THE INFLUENCE OF STORAGE CONDITION ON SOME BIOACTIVE COMPOUNDS OF BERRIE FRUITS AND THOSE HUMAN HEALTH PROMOTING

INFLUENŢA CONDIŢIILOR DE PĂSTRARE ASUPRA UNOR COMPUŞI BIOACTIVI DIN FRUCTELE DE PĂDURE ŞI CONTRIBUŢIA ACESTORA ASUPRA SĂNĂTĂŢII UMANE

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Abstract. *The main criteria underlying this research consist in assessing the influence of the principal storage technologies on the content of some bioactive compounds contained by berry fruits. To balance fluctuations in product supply and market demand, fresh berry fruits often require short- or long-term storage in order to extend the supply of the berry fruits beyond the end of the harvest season. Understanding the interaction between the fruits and the environment is crucial for obtaining the most suitable conditions for extending shelf life. Portions of 250 g of strawberries, cranberries, gooseberries, blackberries or raspberries contain considerably more than the minimum daily requirement of vitamin C, while most of the other fruit can provide more than half the daily requirement. In order to freeze the berries fruits, generally no pretreatments are applied and therefore no changes in nutritive values occur during storage if proper packaging is used. During thawing, however, losses may occur. The fruits were monitorized in three fixed time points of refrigerated storage conditions at 2^0C, and also after different freezing condition (-18^0C in laboratory freezing condition and from supermarket freezing condition). The biological material studied was represented by 4 types of berries, as follows: Vaccinum myrtillius, Ribes rubrum, Rubus fructicocus and Rubus idaeus which were asseassed in terms of quality in fresh condition (T0 – moment), and after 3, respectively 7 days of refrigerate storage condition as well as after 6 month of freezing (in bulk and packaged in polyethylene bags). The soluble dry matter substances content was noticed to decrease in refrigerated storage condition between T1 and T2 time points ($p<0.001$). As concerning the differences in vitamin C content between fruits storage in bulk and packaged with polyethylene film were highlight significantly higher values ($p<0.001$) for all analyzed species that were packaged also in freezing storage conditions. When compared to the other fruits tested, the red gooseberries (43.5 mg/ 100 g), followed by raspberries (35.6 mg/ 100 g) were evidenced by their high vitamin C content. By keeping the fruits refrigerated for 7 days, although the sensory characteristics have undergone major changes, a significant decrease in vitamin C content is noted, however its final values at Tf moment are still remarkable: 27.8 mg/ 100 g for currants and 24.3 mg/ 100 g for raspberries.*

Key words: berries, vitamin C, storage condition

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Rezumat. *Principalul criteriu care a stat la baza acestor cercetări a constat în evaluarea influenței principalelor tehnici de păstrare asupra conținutului unor compuşi bioactivi din fructele de pădure. Pentru a echilibra fluctuațiile de aprovizionare cu produse şi cererea de pe piață, ținând cont de faptul că fructele de pădure sunt foarte perisabile, se impune utilizarea unor tehnici de păstrare de lungă durată cu scopul extinderii perioadei de aprovizionare a magazinelor şi după perioada de recoltare. Porțiuni de 250 g de zmeură, agrişe, afine şi mure prezintă un conținut superior în vitamina C comparativ cu cerința zilnică minimă, în timp ce majoritatea celorlalte specii pot asigura doar jumătate din necesarul zilnic. Pentru a congela fructele şi legumele, în general nu se aplică pretratamente şi, prin urmare, nu au loc modificări ale valorii nutritive pe parcursul stocării, dacă ambalarea este corespunzătoare. Totuşi, pe parcursul decongelării pot să apară pierderi. Fructele au fost monitorizate în trei moment prestabilite din timpul refrigerării şi de asemenea după aplicarea unor tehnioci de congelare. Materialul biologic studiat este reprezentat de 4 specii de fructe de pădure: Vaccinum myrtillius, Ribes rubrum, Rubus fructicocus and Rubus idaeus, care au fost evaluate în stare proaspătă (T0) şi după 3,7 zile de refrigerare, precum şi după 6 luni de stocare în condiții de congelare. Conținutul în SUS scade distinct semnificativ ($p<0.001$) în condiții de refrigerare în intervalul dintre T1 şi T2. Conținutul de vitamina C a prezentat diferențe foarte semnificative ($p<0.001$) pentru fructele stocate prin congelare, diferențele fiind influențate de modul de ambalare (vrac/ polietilenă). Coacăzele (43,5 mg/100 g), urmate de zmeură (35,6 mg/100 g) s-au evidențiat prin cel mai ridicat conținut în vitamina C. Prin păstrarea fructelor de pădure în condiții de refrigerare timp de 7 zile,pe lângă modificările majore sub aspect organoleptic s-a evidențiat şi o scădere a conținutului de vitamina C, cu toate că în momentul Tf acesta încă mai este considerabil pentru unele specii: 27,8 mg/ 100 gla coacăze şi 24,3 mg/ 100 g la zmeură.*

