

STUDIES REGARDING THE STORAGE CAPACITY AND THE DYNAMICS OF THE MAIN PHYSICAL-CHEMICAL CHARACTERISTICS OF SOME CHERRY FRUITS VARIETIES, UNDER DIFFERENT STORAGE PARAMETERS

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Abstract

The studies carried out and shown in the present paper were performed for four cherry varieties: 'Hedelfinger', 'Stella', 'Boambe de Cotnari' and 'Durone di Vignola'. The storage capacity, the weight losses and the quality depreciations were measured as well. The fruits were stored in the following environment condition variants: V1 = modified atmosphere, at 2-3°C and 85-90% RH; V2 = modified atmosphere at 24 - 25°C and 80-85% RH; V3= cold storage, at 2-3°C and 75-80% RH; V4 = room temperature conditions at 24 - 25°C and 70-75% RH. The results obtained have proven the advantage of storing fruits in modified atmosphere, the storage durations ranging from 12 days for the 'Boambe de Cotnari' variety to 18 days for the 'Durone di Vignola' variety. The 'Durone di Vignola' variety has proven to have been the best preserved at the end of the storage period, the total losses recorded being of 2.3% in room temperature conditions after 8 days and only 9.2% after 18 days of storage in modified atmosphere.

Key words: cold storage, modified atmosphere, storage capacity, total losses.

INTRODUCTION

Cherries are much appreciated fruits, firstly for their earliness (some varieties - in the May month) when most other fresh fruits are not available and also for their nutritional and technological value given by the many possibilities of processing (Chira et al., 2002). During trading and distribution up to the moment the produce arrives at the final consumer, the quality may change quite rapidly, depending on the circumstances during storage and transport, thereby affecting both the possibilities of selling the produce and the price that can be obtained (Asănică et al., 2003; Chira et al., 2008).

Cherry fruits belong to the category of the perishable horticultural products and have a reduced storage capacity of only a couple of days. For this reason, there are studies carried out through which the extension of the storage period is attempted and at the same time the decrease of the quantitative and qualitative losses this type of fruit undergoes (Chira et al., 2014). This is the area of interest of the research carried out and put forward in the present paper.

A deep concern is represented by the storage of the cherry fruits in modified atmosphere conditions, which is obtained with low costs and can be kept constant throughout the entire storage period (Aglar et al., 2017, Çelikel F.G et al., 2003, Singh Sandhya, 2010). The research results carried out worldwide have given proof the superiority of this storage method in comparison with keeping fruits in normal cold storage conditions (Goliáš et al., 2007, Mangaraj et al., 2009, Sypula et al., 2018).

The research conducted within the Faculty of Horticulture in Bucharest has aimed to highlight the main aspects (the development of the main physical-chemical characteristics of fruits during storage, weight losses, quality losses, etc.) regarding the response behaviour of certain cherry varieties in modified atmosphere conditions in comparison to storage in cold or ambient conditions.

MATERIALS AND METHODS

The research conducted for the present paper has taken under study four cherry varieties: Hedelfinger, Stella, Boambe de Cotnari and

Durone di Vignola, grown in 10-year-old orchard situated in the Bucharest area.

The cherry fruit varieties' characteristics are as follows:

1. The 'Hedelfinger' variety of German origin is very productive, displays winter-hardiness, is vigorous and has a long lifespan. It blossoms late and has a good production even in unfavourable years with late frosts. The fruits are very big, weighing between 8.5 and 9.5 grams, have a ruby-red hue and turn dark red when overripe. The pulp is firm (stony), succulent, sweet, with medium acidity. The fruits do not crack, not even in very rainy years.

2. The 'Stella' variety of Canadian origin is very productive and bears fruit early. The fruits are medium-large, weighing between 7 to 8 grams, with a pink-reddish hue. The pulp is firm (stony), of a red colour, with a pleasant bitter- sweet taste.

3. The 'Boambe de Cotnari' variety of Romanian origin is very resistant to frost and to the main diseases. It is productive and bears fruit annually. The fruits are medium-large, weighing between 7 to 8 grams, they are bicolor (yellow and red) and resistant to transportation. The pulp is yellowish-white, firm (stony) sweet and with low acidity.

4. The 'Durone di Vignola' variety of Italian origin has large to very large fruits, weighing around 9.5-10.5 grams. Their colour is dark red. The pulp is firm (stony), with a specific and very pleasant taste and is also dark red.

