technique will be used but, in this case, it will be for long term.

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