STUDY REGARDING THE DURATION OF STORAGE AND ANALYSIS OF THE QUALITY INDICES OF FRESH FRUIT PRESERVED THROUGH REFRIGERATION

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RESEARCH ARTICLE

Abstract

Fresh fruits are living organisms, in the tissues of which complex metabolic processes take place even after harvesting, under the action of their own enzymes. Preservation technologies aim to reduce the intensity of metabolic processes, especially respiration and transpiration, as well as the activity of pathogenic microorganisms that start decomposition processes.

Fresh or processed fruits cover about 15% of human energy needs. Fresh fruits are considered both as food, but also as raw materials because they are used to obtain culinary preparations, but also industrialized products intended for food consumption.

Preservation of fruits represents a set of technological operations carried out with the aim of maintaining the quality of fruits for consumption in a fresh state, an admissible time interval, characteristic of each species and implicitly variety, in order to extend the duration of consumption.

Refrigeration is the process most often used both for food preservation and treatment, as well as in industrial processes, and as a result two-thirds of fruits are refrigerated.

The main purpose of refrigeration is to preserve or extend the shelf life of food products.

The shelf life of fresh fruits represents their property of resisting the alteration processes for a certain period of time after harvesting, while maintaining the parameters that constitute quality, within the limits accepted by commercial standards, in all stages of the capitalization circuit. It is a genetically transmitted biological characteristic, which is estimated by referring to the length of time fresh product maintains its quality, from harvest and until there is a danger of compromising their use value.

The shelf life of fresh fruit differs from one fruit species to another, being influenced by the multiple and combined action of numerous factors: species, variety, chemical composition, climatic conditions of the growing season, applied agricultural techniques, metabolic and microbiological processes that take place in horticultural products after harvesting.

The admissible storage period is the period of time during which the fruits maintain their quality for fresh consumption, under certain environmental conditions.

The study on the duration of storage and the analysis of the quality indices of fresh fruit preserved by refrigeration was carried out for strawberries, cherries and blueberries, in two variants for each species.

Key Words: refrigeration, preservation, organoleptic characteristics, acidity, vitamin C
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INTRODUCTION

Refrigeration is the first step in the preservation process that is based on the use of low temperature levels, but above freezing point. Products from the excessively perishable and very perishable group must be pre-cooled as quickly as possible after harvesting (2-6 hours). In the case of less perishable products, for long-term storage, refrigeration is carried out for longer periods (at least a few days), in the same spaces where storage is done. Refrigeration involves the removal of field heat (heat that the products have when harvesting), up to the storage temperature (Lazăr Vasile, 2006).

Refrigeration is applied for the actual preservation of the products. However, refrigeration can also be used for the purpose of ensuring optimal conditions for the development of biochemical processes needed for the manufacture of food products or for physical-chemical processes required in certain phases of food technologies, or it can constitute a preliminary cooling phase in the case of freezing technologies of food products (Petru Niculita, Nicolae Purice, 1986).

In order for refrigeration to be successful, the food product must be healthy, it must be

cooled as soon as possible after harvesting and the action of the cold must be uninterrupted (Gheorghe Mihalca, Veronica Mihalca, 1986).

Refrigeration is characterized by cooling the product at temperatures usually between 0 and 4oC and even more. Refrigeration results in: slowing down the development of microflora originating from internal and external contamination; reducing the speed of hydrolytic and oxidative reactions catalyzed by enzymes; the reduction of some physical processes (Banu Constantin, 2008).

Refrigeration is used to reduce the speed of biochemical and microbiological transformations, and therefore to extend the shelf life of fresh and processed products. This causes minimal changes in the sensory characteristics and nutritional properties of food, and refrigerated food is perceived by consumers as affordable, easy to cook, of good quality, healthy, natural and fresh. In fresh fruits, refrigeration causes both a reduction in the speed of enzymatic and microbiological transformations and a slowing down of their respiratory activity (Violeta Nour, 2014).