It is a self-pollinated variety so it requires the presence of other varieties in the vicinity for pollination. It has low resistance to the attack of the *Monilinia laxa*.

The optimal time of fruit harvesting was determined by phenological and physico-chemical criteria.

The fruits were harvested in 2020, at the full ripeness stage, making sure that cherry fruits would not continue the ripening process after harvesting.

Both after harvesting and at the end storage period, fruits were physical-chemical analysed, taking in consideration weight losses and depreciation.

The fruits were stored in the following conditions:

V1 = modified atmosphere, at 2-3°C and 85-90% RH;

V2 = modified atmosphere, at 24-25°C and 80-85% RH;

V3= cold storage conditions, at 2-3°C and 75-80% RH;

V4 = ambient conditions, at 24-25°C and 70-75% RH.

The cherry fruits were stored in specific conditions immediately after harvest and cooling down, but only the first and extra quality fruits, in accordance with Regulation (EC) 543/2011.

The experimental variants for each variety consisted of 3 repetitions. Each repetitions consisted of 2 kg of packaged fruits.

Based on the results of worldwide research and due to the limited practical possibilities of obtaining modified atmosphere different from the ambient one, the research was carried out using a gaseous composition of 3% O₂ and 5% CO₂.

This type of modified atmosphere was achieved by covering the wrappers containing fruit with a low-density semipermeable polyethylene film (LDPE), with a thickness of 15μ (microns), figures 1, 2, 3, and 4. The modified atmosphere was obtained after seven days, by the natural fruits respiration.

During the respiration process the O₂ content decrease and the CO₂ content increase and the constant level of the gas concentration is assured by using the low-density semipermeable polyethylene film.

The measurements and analysis made after harvesting and at the end of storage period tracked the following:

- the evolution of the main physical-chemical characteristics of the fruits (total soluble solids, total titratable acidity and the content of ascorbic acid). The content of the total soluble solids was measured using the Atago electric refractometer. The total titratable acidity was measured by titration with a NaOH 0,1N solution. The results, expressed in percentage of malic acid was calculated with the specific formula for the Total titratable acidity. The content of ascorbic acid was measured using the iodometric method.

- establishing the weight losses and quality depreciation, by quantity and percentage;

- determining the temperature and relative air humidity of the cherries storage environment, using the Hanhart thermo hygrometer;

- determining the concentration of the main component gases (O_2 and CO_2) in the wrappers with modified atmosphere, using the Oxybaby gas analyser.



Figure 1. 'Hedelfinger' variety, in cold storage under modified atmosphere (own source)



Figure 2. 'Stella' variety, in ambient storage conditions (own source)



Figure 3. 'Boambe de Cotnari' variety, in cold storage conditions (own source)



Figure 4. 'Durone di Vignola' variety, in cold storage under modified atmosphere (own source)

RESULTS AND DISCUSSIONS

Physical-chemical results measured immediately after harvesting (Table 1) have highlighted

differences between varieties for all analysed characteristics.

Table1. The main physical-chemical characteristics of the cherry fruits at harvesting

Variety	Weight average -g-	Total Soluble Solid -%-	Total titratable acidity -%-	Ascorbic acid mg/100g
Hedelfinger	9.5	13.8	0.87	8.5
Stella	8.5	14.2	0.82	9.2
Boambe de Cotnari	8.5	13.0	0.85	8.7
Durone di Vignola	10.5	14.0	0.72	9.0

Source: own determination

Thus, the total soluble solids shown values between 13% for 'Boambe de Cotnari' variety and 14.2% for 'Stella' variety. The total titratable acidity values oscillated between 0.72% for the 'Durone di Vignola' variety and 0.87% for 'Hedelfinger', while the ascorbic acid content oscillated between 8.5 mg/100 g for 'Hedelfinger' and 9.2 mg/100g for 'Stella'. After determining the main physical-chemical characteristics of the cherry fruits, these were stored in different conditions, as shown in the material and method section. Fruits were stored for many days, just before they lose their commercial value suitable for market sold they were again analysed.

Regarding the duration of the storage (Table 2) it can be seen that it was longer for cold storage conditions under modified atmosphere (V1). The storage period was developed between 12 days for the 'Boambe de Cotnari' variety and 18 days for 'Durone di Vignola'.

Cherries kept in ambient conditions (V4), were stored for the shortest period, ranging from 5 days for the 'Boambe de Cotnari' variety and 8 days for 'Durone di Vignola'.

