

INFLUENTA DIFERITELOR METODE DE PASTRARE ASUPRA CALITATII FRUCTELOR LA UNELE SOIURI DE CIRES THE INFLUENCE OF DIFFERENT STORAGE METHODS ON FRUITS QUALITY OF SOME SWEET CHERRY CULTIVARS

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Abstract

Consumer's demand for sweet cherry has increased due to its attractive fruits, taste, color, nutritional values and health effects. However, the fruits are highly perishable with a limited shelf life of 7-10 days. All quality traits are affected by growth conditions, picking, packing, transport and storage. Loss of fruits weight, firmness, color and flavor and the appearance of fungi or other physiological diseases limit their shelf life over extended periods of time. The temporary storage of fruits as long as possible without qualitative depreciation and significant quantitative loss is a major objective for the rhythmical supply of the market. The aim of this paper is the evaluation of influence of two storage methods on fruits quality of four sweet cherry cultivars. Fruit samples from four sweet cherry cultivars ('Daria', 'Severin', 'Superb', 'Stella'), grown in demonstrative plots managed in ecological system, were stored for one month by two storage methods: classical storage at low temperature (1-4°C) and high humidity (85-90%) and controlled atmosphere storage in Janny MT boxes at 2-4°C temperature, 95-100% humidity, 2-3% O₂ concentration and 2-5% CO₂ concentration. After a month of storage, it was found that the two storage methods prolong the shelf life of the fruits. However, for all cultivars studied, loss of fruits weight, firmness and sourness were lower in the Janny MT boxes storage than in the classical method. Also, the percentage of depreciated fruits due to the appearance of storage diseases was lower in the case of storage in Janny MT boxes than in the case of storage in the cold.

Cuvinte cheie: cireș, păstrare la frig, păstrare în atmosfera controlată, calitate fruct.

Key words: sweet cherry, cold storage, controlled atmosphere storage, fruit quality.

1. Introduction

In 2018, the world cherries production is about 2.5 million tons, the largest producer being Asia (45%), Europe (34%) and America (20%). The largest producers are Turkey (599,650 t), the USA (315,454 t) and China (220,000 t). Romanian production (according to FAO Stat Data Base, 2020) is about 91,000 t.

Consumer's demand for sweet cherry has increased due to its attractive fruits, taste, color, nutritional values and health effects. However, the fruits are highly perishable with a limited shelf life of 7-10 days (Crisosto et al., 2003, Correia et al., 2017, Dziedzic et al., 2017, Dziedzic and Blaszczyk, 2019, Wani et al., 2014).

All quality traits are affected by growth conditions, picking, packing, transport and storage. Loss of fruits weight, firmness, color and flavor and the appearance of fungi or other physiological diseases limit their shelf life over extended periods of time. To extend the period of fresh sweet cherry fruit consumption, the fruit can be stored for a relatively short time (up to 8 weeks) under optimal storage conditions (Dziedzic, et al., 2017, Dziedzic and Blaszczyk, 2019). Lately, new storage technologies (in modified atmosphere) have been tested to prolong the postharvest life of fresh fruits (Chiabrande et al., 2019, Dziedzic et al., 2017, Dziedzic and Blaszczyk, 2019, Giacalone and Chiabrande, 2013, Khorshidi et al., 2011, Remon et al., 2000). The quality of stored fruits depends on storage conditions (temperature, atmosphere composition, humidity), which influence physiological and biochemical composition of the fruits (Dziedzic et al., 2017, Meheriuk et al., 1995, Sen et al., 2014).

The aim of this paper was to compare the effect of cold storage and controlled atmosphere on fruit quality of four sweet cherry cultivars ('Daria', 'Severin', 'Superb' and 'Stella').