Refrigeration reduces the intensity of the metabolic processes of the products to the limit necessary for preservation. It must be done immediately after harvesting and can be done in a cold air current, with chilled water, in a vacuum, in a mixture with water ice, in a wet state and by fogging. The choice of the refrigeration agent and method is made according to the characteristics of the product, the harvesting stage, destination, etc. (Tofan Ioan, 2005).

Refrigeration represents a certain process of heat transfer, without changing the state of aggregation, accompanied in most cases by a transfer of mass (moisture) from the food product with a higher temperature to the cooling medium with a lower temperature. The final refrigeration temperature of food products is usually above their freezing point, between 0 and +5^{o}C (Banu Constantin, 2007).

The storage temperature determines the rate of chemical and biochemical reactions, as well as the rate of evaporation of water that inhibits the development of microorganisms.

The choice of the storage temperature must be made in such a way as to minimize aerobic respiration, which is responsible for the consumption of leftover substances, without causing anaerobic respiration, which affects the metabolism (Banu Constantin, 2009).

The optimal storage conditions for cherries are: temperature of 1-2^{o}C, relative air humidity of 90-95% and moderate air circulation, avoiding dehydration of the product. The lower temperatures (-0.5^{o}C...+0.5 ^{o}C) recommended as optimal by some standards, although they ensure a good visual quality (appearance), adversely affect the taste and aroma of cherries. The storage time, variable as it's variety specific, under optimal environmental conditions, is between 14-21 days. The upper limit being characteristic of varieties with firm, stony pulp (Hedelfinger, Germesdorf).

For strawberries, the optimal storage temperature is between 0oC and +2.5^{o}C, and the relative air humidity varies between 85-90%. The duration of storage at a temperature of 0oC for strawberries of class I is 3-6 days, even 10 days for some varieties, while for strawberries of class II it is a maximum of 3 days. (Beceanu Dumitru, Adrian Chira, Paşca Ioan, 2008).

Cold preservation of food products does not substantially impact their nutritional value adversely. On the links of the cold chain between harvesting or production or consumption, losses or distortions of some components that reflect the nutritional value of the products may occur. Due to the low pH value represented by the vast majority of fruits, the vitamin C contained in them has a relatively high stability, the greater the lower the temperature (Niculita Petru, Mona Popa, 2002).

Refrigeration is a process widely used to keep food products fresh for a short period of time. It has the following impact: it slows down the proliferation of microorganisms; inhibits metabolic activities in plant tissues after harvest; reduces the rate of chemical decomposition reactions, including the activity of enzymes that catalyze a good part of these reactions; reduces tissue moisture loss.

MATERIAL AND METHODS

For the study on the duration of storage and the analysis of the quality indices of fresh fruit preserved by refrigeration, 3 varieties of fresh fruit were analyzed, two variants of each variety, which were kept under refrigeration conditions for a period of 7 days. They were purchased from a high-street supermarket and from the traditional market, they were kept in plastic containers, an operation that was carried out in the food preservation laboratory of the Faculty of Environmental Protection.

The conclusions regarding the quality indices for the aforementioned samples were: storage time, organoleptic characteristics and physico-chemical analyses all performed on fresh fruit and refrigerated fruit after a 7-day storage period.

The organoleptic characteristics considered for the analysis were: consistency, color, taste, smell and shape, using grades from 1 to 10 as indicators.

Each organoleptic characteristic is given a grade(n) from 1 to 10, which is multiplied by a proportionality factor (Fp), which then shows the importance of the respective property for the product in question. The sum of the proportionality factors must be 10.

For fresh and refrigerated fruits, the following values were taken for proportionality factors: taste – 3, consistency – 3, smell – 2, color -1, shape -1.

The chemical analyses performed were: soluble dry matter; the pH; acidity and amount of vitamin C.

Carrying out the soluble dry matter content (oBrix) analysis of the fruits was carried out with the help of the ABBE digital refractometer.