For the fruits stored in modified atmosphere (V2) the storage period ranged from 6 days for the 'Boambe de Cotnari' variety to 9 days for 'Durone di Vignola'. Storage in cold storage V3) increased the commercial period of valorisation by one day, compared with V2, therefore it ranged from 7 days for the 'Boambe de Cotnari' variety to 10 days for 'Durone di Vignola'.

The weight losses determined at the end of storage period varied widely depending on the variety, and particularly on the storage conditions. The main reduced losses were

recorded for V2 variant, with values ranging between 4.2% for 'Durone di Vignola' and 5.5% for 'Boambe de Cotnari', after 9 and 6 storage days, respectively. The most important weight losses were recorded at the end of storage period in ambient conditions (V4), the values oscillating between 9.8% for 'Durone di Vignola' and 11.4% for 'Boambe de Cotnari'. Regarding the weight losses, the significant data is the daily average losses weight. From this perspective it can be seen that for all the varieties the lowest values were recorded for V1, as for example 0.38% for 'Durone di Vignola' and 0.72% for 'Boambe de Cotnari', while for V4 the highest values were recorded, as for example 1.22% for 'Durone di Vignola' and 2.28% for 'Boambe de Cotnari', respectively.

For the V2 and V3 storage conditions, intermediary values were recorded for all of the analysed varieties, after 7 days of storage.

During storage some of the fruits rotted mainly as a consequence of the *Monilinia laxa* attack (Figure 5).



Figure 5. 'Hedelfinger' variety at the end of storage period in ambient conditions with symptom of *Monilinia laxa* - brown mould (own source)

The obtained results have proven once again the advantage of storage in cold conditions and in modified atmosphere (V1). For this storage variant, the daily average ranged between 0.13% for 'Durone di Vignola' and 0.4% for 'Boambe de Cotnari'. The highest number of rotten fruit was recorded in the case of ambient room storage conditions (V4), the daily average ranging between 1.68% for 'Durone di Vignola' and 3.8% for 'Boambe de Cotnari'.

A relatively good behaviour from fruits rotting point could be observed at V3, were daily average looks like: 0.44% for ‘Durone di Vignola’, 0.58% for ‘Stella’, 0.72% for ‘Hedelfinger’ and 0.91% for ‘Boambe de Cotnari’.

The total losses recorded were calculated from the sum of weight losses and quality depreciations due to rot. Thus, the lowest values were recorded for the V1, as for example 0.51% for ‘Durone di Vignola’ and 1.12% for ‘Boambe de Cotnari’, while the

highest values could be seen for V4, as for example 2.9% for ‘Durone di Vignola’ and 6.8% for ‘Boambe de Cotnari’.

At the end of storage period the main physical-chemical characteristics of the cherry fruits were determined.

From the results obtained (Table 3) is can be seen that the total soluble solids values were higher compared to those obtained immediately after harvest for all varieties, irrespective of the storage conditions, due to the water losses transpiration rate.

Table 2. The cherry fruits storage capacity, under different storage conditions (mean \pm SD; n = 3)

VARIETY	Storage conditions (variant)	Storage duration -days-	Weight losses - % -		Rotted fruits - % -		Total losses - % -	
			Total	Daily average	Total	Daily average	Total	Daily average
HEDELFINGER	V1	14	8.10 \pm 0.03	0.58	3.70 \pm 0.49	0.26	11.80 \pm 0.51	0.84
	V2	7	5.20 \pm 0.16	0.74	13.20 \pm 0.47	1.88	18.40 \pm 0.47	2.62
	V3	8	6.70 \pm 0.19	0.84	5.80 \pm 0.60	0.72	12.50 \pm 0.49	1.56
	V4	6	10.90 \pm 0.34	1.82	18.40 \pm 1.44	3.06	29.30 \pm 1.59	4.88
STELLA	V1	16	7.80 \pm 0.21	0.48	3.20 \pm 0.48	0.20	11.00 \pm 0.68	0.68
	V2	8	5.00 \pm 0.60	0.62	12.30 \pm 0.74	1.54	17.30 \pm 1.07	2.16
	V3	9	6.20 \pm 0.40	0.69	5.20 \pm 0.50	0.58	11.40 \pm 0.90	1.27
	V4	7	10.50 \pm 0.69	1.50	17.20 \pm 0.70	2.46	27.70 \pm 0.49	3.96
BOAMBE DE COTNARI	V1	12	8.60 \pm 0.56	0.72	4.80 \pm 0.38	0.40	13.40 \pm 0.94	1.12
	V2	6	5.50 \pm 0.56	0.92	13.80 \pm 0.74	2.30	19.30 \pm 1.29	3.22
	V3	7	7.20 \pm 0.34	1.03	6.40 \pm 0.66	0.91	13.60 \pm 0.85	1.94
	V4	5	11.40 \pm 0.56	2.28	19.00 \pm 0.56	3.80	30.40 \pm 1.12	6.08
DURONE DI VIGNOLA	V1	18	6.80 \pm 0.56	0.38	2.40 \pm 0.32	0.13	9.20 \pm 1.20	0.51
	V2	9	4.20 \pm 0.41	0.47	10.80 \pm 0.53	1.20	15.20 \pm 0.35	1.67
	V3	10	4.60 \pm 0.56	0.46	4.40 \pm 0.68	0.44	9.00 \pm 1.23	0.90
	V4	8	9.80 \pm 0.60	1.22	13.50 \pm 0.67	1.68	23.30 \pm 1.21	2.90