2. Material and methods

Fruit samples from four sweet cherry cultivars ('Daria', 'Severin', 'Superb' – Romanian cvs. and 'Stella' – Canadian cv.), grown in demonstrative plots managed in ecological system, were stored for one month by two storage methods: classical storage (in cold) at low temperature (1-4°C) and high humidity

(85-90%) and controlled atmosphere storage in Janny MT boxes at 2-4°C temperature, 95-100% humidity, 2-3% O₂ concentration and 2-5% CO₂ concentration.

The Janny MT module (boxes) is made up of a rigid plastic box and a Tiempo Cap lid. They form an individual module of 430 litres inside which fruits are stored in a controlled atmosphere. The passive diffusion of gas through the membrane of the lid creates an optimised atmosphere in the Janny MT module that is capable of satisfying the preservation standards for fruits and extending the preservation time period. Inside the Janny MT modules the atmosphere is natural, there is no added gas required. The atmosphere is stabilised by the breathing of the fruit and by passive diffusion through the membrane. The drop in the level of oxygen and the increase in the level of carbon dioxide in the Janny MT module are regulated by the membrane. Long term storage is now possible inside a traditional cold room. Each unit is independent and the Janny MT modules can be stacked. When the lid of the Tiempo Cap is closed, the hygrometry inside the module remains high (close to 100%), thus avoiding significant losses in weight. This is a fundamental aspect to keep fruits. With the Janny MT module, fruits keep all of their turgescence by example (sweet cherry lose less than 1.0% in weight after one months of storage).

The presents studies were performed during 2019-2020 and the following measurements were carried out: fruit weight in g; soluble solids content (SSC) with a digital refractometer in % Brix; malic acid (MA) content in % with the device Minitrator Hanna Instrument 84532; fruit firmness (HPE units) was measured with non-destructive penetrometer Qualitest HPE equipped with a plunger of diameter 0.10 cm; susceptibility of the fruits to storage fungal diseases in %. All measurements were performed in two moments: before storage and after one month of storage. After one month of storage we also determined the weight loss (by the difference between the fruit weight before the storage and the fruit weight after one month of storage) and the percentage of depreciated fruits by some storage diseases.

The results of the experiment were analyzed statistically using Duncan test.

3. Results and discussions

3.1. Fruits weight and weight loss

If the average fruits weight before storage was 8.31 g, with very significant differences between cultivars, after one month in classical storage, the average weight of the fruits decreased to 7.15 g, weight loss being 1.16 g. The highest weight loss was recorded at the 'Daria' cv. (1.24 g), and the lowest weight loss at the 'Stella' cv. (1.03 g) (Table 1; Fig. 1).

The average fruits weight before storage in controlled atmosphere in Janny MT boxes was 7.77 g, varying between 8.36 g at the 'Severin' cv. and 7.27 g at the 'Daria' cv., with very significant differences between the cultivars studied. After one month of storage in Janny MT boxes the average fruits weight decreased, but much less than in the case of cold storage, the weight loss being only 0.08 g (Table 1; Fig. 1).

Thus, during storage, the fruits weight decreased in both storage methods due to the loss of water through the fruit and peduncle (Linke et al., 2010, Dziedzic and Blaszczyk, 2019).

Sweet cherry fruits are characterized by low resistance to diffusion through the skin than other fruits (Wani et al., 2014).

Regarding weight losses of the fruits after storage in different conditions, many other authors have observed the same trend in other sweet cherry cultivars: Szymczak et al. (2003) at 'Kordia' cv., Padilla-Zakour et al. (2004) at 'Hedelfinger' and 'Lapins' cvs., Chiabrande et al. (2019) at 'Ferrovia' cv., Dziedzic and Blaszczyk (2019) at 'Regina' cv.

Loss of fruits weight during storage affects the shelf-life and deteriorates fruit quality after storage (Serrano et al., 2005).

3.2. Fruits taste

Sweet cherry fruits taste attributes, sweetness and sourness, are important for consumer acceptance (Correia et al., 2017).

