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RESEARCH REGARDING THE BEHAVIOUR OF APPLE VARIETIES DURING STORAGE IN UNEQUIPPED SPACES

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Abstract

Autumn and winter apples have the ability to evolve in ripening after harvest, which allows them to be kept for a certain period depending on storage conditions. During storage in unoccupied spaces, a series of qualitative and quantitative depreciations takes place, which, in turn, limit the duration of the storage period.

Key words: apples, consumption maturity, storage, unequipped spaces, qualitative and quantitative impairments.

INTRODUCTION

Autumn and winter varieties of extra and first quality apples are suitable for storage, valuable and appreciated by consumers, with a good storage capacity: Golden Delicious, Jonathan, Starking Delicious, Starkrimson, Red Delicious, Wagner Premiat, Jonagold, Florina, Idared, Granny Smith, etc.

Apples can be stored for a longer or shorter period of the time, depending on the physiological characteristics of the fruit and the storage conditions. Additionally, of significant importance are the ecological and agro-technical factors, harvesting at the optimal time, transport and packaging operations, handling and conditioning. The more on time and correctly undergone these operations are, lesser the integrity of the fruit is affected.

Technologies used to store apples are based on controlling and directing external factors, in order to reduce metabolic activity and maintain their quality.

The main environmental factors that must be carefully managed in the storage spaces are the temperature and the relative humidity of the air, chemical composition and speed of air circulation, light, etc.

Temperature plays a key role in the shelf life of apples, influencing the metabolic activity of the fruits. Research showed that low temperatures reduce the metabolic activity of the fruits, cosequently reducing the biochemical reactions so that fruit ripening during storage is slow and the biological aging decreased. Moreover, low temperatures decrease or even inhibit the activity of microorganisms that cause qualitative depreciations of apples. However, it is recommended to keep the fruit at slightly higher temperatures, as practical results have revealed the appearance of certain physiological disorders in the superficial or deep states of the fruit, known as cold sores. This temperature threshold depends on the resistance of the varieties to low temperatures.

The relative humidity of the air (%) indicates the ratio between the amount of water in the air and the needed quantity to saturate it at a certain temperature. The relative humidity of the air directly influences the sweating process, which is more intense at low humidity values. At the same time, if high relative humidity is too high, an intense activity of microorganisms takes place, which, in turn, causes the fruit to rot, as well as a poor development of aroma and taste.

A relative humidity of the air in the storage spaces of 85-95% is recommended, being in close correlation with the ambiental temperature.

. The chemical composition of the air greatly influences the storage capacity of apples through the content of oxygen, carbon dioxide, ethylene, etheric substances, etc.

Decreased oxygen causes a reduction in the respiratory activity of fruits, the degradation of chlorophyll pigments, further inhibiting the oxidation of various organic components (sugars, organic acids, vitamins, pectic substances) and reducing the rate of ethylene production, preventing the appearance of various physiological disorders (scalding). Moreover, concentrations of 2-21% oxygen decrease the risk of disease, and concentrations below 5% lower the germination and spread of spores. In areas where the oxygen content is low, the carbon dioxide content is high. Fruits are sensitive to low oxygen concentrations. Thus, apples are sensitive to concentrations of less than 3%.

Carbon dioxide is naturally found in the environment at a concentration of 0.03%. An increase in the concentration of carbon dioxide above this value and up to 8% reduces respiratory activity, inhibits the oxidation of chlorophyll pigments and various organic components (sugars,

organic acids, vitamins, etc.), delays fruit ripening and aging. Additionally, it reduces the intensity of metabolism of pectic substances, which, in turn, maintain the structure of the fruit. These higher concentrations inhibit the activity of microorganisms and physiological diseases such as blemishes (Jonathan variety), scalding and internal browning of apples.

Carbon dioxide in high concentration, above the allowed limits, produces a series of undesirable phenomena: internal fermentation of fermentative nature, appearance of caves in the fruit pulp, pulp flouriness, accumulation of alcohol and acetic aldehyde and aroma degradation.

The air circulation in the storage spaces allows the homogenization of the temperature and humidity and proper dispersion of volatile products of metabolism released by the fruits. Air circulation prevents the formation of hot or cold nests in less accessible areas and corners, or the formation of hot and cold layers and the accumulation of volatile substances in certain parts of the storage unit. The speed of air circulation must also be carefully controlled, too high of a speed in conditions of low relative humidity causing the fruit to wither. An air circulation speed of 0.25 m / s is recommended, with a coefficient of 30 recyclings / hour.