Determining the acidity levels expressed in g malic acid/100ml was carried out by titrating the working samples with sodium hydroxide, and the pH using the pH-meter.

Determining the levels of vitamin C in fruits was carried out by titrating the samples with an iodine solution, in the presence of starch as an indicator.

The physical-chemical analysis methods allow the assessment of the quality level of the products, and the follow-up over time of the evolution of the physical-chemical parameters, allows the establishment of the storage period for fruits kept by refrigeration.

RESULTS AND DISCUSSION

In the study regarding the duration of storage and the analysis of the quality indices of the fresh fruits preserved by refrigeration, the organoleptic characteristics of the fresh fruits and after their storage for 7 days by refrigeration, and the chemical physico-chemical components were followed: soluble dry matter, pH, acidity and vitamin C content of fresh and refrigerated fruits for 7 days.

- **Determining organoleptic characteristics**

The organoleptic characteristics are a main element for assessing the quality of fresh fruits in terms of keeping them as long as possible through refrigeration.

The organoleptic control was done on the 3 varieties of fresh fruit, each with 2 working variants, at the time of purchase and after 7 days of storage. The fruits were stored under refrigeration conditions at a temperature of approx. 4^{o}C.

Based on the organoleptic analysis: color, taste, smell, and a general organoleptic score was calculated, obtaining quality ratings for the 6 variants.

The grades obtained for the 3 varieties of fresh fruit: strawberries V1, strawberries V2, cherries V3, cherries V4, blueberries V5 and blueberries V6 are recorded in table 1.

Table 1

Organoleptic notes

No. Prb.	Fruit assortment	Organoleptic note	
		Fresh fruit	Fruit kept for 7 days
1.	Strawberries V1	8.5	6
2.	Strawberries V2	9.5	7.5
3.	Cherries V3	9.5	8
4.	Cherries V4	10	9
5.	Blueberry V5	9.5	8
6.	Blueberry V6	10	9

From the analysis of the organoleptic notes, it is observed that: the fresh fruits received a score between 8.5 and 10, having a specific shape and color, the texture and consistency were firm, with a characteristic taste and smell, and during storage for 7 days, scores range from 6 to 9.

During storage, the organoleptic characteristics register lower scores after storage for 7 days: for strawberries the scores obtained were 6 at V1 and 7.5 at V2; for cherries the scores obtained are 8 for V3 and 9 for V4, and for blueberries V5 received a score of 8 and V6 received a score of 9.

Strawberries are highly perishable fruits, which can be kept for a shorter period of time under refrigeration conditions, which is why the scores obtained after keeping for 7 days were much lower, and some of them were eliminated, being unfit for consumption.

The texture and consistency of the pulp of cherries and blueberries stored for 7 days by refrigeration shows signs of softening, due to fruit ripening through the transformation of carbohydrates and protopectin into pectin, and

in the case of strawberries, their texture was soft due to overripening of the fruit during storage. The pulp's juiciness is lower, due to water losses, and the taste and aroma have lost intensity.

From an organoleptic point of view, the storage time is shorter in the case of strawberries, some of those subjected to the analysis being unfit for consumption, while cherries and blueberries mostly kept their qualities for consumption.

• Soluble dry matter content

The soluble dry matter content of the analyzed fresh fruits is presented in Table 2.

Table 2

The content of s.u.s. of fruits

No. Prb.	Fruit assortment	Fruit storage time	
		Fresh fruit °Brix	**Fruit kept for 7 days** ° Brix
1.	Strawberries V1	10.8	8.3
2.	Strawberries V2	8.5	8.9
3.	Cherries V3	14.7	1.6
4.	Cherries V4	14.9	14.1
5.	Blueberry V5	10.2	9.4
6.	Blueberry V6	13.8	11.0

From the data analyzed, it can be observed that fresh fruits show variations in dry matter content, even within the same species, as well as after storage.