Cuvinte cheie: fructe de pădure, vitamina C, condiții de păstrare

INTRODUCTION

To balance fluctuations in product supply and market demand, fresh berry fruits often require short- or long-term storage in order to extend the supply of the berry fruits beyond the end of the harvest season. Understanding the interaction between the fruits and the environment is crucial for obtaining the most suitable conditions for extending shelf life (Murariu *et al.,* 2015).

Berry fruits consumption play an important role in balancing the human diet, mainly because the composition of fruit differs markedly from other food items of plant and animal origin. The contribution of fruit to the protein requirement is slight, and it is not a good source of calcium, thiamine and riboflavin. However, this type of fruit is particularly rich in antioxidants such as ascorbic acid and anthocyans (Agnieszka, 2008; Murariu *et al.*, 2014).

Previous literature in this field have shown that ascorbic acid of natural origin is superior when compared to the synthetic product, due to the presence of certain flavonoid compounds in those fruits which influence the blood circulation, increasing the permeability and the elasticity of the capillary vessels (Bazzano *et al.*,

2003). There are considerable differences of opinion when addressing the minimum daily requirement of ascorbic acid. In some countries, a daily allowance of 20 mg is considered sufficient, but in other countries quantities of up to 70 mg/day are recommended. Portions of 250 g of strawberries, cranberries, gooseberries, blackberries or raspberries contain considerably more than the minimum daily requirement of vitamin C, while most of the other fruit can provide more than half the daily requirement. In order to freeze the berries fruits, generally no pretreatments are applied and therefore no changes in nutritive values occur during storage if proper packaging are used. During thawing, however, losses may occur (Murariu *et al.,* 2014).

The diversity of bioactive compounds found in berries is reflected by the wide spectrum of their biological and medicinal properties. Bioactive compounds found in berries strengthen the walls of blood vessels, improve their elasticity and peripheral blood circulation, and increase the body's resistance to infections (Skrovankova *et al.*, 2015). The most significant health benefits are attributed to phenolic compounds and vitamin C. Due to the rich and varied composition of bioactive compounds and beneficial health benefits resulting largely from their antioxidant activity, berries are widely recognized as natural functional products.

MATERIAL AND METHOD

To characterize the influence of some preservation technologies applied and the potential health benefit of the berries, quality and physico-chemical parameters along with the vitamin C content, were evaluated for three fixed time points of refrigerated storage condition at 2^0C, and also after different freezing condition (-18^0C in laboratory freezing condition and from super market freezing conditions).

The biological material studied was represented by 4 types of berries, as follows: cranberries (*Vaccinium myrtillius*), gooseberry (*Ribes rubrum*), blackberries (*Rubus fructicosus*) and raspberry (*Rubus idaeus*) which were assessed in terms of quality in fresh condition (T0 – moment), after 3 days (T1 – moment), respectively after 7 days (T2 – moment) of refrigerate storage condition as well as after 6 month of freezing (in bulk and packaged in polyethylene bags).

The vitamin C content was determined using the extraction method with oxalic acid and titration with 2,6 – dichlorophenol – indophenols. The pH values were determined by direct potentiometric method using Hanna Instruments. The soluble dry matter was determined with Zeiss refractometer.

RESULTS AND DISCUSSIONS

The rol of vitamin C in berries constitution is represented by the participation in the growth and development precesses associating division and cell expansion (Smirnoff, 2000b), enzyme cofactor (Ariggoni and De Tullio, 2002), antioxidant, against pathogens and in the photosynthesis process (Kazuya, 2017, Velescu *et al.,* 2014). Some nutrients from fruit berries such us the antioxidant and vitamins appear to play a double role in metabolism. These are required for normal growth and development and they appear to provide antioxidant protection

against chronic diseases, including chronic heart disease, arthritis and cancer (Krinsky *et al.,* 2005).