Light also has a significant impact on the storage capacity of apples, due to its facilitation of redox processes in fruits. As a result, keeping the fruit in the dark is recommended.

Other factors with potential influence on the storage capacity of apples are foreign odors and the sanitation of storage spaces and packaging. Foreign odors may come from the coolant, the wood used for packaging, the development of fungi on the walls or from other species or varieties stored previously or simultaneously with apples.

Small quantities of horticultural products are stored in spaces with no utilities for short period of time, due to the fact that indoor environmental factors largely depend on outdoor weather conditions. In such constructions, the temperature varies greatly, the relative humidity of the air being much reduced, consequently causing weight loss and wilting of the products, and poor air circulation, which leads to the accumulation of volatile products that accelerate the maturation and aging of stored products.

During storage, the fruits may suffer qualitative and quantitative depreciation, primarily due to inadequate storage conditions, as well as non-compliance with all ecological and agro-technical factors. Moreover, the

operations of harvesting, transport, packaging, handling and conditioning must be carried out correctly and on time.

The recorded qualitative impairments are due to physiopathies or the emergence of certain diseases.

Physiopathies occur due to physiological changes that take place in the fruit and may begin in the orchard, as a result of soil and climatic conditions and maintenance work applied to trees and soil or occur during storage, being favored by environmental storage conditions. Additionally, some varieties are prone to develop certain physiopathies.

Impairment caused by microorganisms may occur as a result of their introduction together with fruits or poor hygiene in storage units.

MATERIAL AND METHOD

The study included two varieties of apple: Golden Delicious and Jonathan, which were obtained in the 2020 harvest. The apples intended for storage were obtained in a semi-intensive orchard, in the 6th year of production. Regarding the maturity of the orchard, the orchard system and the varieties produced, the fruits are recommended for storage.

During the vegetative resting period of the trees, crown maintenance works were carried out, which are applied annually, aiming to achieve a balance between vegetative growth and fruit formations.

Plantation maintenance work reffers to autumn fertilizers using chemical fertilizers with phosphorus and potassium and phase fertilizers with nitrogen. No additional irrigation was performed. The control of diseases and pests was achieved with fungicides and insecticides, both during the vegetative rest and during the vegetation period.

The fruits were harvested by hand in buckets, in the first half of October. Simultaneously with the harvesting operation, the fruits were conditioned by sorting and calibration. The extra quality and first quality fruits were destined for storage, the second quality fruits for consumption in fresh condition, and the rest for industrialization. The extra quality includes fruits that have the shape, size and color specific to the variety, with the stalk intact and free of any defects. For the first quality, slight deviations from the shape, size and color of the fruit are allowed, the stalk can be broken or without the stalk, as well as other defects on very small surfaces (insect bites, spots, small, scarred wounds, lightly pressed fruit).

The storage was done in unequipped spaces, respectively, in the cellar. The cellars arranged for storing apples are equipped with wooden shelves, overlaid at a distance of 60 cm between them, the apples being placed in a single layer. In these spaces, the regulation of environmental factors

(temperature, humidity, oxygen and carbon dioxide content) is achieved by opening doors and windows. Shelf life can be 3-5 months. These spaces are used in households, for quantities that satisfy the consumption during the autumn-winter period.

The storage space and the shelves on which the fruits were placed were previously disinfected by burning of sulfur flower (2.5 g / m3).

Being autumn- winter varieties, the metabolic activity of apples continues with a certain intensity, even after harvesting, depending on the environmental conditions in the storage spaces.

During storage, the parameters of environmental factors and the behavior of fruits during storage were monitored.

Adjusting the storage regime factors is difficult in this type of space, as they depend on the temperature and humidity of the ambient air. Thus, in the autumn when the fruit was introduced into the warehouse, the temperature was quite high at 140^{o}C. During storage, in the autumn and winter of 2020-2021 the temperatures decreased. However, when compared to recent years, they were quite high, so that the storage space did not reach the value of frost.