V1 = modified atmosphere, at 2-3°C and 85-90% RH

V2 = modified atmosphere, at 24-25°C and 80-85% RH

V3 = cold storage, at 2-3°C and 75-80% RH

Table 3. The main physical - chemical characteristics of the cherry fruits at the end of storage period

Variety	Variant	Storage Duration -days -	Total soluble solid - % -	Titrateable acidity - % malic acid -	Ascorbic acid - mg/100 g fresh product -
HEDELFINGER	V1	14	14.2	0.80	7.9
	V2	7	14.5	0.73	8.3
	V3	8	14.3	0.70	8.1
	V4	6	14.7	0.68	7.8
STELLA	V1	16	14.7	0.70	8.7
	V2	8	14.8	0.67	8.9
	V3	9	14.9	0.65	8.9
	V4	7	15.1	0.64	8.6
BOAMBE DE COTNARI	V1	12	13.4	0.82	8.1
	V2	6	13.7	0.75	8.5
	V3	7	13.5	0.72	8.3
	V4	5	13.9	0.70	8.0
DURONE DI VIGNOLA	V1	18	14.4	0.67	8.3
	V2	9	14.8	0.62	8.7
	V3	10	14.6	0.60	8.5
	V4	8	14.9	0.60	8.2

The higher values of total soluble solid were recorded for V4, as for example 13.9% for 'Boambe de Cotnari' and 15.1% for 'Stella'. The values of the total titratable acidity decreased during storage for all the varieties and in all storage conditions. The decrease was more accentuated in the V4 conditions than in V1, due to the intense metabolism of cherries stored in room temperature conditions in comparison to those stored in modified atmosphere.

The same tendency could be observed in the case of ascorbic acid content.

The values of ascorbic acid content have decreased in comparison to the harvesting date, but the oscillations were not as significant for each variety and storage variant.

CONCLUSIONS

As a consequence of keeping cherry fruits in cold storage and modified atmosphere, achieved with the aid of the low-density semipermeable polyethylene film (LDPE), superior results are obtained compared to storage in normal refrigerator conditions or at room temperature.

The storage period of cherry fruits in cold storage and in controlled atmosphere varied between 12 days for 'Boambe de Cotnari' and 18 days for 'Durone di Vignola', while at room temperature fruits could only be stored for 5 days for 'Boambe de Cotnari' and 8 days for 'Durone di Vignola'.

The weight losses recorded at the end of storage were by 24.6% ('Boambe de Cotnari' variety) to 30.6% ('Durone di Vignola' variety) lower in modified atmosphere under cold storage in comparison to storage at room temperature.

The quality depreciations due to the fruits rotting at the end of storage period were by 25.2% ('Boambe de Cotnari' variety) to 17.8% lower in modified atmosphere under refrigeration in comparison to room temperature storage.

The total losses determined at the end of storage period were by 44% ('Boambe de Cotnari') to 39.5% ('Durone di Vignola') lower in modified atmosphere under cold storage than in room temperature storage.

As a consequence of the metabolic activity during the cherries storage the main physical-chemical characteristics have not recorded a downward trend, with the exception of the total soluble solids, which increased due to concentration as a result of the water loss through transpiration rate. The decreases were more significant for the fruits stored in room temperature conditions.

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