In fresh strawberries, the soluble substance content has a value of 10.8°Brix at V1 and 8.5°Brix at V2. The higher s.u.s content in V1 is due to the fact that the analyzed sample was purchased from the market fully ripe, and V2, was purchased from the supermarket.

After storage for 7 days it is observed that in sample V1, the content of soluble substances decreases to 8.3°Brix, and in sample V2, the content of soluble substances increases to 8.9 °Brix.

In fresh cherries, the content of soluble substances was 14.7°Brix in V3 and 14.9°Brix in V4, and after 7 days of storage, their content increases to 15.6°Brix in the case of V3 and decreases to 14.1°Brix to V4.

In fresh blueberries, the content of soluble substances was 10.2°Brix in V5 and 13.8 °Brix in V6, and after 7 days of storage, the content of soluble substances decreases to 9.4 °Brix in the case of V5 and to 11.0°Brix in the case of V6.

The lower content of soluble substances in fruits kept for 7 days by refrigeration is due to the chemical and biochemical transformations that take place in their composition, namely the transformation of polysaccharides into monosaccharides, the increase in the content of soluble carbohydrates, but which are subsequently degraded oxidatively, and the total amount shrinks.

• Determining the acidity and pH

The acidity content of the analyzed fruits fresh and refrigerated for 7 days is presented in Table 3.

Table 3

Fruit acidity and pH

No. Prb.	Fruit assortment	Fruit storage time			
		Fresh fruit		**Fruit kept for 7 days**	
		Acidity g malic acid/100 ml	pH	Acidity g malic acid/100 ml	pH
1.	Strawberries V1	0.60	4.33	0.55	4.51
2.	Strawberries V2	0.70	4.10	0.60	4.38
3.	Cherries V3	0.65	4.45	0.60	4.37
4.	Cherries V4	0.60	4.35	0.55	4,.49
5.	Blueberry V5	0.75	4.16	0.70	4.12
6.	Blueberry V6	0.70	4.08	0.65	4.47

From the data presented, it can be seen that the acidity of fresh fruit has values between 0.60 malic acid/100 ml for V1 strawberries and V4 cherries, 0.65 g malic acid/100 ml for V3 cherries, 0.70 malic acid/100 ml in V2 strawberries and V6 blueberries, and V5 blueberries contain 0.75 malic acid/100 ml.

In the case of fruits kept by refrigeration for 7 days, the acidity shows lower values, with values between 0.55g malic acid/100 ml for V1 strawberries and V3 cherries, and 0.60 malic acid/100 ml for V2 strawberries and V3 cherries, blueberries V6 of 0.65 malic acid/100 ml, and blueberries have the highest acidity V5, of 0.70 g malic acid/100 ml.

Regarding the pH, the cellular juice undergoes important changes during the refrigeration process, determined by the concentration of the vacuolar juice as a result of the loss of water through evaporation, thus it becomes acidified, the hardly soluble salts found in small quantities in the cellular juice shift more easily changing the composition and the pH.

Fresh fruit pH ranges from 4.08 for V6 blueberries, 4.12 for V5 blueberries, 4.37 for V4 cherries and 4.45 for V3 cherries, and 4.10 for V2 strawberries and 4.33 for strawberries V1.

Fruits kept under refrigeration for 7 days have a pH between 4.12-4.49. The lowest pH is recorded for V1 strawberries, and the highest value is for V4 cherries.

It can be observed that the lower acidity values are recorded in fruits that have a higher pH, both in fresh fruits and in those preserved by refrigeration.

- **Determining vitamin C content**

The vitamin C content of the fresh and refrigerated fruits analyzed is shown in Table 4.

Table 4.