The regulation of temperature, humidity and chemical composition of the air was done only by opening the windows and doors. Throughout the storage, the health status of the fruits was evaluated every three days, together with the qualitative depreciations that occur (Alina, Ardelean, 2019, Radu, I.F., Gherghi A., 1967 Marca, Gh., 1987, Beceanu, D., 1994, 1998, 2000, 2002, 2003, Ceaușescu, I., Iordăchescu, C., 1987, Gherghi, A., et al., 1981, 1983, 1984,1989, 1994, Burzo, I., et. al., 1984, 1986,. Marca, Gh., 2004, Potec, I., et. al., 1983, 1985).

RESULTS AND DISSCUSIONS

The qualitative depreciations that appeared were determined by the metabolic activity of the fruits, the activity of the microorganisms and the physiological disturbances.

Depreciation due to the metabolic activity of apples affects the organoleptic properties: taste change, loss of flavor, decreased nutritional value, degradation of color, firmness of the pulp, wrinkling of fruits, etc

The change in taste during storage is mainly due to oxidation processes and changes in the ratio of organic components in fruits (sugars, acids, tannins).

Flavor losses occur in storages where the temperature exceeds the optimum storage threshold, which causes the release of volatile substances

from the fruit. When it comes to apples, the accumulation of volatile substances in the storage spaces accelerates the maturation favoring the appearance of physiological disturbances in some varieties (scalding).

Table 1 shows the types of qualitative depreciation (per 100 kg of stored fruit) for the two varieties of apples during storage.

Table 1

Qualitative depreciation recorded during storage

Soiul	Physiological malfunctions (%)	Alterations induced by the development of microorganisms (%)	Total qualitative depreciation (%)
Golden delicious	8	5	13
Jonathan	10	5	15

Among the alteration phenomena due to the development of certain diseases were moniliosis caused by the fungus *Monilinia fructigena* and alternariosis due to infection with the fungus *Alternaria tenuis*.

Physiopathies occur due to physiological changes that occur in fruits during storage, being favored by environmental storage conditions.

The recorded physiopathies recorded were bitter pit, browning of the pulp and Jonathan spot. It is known that some varieties are prone to develop certain pathophysiologies. In this sense, it was observed that the Jonathan variety is prone to bitterness and Jonathan's spot, and the browning of the pulp was recorded in the Golden variety.

The depreciated fruits were immediately removed, weighed, thus establishing the type of depreciation.

The storage period was 4 months. After this period, it was decided to stop the storage, because the outside temperature and implicitly the one in the storage space was increasing, which led to an increase in the percentage of qualitative depreciations.

The qualitative depreciations recorded were 15% for the Jonathan variety and 13% for the Golden Delicious variety.

Qualitative impairments can have several causes. First of all, after the conditioning operations, the fruits were not washed and treated with fungicides, which allowed the penetration of microorganisms into the

storage spaces, and the values of environmental factors were higher than the optimal ones for storage. These qualitative depreciations were also quantitative depreciations because the affected fruits could not be eaten.

CONCLUSIONS

The following conclusions can be drawn regarding the behavior of apples during storage in non-equipped spaces:

1. The qualitative depreciations that occurred were determined by the metabolic activity of fruits, the activity of microorganisms and physiological disorders (physiopathies).

2. The highest percentage of depreciation is represented by the physiopathies, being favored by environmental storage conditions (temperature, relative humidity, air composition, air circulation).

3. Apple varieties are prone to develop certain physiopathies. Thus, the Jonathan variety is prone to bitterness and Jonathan's stain, and the Golden variety was mainly affected by the browning of the pulp.

4. The metabolic activity of fruits affects the organoleptic properties: change in taste, loss of flavor, decreased nutritional value, degradation in color and firmness of the pulp, wrinkling of the fruits, etc.

5. The change in taste during storage is mainly due to oxidation processes and changes in the ratio of organic components in fruits (sugars, acids, tannins).

6. Flavor losses occur in warehouses where the temperature exceeds the optimum storage threshold, which causes the release of volatile substances from the fruit. When it comes to apples, the accumulation of volatile substances in the storage spaces accelerates the maturation and favors the appearance of physiological disturbances in some varieties (bitterness).

7. Qualitative depreciation also led to quantitative depreciation, as the affected fruit could not be eaten.

8. Recorded causes of qualitative depreciation were the failure to perform fruit conditioning operations (washing and treatment with fungicides), which allowed the penetration of microorganisms into storage spaces, together with the values of the environmental factors being higher than the optimal ones for storage.

9. Further research is recommended on changes in fruit during storage.

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