The daily requirement of vitamin C for a healthy adult body is 0 – 90 mg/day, for women during pregnancy 100 mg/day, for breastfeeding women 130 mg/day and for children 1.5 – 2 mg/kg body/ day depending on age.

The soluble dry matter substances content was noticed to decrease in refrigerated storage condition between T_1 and T_2 time points ($p<0.001$) for all analyzed parameters. Instead storage on freezing condition highlights a decrease only for cranberries and raspberries ($p<0.001$), the gooseberries barely decrease and blueberries content highlight a slight increase (0.1–0.2 U.N. $p<0.05$) (tab. 1).

The significant decrease of the soluble dry matters content at the T_1, T_2 analysis moments and after defreezing of the samples revealed low values for the all fruit berries sold in bulk. The bulk raspberry values (6.8% in T_1; 5% in T_2 and 4.9 after defreezing are inferior to those specified in the literature (7 - 12%) (after Beceanu, 2010). Similar results were also obtained for bulk blackberries, but the values decrease below those presented in the literature occurred in T_2 moment. It is also noted that soluble dry matter values of bulk blueberries were inferior to those in the literature at all times of analysis (tab. 1).

Of note is that all analyzed samples in the three moments (T_0, T_1 and T_2) which have been purchased and storage in pre - packeged form presented superior values to those marketed in bulk form, values that fall within the limits specified in the literature.

Table 1

Mean values of soluble dry matters content of berries and statistical differences functional by storage period

Specification	T0	T1 (T0 vs T1)	T2 (T0 vs T2)	Defreezing (T0 vs defreeze)	Reference values
Cranberries	10.2	9.8*	9.4***	9***	8-12
Pre-packaged raspberries	9.8	9.4*	9.3***	9.1***	7-12
Bulk raspberry	8	6.8***	5***	4.9***	7-12
Pre-packaged blueberries	8.2	8***	7.8***	7.9***	7-12
Bulk blueberries	6.2	5.5***	4.9***	6.2i.s.	7-12
Pre-packaged blackberries	10.4	10.02***	9.6***	10.5*	8-12
Bulk blackberries	9	8***	7.5***	9.2i.s.	8-12

i.s. – insignifical statistical differences ($p<0.05$); * - significant statistical differences ($p<0.01$); ** - distinct significant differences ($p<0.001$) and *** - very significant differences ($p<0.001$); To – the first moment of analysis in fresh condition; T1 – result obtain for all analysis after 3 days of refrigerate storage condition; T2 - result obtain for all analysis after 7 days of refrigerate storage condition.

As concerning the differences in vitamin C content between fruits storage in bulk and packaged with polyethylene film were revealed significantly higher values ($p<0.001$) for all analyzed species that were packaged also in refrigerated and freezing storage conditions. When compared to the other fruits tested, the red gooseberries (43.5 mg/100 g), followed by raspberries (35.6 mg/100g) were evidenced by their high vitamin C content.

Cranberries, bulk blue berries and pre-packaged black berries showed lower vitamin C content than the limits specified in the literature (tab. 2), and pre-packaged raspberries, bulk raspberry, pre-packaged blue berries and bulk blackberries were superior to those in literature.

It is revealed very significant differences ($p<0.001$) for vitamin C content of de-freezing fruit berries by comparation with the values obtain in T_0 moment at the cranberries, bulk raspberries and blueberries.

Although independently of the preservation technique applied (refrigeration or freezing) the vitamin C content of the tested fruits was noticed to significantly decrease, it could be evidenced that it's concentrations were measured at still high values: 27.8 mg/100 g for gooseberries and 24.3 mg/100 g for raspberries even after 7 days of storage at 2^0C. Regarding the type of packaging used, it is noted that all products purchased from retail packaged in closed polyethylene recorded higher values of the bioactive compounds analyzed in all time points considered (T_0, T_1, T_2 and after freezing) (tab. 2).