Vitamin C content

No. Prb.	Assortment of fruit	Fruit storage time		
		Fresh mg/100g	Preserved 7 days mg/100g	Differences
1.	Strawberries V1	51.30	42.58	-8.72
2.	Strawberries V2	48.24	42.26	-4.98
3.	Cherries V3	26.86	23.52	-3.34
4.	Cherries V4	29.65	26.14	-3.51
5.	Blueberry V5	**20.25**	16.44	**-3.81**
6.	Blueberry V6	19.54	15.65	-3.89

The content of vitamin C in fresh fruits varies between 19.54 mg/100g for blueberries V6 and 51.30 mg/100g for strawberries V1. Cherries show intermediate values, respectively 26.86 mg/100g at V3 and 29.65 mg/100g at V4.
After storing the fruits for 7 days, the vitamin C content drops significantly in the case of strawberries, thus in V1 from 51.30mg/100g it reaches 42.58 mg/100g, respectively a difference of -8.72, and in V2 by at 48.24 mg/100g it reaches 42.26mg/100g, the difference being -4.98; the losses are lower in cherries, thus in V3 from 26.86mg/100g it reaches 23.52mg/100g, resulting in a difference of -3.34, and in V4, the difference is -3.51; in blueberries the losses are close, respectively -3.82 at V5 and -3.89 at V6.
The higher losses of vitamin C are recorded in strawberries, which are perishable fruits, compared to cherries that are part of the stone category and blueberries that have berries, and their skin better preserves the integrity of the fruit and its chemical components during refrigeration storage.

CONCLUSIONS

Fresh fruits are one of the indispensable components of a rational human diet. The nutritional value of fruits eaten fresh is due to their chemical components easily accessible to the human body, to which are added a series of gustatory, olfactory and visual stimulants, which make them easily consumed at any time of the day or season.

Refrigeration is the process most often used both for food preservation and treatment, as well as in industrial processes. Refrigeration is based on the use of temperatures in the vicinity of the freezing point of food, with the water contained by them remaining in a liquid state. The main purpose of refrigeration is to preserve or extend the shelf life of food products.

In the study of the shelf life and quality indices of the fruit assortment: strawberries, cherries and blueberries, fresh and refrigerated for a period of 7 days, we followed the organoleptic and physic-chemical characteristics.

Regarding the organoleptic characteristics, the fresh fruits received

organoleptic scores between 8.5 and 10 and between 6 and 9 for the fruits kept for a period of 7 days by refrigeration.

The organoleptic characteristics of the fruits preserved by refrigeration for a period of 7 days kept their color well, this is due to the lack of air, which causes the oxidation of the fruits. Color changes occur through the degradation of pigments in colored products and especially through browning of an enzymatic nature, caused by the activity of polyphenol oxidase.

Regarding the physico-chemical components, their values differ depending on the type of fruit and the degree of ripening at harvest.

During the refrigeration storage, the dry matter content decreased, with the exception of strawberries V2 and cherries V3, this is because the polyglycerides are degraded hydrolytically to monoglycerides, resulting in an increase in the content of soluble carbohydrates, but which are subsequently degraded oxidatively, and the total amount which decreases goes down.

In terms of pH, refrigerated fruits have a higher pH than fresh fruits, and lower acidity values are recorded for fruits that have a higher pH, both fresh and refrigerated.

The cellular juice undergoes important changes during the refrigeration process, determined by the concentration of the vacuolar juice as a result of the loss of water through evaporation, thus it becomes acidified, the hardly soluble salts found in small quantities in the cellular juice shift more easily, which changes the composition and their pH levels.

The vitamin C content of refrigerated fruits is lower than that of fresh fruits, because vitamin C is soluble in water and decomposes in prolonged contact with air.

The highest losses were recorded in strawberries, due to their perishability factor, and the lowest in cherries, due to the more resistant skin that better preserves the integrity of the fruit and its chemical components during refrigeration storage.

Of the three varieties of fruit chosen for the study, kept under refrigeration conditions for a period of 7 days, at a temperature of approx. 4oC, it is observed that cherries and blueberries have best preserved their organoleptic characteristics and physico-chemical indicators, unlike strawberries, which have undergone significant negative changes, because they are perishable fruits, and even under refrigeration conditions they undergo qualitative changes or even distortions.

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