During the storage of the fruits in classical and in controlled atmosphere conditions the SSC of fruits increased, results being similar to those obtained by other researchers (Chiabrande et al., 2019, Dziedzic et al., 2017, Jing et al., 2002).

Immediately after harvest, before classical storage, the SSC in the fruits had an average value of 11.71%, varying from 11.16% at the 'Superb' cv. and 12.10% at the 'Stella' cv. with very significant differences between cultivars (Table 2).

After one month of storage in classical conditions, the SSC in the fruits increased slightly from 11.71% to 11.79%. Of the 4 cultivars studied at the 'Daria' cv., the SSC increased the most, from 11.87% to 12.11% (Table 2).

If the fruits were stored in a controlled atmosphere in Janny MT boxes, the SSC of the fruits increased less from 11.57% to 11.63%. Of the four cultivars studied at the 'Severin' cv., the SSC increased the most, from 10.65% to 10.73% (Table 2).

Regarding sourness, we can observe that the malic acid content of the fruits was lower after storage in classical and in controlled atmosphere conditions compared to at harvest time, because organic acids are involved in respiration processes (Wang and Long, 2014, Wani et al., 2014).

Storing the fruits in classical and in controlled atmosphere conditions enables the slowing down of life processes, which in turn limits the decrease in acidity (Dziedzic et al., 2017).

In our study, after one month of storage in classical conditions the MA content of the fruits decreased from 0.66 % to 0.57 %. After one month of storage in controlled atmosphere conditions, the MA content of the fruits decreased from 0.61% to 0.56%, the differences between the two storage methods being very small (Table 3).

3.3. Fruits firmness

Storage conditions affected the sweet cherry fruits firmness.

In both storage methods the fruits firmness was lower after one month of storage than at harvest time.

The average fruits firmness before storage in classical conditions was 40.15 HPE units, with significant differences between cultivars. After one month of storage in classical conditions, the average fruits firmness decreased to 36.65 HPE units, differences being 3.50 HPE units. The highest decreases of firmness were recorded at the 'Stella' cv. (5.56 HPE units), and the lowest decreases at the 'Superb' cv. (1.47 HPE units) (Table 4).

The average fruits firmness before storage in controlled atmosphere in Janny MT boxes was 41.43 HPE units, varying between 36.11 HPE units at the 'Severin' cv. and 46.42 HPE units at the 'Superb' cv., with very significant differences between the cultivars studied. After one month of storage in Janny MT boxes the average fruits firmness decreased, but much less than in the case of cold storage, the decreases of firmness being only 1.89 HPE units (Table 4).

Generally, the fruits firmness was higher in case of storage in controlled atmosphere in Janny MT boxes than in cold conditions, because the fruits ripening are slower.

Some authors had shown the ability of sweet cherry fruits to maintain firmness for up to 8 weeks of storage or decrease slightly during storage (Dziedzic and Blaszczyk, 2019, Meheriuk et al., 1995).

3.4. Fungal decay

One of the factors limiting successful storage of sweet cherry fruits for longer periods is the susceptibility of the fruits to fungal diseases, mainly to brown rot (*Monilia laxa*) (Dziedzic et al., 2017).

Fungal decay in fruits depends of fruit health status at harvest time and of storage conditions (mainly high air humidity).

In our study, after storing, fungal decay caused by *Monilia laxa* was observed both in classical conditions and in controlled atmosphere in Janny MT boxes (Fig. 2 and 3).

In classical method of storage the percentage of depreciated fruits was 14.52 % and in controlled atmosphere in Janny MT boxes was 14.25%, the differences between the two storage methods being very small and insignificant (Fig. 2).

The most sensitive to brown rot were 'Stela' and 'Daria' cvs. and the most resistant were 'Severin' and 'Superb'.

4. Conclusions

Maintaining the quality of highly perishable fruit, such as sweet cherries is challenging.

This study demonstrated that, after a month of storage, the two storage methods prolong the shelf life of the fruits.