Table 2

Mean values of vitamin C content [mg/100g] of berries and statistical differences functional by storage period

Specification	T0	T1 (T0 vs T1)	T2 (T0 VS T2)	Defreezing (T0 vs defreeze)	Reference values
Cranberries	14.1±0.01	13.3±0.01**	12.1±0.01***	3.6±0.1***	15-20
Pre-packaged raspberries	35.6±0.02	29.4±0.04***	24.43±0.3***	30.1±0.01***	15-25
Bulk raspberry	30.3±0.01	21.4±0.01***	17.8±0.04***	3.7±0.01***	15-25
Pre-packaged blueberries	43.5±0.04	38.9±0.04***	27.8±0.04***	34.26±0.4***	36
Bulk blueberries	30.6±0.04	23.4±0.04***	14.6±0.04***	9.5±0.01***	36
Pre-packaged blackberries	15.6±0.2	9.5±0.02**	13.4±0.07**	10.1±0.04***	17
Bulk blackberries	21.5±0.1	20.8±0.07n.s	13.5±0.04***	12.6±0.04***	17

i.s. – insignifical statistical differences ($p<0.05$); * - significant statistical differences ($p<0.01$); ** - distinct significant differences ($p<0.001$) and *** - very significant differences ($p<0.001$); To – the first moment of analysis in fresh condition; T1 – result obtain for all analysis after 3 days of refrigerate storage condition; T2 - result obtain for all analysis after 7 days of refrigerate storage condition.

The pH values obtained at T_0 moment of the analyzed for fruit berries ranged in the interval inferior delimited by 2.65 value pre-packaged blueberries and superior of 3.58 value for Pre-packaged blackberries (tab. 3).

There is an increase in values in the 7 days of refrigeration evidenced by very significant differences for all analyzed samples.

Frozen fruits revealed very significant increased for all pH values compared to the values obtained at time T0 for all analyzed samples.

Table 3

Mean values of pH values of berries and statistical differences functional by storage period

Specification	T0	T1 (T0 vs T1)	T2 (T0 VS T2)	Defreezing (T0 vs defreeze.)
Cranberries	3.17±0.02	3.16±0.04^{IS}	4.19±0.02***	3.45±0.04***
Pre-packaged raspberries	2.87±0.09	3.2±0.09***	3.64±0.01***	3.13±0.01***
Bulk raspberry	3.11±0.01	3.24±0.01***	3.48±0.01***	3.36±0.04***
Pre-packaged blueberries	2.65±0.01	2.69±0.01*	3.05±0.01***	2.98±0.01***
Bulk blueberries	2.7±0.001	2.8±0.04*	3.02±0.05***	2.94±0.05***
Pre-packaged blackberries	3.58±0.03	3.65±0.01*	3.74±0.01***	3.79±0.02***
Bulk blackberries	3.42±0.05	3.44±0.01*	3.72±0.06***	3.61±0.01***

i.s. – insignifical statistical differences ($p<0.05$); * - significant statistical differences ($p<0.01$); ** - distinct significant differences ($p<0.001$) and *** - very significant differences ($p<0.001$); To – the first moment of analysis in fresh condition; T1 – result obtain for all analysis after 3 days of refrigerate storage condition; T2 - result obtain for all analysis after 7 days of refrigerate storage condition.

CONCLUSIONS

The presented component analyzed of the various berry fruits species point the vast differences related to the storage condition applied. The most significant health benefits are ascribed to the antioxidants like vitamin C. Owing to the rich composition in this bioactive compound and their healh promoting properties , berry fruits are widely recognized as functional products. The results obtained for the chemical components studied from the berries constitution revealed superior values for most samples of pre-packaged fruits. Taking into account that these products have a very high level of perishability, they are recommended to be marketed in small quantities packing (250 - 500 g) made of polyethylene for storage in both refrigeration and freezing conditions to ensure optimum nutritional and antioxidant properties for the consumares.

Lien A. *et al.* (2008) related that free radicals play a toxic role for the human body. The free radicals are produced from normal cell metabolism "in situ" or from external sources pollution, cigarette smoke, radiation or medication. Tose accumulation in high quantities generates the oxidative stress appereance,

process with major part in the development of chronic diseases, aging, cardiovascular and neurodegenerative diseases.

Due to the inability of the human body to conteract oxidative stress by producing antioxidant it is recomanded the externally supplied throw food products and/or supplements that are rich in antioxidants (Murariu *et al.,* 2016) such us most of berrie fruits.

It is also recomanded that the industrialization to be made throw advanced systems of processing and/or storage, so that it can be guaranteed their availability throughout the year, keeping them in a high value the bioactive compounds such us antioxidants.

By conducting this research is considereded opportrune to open another theme, applying other techniques of preserve (in controlled atmosphere or storage refrigerated or freezing in vacuum conditions) in order to ensure a minimal degree of bioactive compounds with hight benefits in human health.

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