

LUCRĂRI ȘTIINȚIFICE SERIA HORTICULTURĂ, 61 (2) / 2018, USAMV IAȘI

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

INFLUENȚA CONDIȚIILOR DE PĂSTRARE ASUPRA UNOR COMPUȘI BIOACTIVI DIN FRUCTELE DE PĂDURE ȘI CONTRIBUȚIA ACESTORA ASUPRA SĂNĂTĂȚII UMANE

MURARIU Otilia Cristina^{1*}, IRIMIA L.M.¹, ROBU T.¹,
MURARIU F.¹, ARSENOAIA V.¹

*Corresponding author e-mail: otiliamurariu@uaiasi.ro

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°C, and also after different freezing condition (-18°C in laboratory freezing condition and from supermarket freezing condition). The biological material studied was represented by 4 types of berries, as follows: *Vaccinium myrtillus*, *Ribes rubrum*, *Rubus fruticosus* and *Rubus idaeus* which were assessed 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 T_f 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

¹ University of Agricultural Sciences and Veterinary Medicine Iasi, Romania

Rezumat. *Principalul criteriu care a stat la baza acestor cercetări a constat în evaluarea influenței principalelor tehnici de păstrare asupra conținutului unor compuși bioactivi din fructele de pădure. Pentru a echilibra fluctuațiile de aprovizionare cu produse și 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 și după perioada de recoltare. Porțiuni de 250 g de zmeură, agrișe, afine și 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 și legumele, în general nu se aplică pretratamente și, prin urmare, nu au loc modificări ale valorii nutritive pe parcursul stocării, dacă ambalarea este corespunzătoare. Totuși, pe parcursul decongelării pot să apară pierderi. Fructele au fost monitorizate în trei momente prestabilite din timpul refrigerării și de asemenea după aplicarea unor tehnici de congelare. Materialul biologic studiat este reprezentat de 4 specii de fructe de pădure: *Vaccinium myrtillus*, *Ribes rubrum*, *Rubus fruticosus* and *Rubus idaeus*, care au fost evaluate în stare proaspătă (T0) și după 3,7 zile de refrigerare, precum și 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 și 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 și 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 g la coacăze și 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 anthocyanins (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°C, and also after different freezing condition (-18°C 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 myrtillus*), gooseberry (*Ribes rubrum*), blackberries (*Rubus fruticosus*) 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 T₁ and T₂ 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 T₁, T₂ 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 T₁; 5% in T₂ 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 T₂ 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 (T₀, T₁ and T₂) which have been purchased and storage in pre - packaged 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 ^{***}	6.2 ^{i.s.}	7-12
Pre-packaged blackberries	10.4	10.02 ^{***}	9.6 ^{***}	10.5	8-12
Bulk blackberries	9	8 ^{***}	7.5 ^{***}	9.2 ^{i.s.}	8-12

i.s. – insignificant statistical differences (p<0.05); * - significant statistical differences (p<0.01); ** - distinct significant differences (p<0.001) and *** - very significant differences (p<0.001); T₀ – 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 comparison 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°C . 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±0.07 ^{n.s}	13.5±0.04***	12.6±0.04***	17

i.s. – insignificant statistical differences ($p < 0.05$); * - significant statistical differences ($p < 0.01$); ** - distinct significant differences ($p < 0.001$) and *** - very significant differences ($p < 0.001$); T_0 – the first moment of analysis in fresh condition; T_1 – result obtain for all analysis after 3 days of refrigerate storage condition; T_2 - result obtain for all analysis after 7 days of refrigerate storage condition.

The pH values obtained at T₀ 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 ^s	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. – insignificant statistical differences (p<0.05); * - significant statistical differences (p<0.01); ** - distinct significant differences (p<0.001) and *** - very significant differences (p<0.001); T₀ – 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 health 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 appearance,

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

Due to the inability of the human body to counteract oxidative stress by producing antioxidant it is recommended the externally supplied through food products and/or supplements that are rich in antioxidants (Murariu *et al.*, 2016) such as most of berry fruits.

It is also recommended that the industrialization to be made through 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 as antioxidants.

By conducting this research is considered opportune 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 high benefits in human health.

REFERENCES

1. Agnieszka Szajdek, E. J. Borowska., 2008. *Bioactive compounds and health – promoting properties of berry fruits: a review*, Plant Foods Human Nutrition, 63:147-156.
2. Arrigoni O., De Tullio M.C., 2000 – *The role ascorbic acid in cell metabolism: between gene-directed functions and unpredictable chemical reactions*, Journal Plant Physiology, 157:481 – 488.
3. Bazzano L.A., Serdula M.K., Liu S., 2003 – *Dietary intake of fruits and vegetables and risk of cardiovascular disease*, Current Atherosclerosis Rep, 5:492 – 499.
4. Beceanu D., 2010 – *The technology of horticultural products preelucration*, Ed. Pim, Iași.
5. Irimia L.M., Patriche C.V., Murariu. O. C., 2017 – *The impact of climate change on viticultural potential and wine grape varieties of a temperate wine growing region*, Applied ecology and environmental research, 16(3): 2663-2680.
6. Kazuya Yoshimura, Takahiro Ishikawa, 2017 – *Chemistry and metabolism of ascorbic acid in plants*: is chapter in **Mohammad Anwar Hossain, Sergi Munne – Bosch, David J., Burritt, Pedro Diaz Vivancos, Masavuki Fujita, Argelia Lorence** – *Ascorbic acid in Plant Growth, Development and Stress Tolerance*, Ed. Springer, 1 – 23.
7. Krinsky N.I., Johnson E.J., 2005 – *Carotenoid actions and their relation to health and disease*, Mol. Aspects Med., 26: 459 – 516.
8. Lien A. Pham – Huy, Hua He, Choung Pham Huy, 2008 – *Free radicals, antioxidants in disease and health*, Int. Jour. Biomed. Sci., 4(2): 89 – 96.
9. Murariu Otilia Cristina, Murariu F., Velescu I., 2014 - *The effect of processing on the vitamin C in peach compote, preserve and jam destined for the retail*, Journal of Biotechnology, Elsevier, Vol. 185S, p. S80, ISSN 0168-1656.
10. Murariu O., Irimia L., Diaconu C.M., Murariu F., 2016 – *The right of a healthy life provided by a healthy eating support*, Revista Universul Juridic, pag. 169.
11. Murariu O., Irimia L., Murariu F., 2014 – *Research on the apples quality marketed in the Moldova area from the physic – chemical and sensorial point of view*, Lucrări științifice, Seria Horticultură, vol 57 (1), pag. 195 – 198.
12. Murariu O.C., 2015 – *Research regarding the influence of storage condition on broccoli vitamin C content*, Agronomy Series of Scientific Research, vol 58 (2), 217 – 220.

13. **Skrovankova Sona, Sumczynski Daniela, Mlcek Jiri, Juricova Tunde and Sochor Jiri., 2015** – *Bioactive compounds and antioxidant activity in different types of berries*, International Journal of Molecular Sciences, 16(10): 24673 - 24706.
14. **Smirnoff N., 2000b** – Ascorbic acid: metabolism and functions of a multifaceted molecule, Current Opinion Plant Biology, 3:229 – 235.
15. **Velescu I., Țenu I, Murariu Otilia Cristina, 2014** - *Influence of air drying temperature on kinetics, physical properties and ascorbic acid content of fruits*, Journal of Biotechnology, Vol. 185S, P. S84, ISSN 0168-1656.