During storage, the fruits weight decreased in both storage methods due to the loss of water through the fruit and peduncle.

After storage of the fruits in classical and in controlled atmosphere conditions the fruits soluble solids content increased at all four cultivars studied.

The malic acid content of the fruits was lower after storage in classical and in controlled atmosphere conditions compared to at harvest time, because organic acids are involved in respiration processes.

In both storage methods the fruits firmness was lower after one month of storage than at harvest time.

After storing, fungal decay caused by *Monilia laxa* was observed both in classical conditions and controlled atmosphere in Janny MT boxes.

However, for all cultivars studied, loss of fruits weight, firmness and sourness were lower in the Janny MT boxes storage than in the classical method. Also, the percentage of depreciated fruits was lower in the case of storage in Janny MT boxes than in the case of storage in classical conditions.

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Tables and Figures

Table 1. The fruits weight (g) of four cultivars stored by two storage methods

| No. | Cultivar | Classical storage | | Controlled atmosphere storage in Janny MT boxes | |
|-----|----------------|-------------------|-------------------|---|-------------------|
| | | Before storage* | After storage* | Before storage* | After storage* |
| 1 | Daria | 8.40 ^b | 7.16 ^b | 7.27 ^c | 7.17 ^c |
| 2 | Severin | 8.88 ^a | 7.69 ^a | 8.36 ^a | 8.31 ^a |
| 3 | Superb | 8.13 ^b | 6.92 ^c | 7.79 ^b | 7.70 ^b |
| 4 | Stella | 7.84 ^c | 6.81 ^c | 7.68 ^b | 7.58 ^b |
| | Average | 8.31 | 7.15 | 7.77 | 7.69 |

*) values in columns that do not have common letters differ significantly for one level of assurance 5% statistic, Duncan test

Table 2. The fruits soluble solids content (% Brix) of four cultivars stored by two storage methods

| No. | Cultivar | Classical storage | | | Controlled atmosphere storage in Janny MT boxes | | |
|-----|----------------|--------------------|--------------------|-----------------------------|---|--------------------|-----------------------------|
| | | Before storage* | After storage* | Differences after one month | Before storage* | After storage* | Differences after one month |
| 1 | Daria | 11.87 ^b | 12.11 ^a | +0.24 | 11.68 ^b | 11.72 ^b | +0.04 |
| 2 | Severin | 11.70 ^c | 11.66 ^b | -0.04 | 10.65 ^d | 10.73 ^d | +0.08 |
| 3 | Superb | 11.16 ^d | 11.21 ^c | +0.05 | 11.50 ^c | 11.57 ^c | +0.07 |
| 4 | Stella | 12.10 ^a | 12.17 ^a | +0.07 | 12.45 ^a | 12.52 ^a | +0.07 |
| | Average | 11.71 | 11.79 | +0.08 | 11.57 | 11.63 | +0.06 |

*) values in columns that do not have common letters differ significantly for one level of assurance 5% statistic, Duncan test

Table 3. The acid malic content of fruits (%) of four cultivars stored by two storage methods

| No. | Cultivar | Classical storage | | | Controlled atmosphere storage in Janny MT boxes | | |
|-----|----------------|-------------------|-------------------|-----------------------------|---|-------------------|-----------------------------|
| | | Before storage | After storage | Differences after one month | Before storage | After storage | Differences after one month |
| 1 | Daria | 0.71 ^b | 0.61 ^b | -0.10 | 0.65 ^b | 0.60 ^b | -0.05 |
| 2 | Severin | 0.49 ^d | 0.37 ^d | -0.12 | 0.51 ^c | 0.45 ^c | -0.06 |
| 3 | Superb | 0.61 ^c | 0.55 ^c | -0.06 | 0.55 ^c | 0.47 ^c | -0.08 |
| 4 | Stella | 0.82 ^a | 0.74 ^a | -0.08 | 0.74 ^a | 0.75 ^a | +0.01 |
| | Average | 0.66 | 0.57 | -0.09 | 0.61 | 0.56 | -0.05 |

*) values in columns that do not have common letters differ significantly for one level of assurance 5% statistic, Duncan test

Table 4. The firmness of fruits (HPE units) of four cultivars stored by two storage methods

| No. | Cultivar | Classical storage | | | Controlled atmosphere storage in Janny MT boxes | | |
|-----|----------------|--------------------|--------------------|-----------------------------|---|--------------------|-----------------------------|
| | | Before storage* | After storage* | Differences after one month | Before storage* | After storage* | Differences after one month |
| 1 | Daria | 38.80 ^b | 35.36 ^b | -3.44 | 44.51 ^a | 42.07 ^b | -2.44 |
| 2 | Severin | 37.23 ^b | 33.70 ^b | -3.53 | 36.11 ^b | 34.33 ^c | -1.78 |
| 3 | Superb | 45.68 ^a | 44.21 ^a | -1.47 | 46.42 ^a | 45.30 ^a | -1.12 |
| 4 | Stella | 38.88 ^b | 33.32 ^b | -5.56 | 38.67 ^b | 36.45 ^c | -2.22 |
| | Average | 40.15 | 36.65 | -3.50 | 41.43 | 39.54 | -1.89 |

*) values in columns that do not have common letters differ significantly for one level of assurance 5% statistic, Duncan test

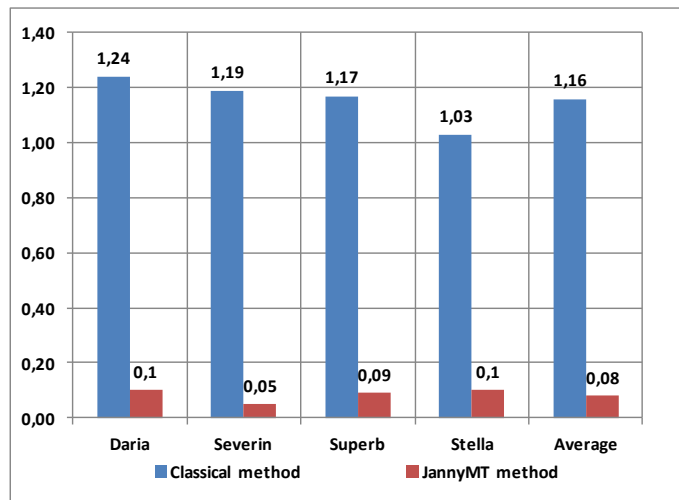


Fig. 1. Weight losses of fruits (g) after storage in different conditions

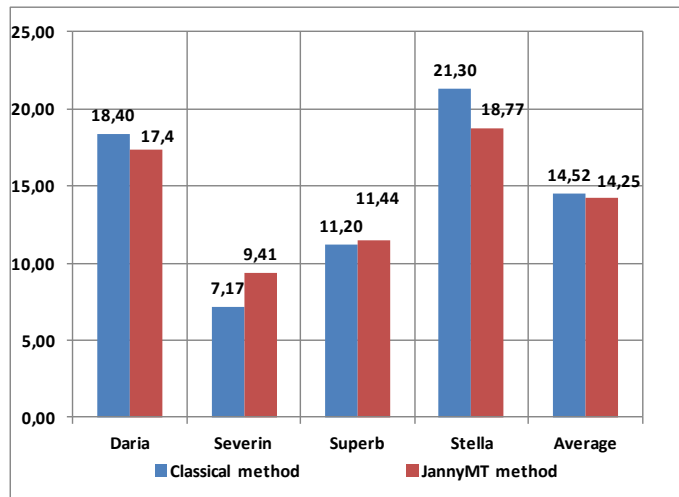


Fig. 2. The percentage of depreciated fruits due to the appearance of storage diseases



Fig. 3. The fruits affected by fungi - storage in Janny MT boxes