

Researches on keeping the quality of the culture blueberries after harvest

Veringă Daniela^{1*}

¹Research and Development Institute for Processing and Marketing of the Horticultural Products Bucharest;

Corresponding autor. Email: tantialexe@yahoo.com

Abstract Blueberries are recognized for their contribution to a healthy diet with different beneficial bioactive compounds such as flavonoids, anthocyanins, and others, which helps to avoid important diseases including different cancers. The purpose of our work was to investigate the influence of temperature and the gaseous composition of the air on keeping the quality of the culture blueberries during storage. There were introduced in testing two varieties of blueberries (Delicia and Bluecrop), the harvest of 2017, from the Research and Development Institute for Fruit Mărăcineni. The blueberries were kept at Research and Development Institute for Processing and Marketing of the Horticultural Products Bucharest, in different technological conditions: ambient temperature (20-22°C), with and without air ionization; temperature of 10-12° C with and without modified atmosphere and temperature of 3-5°C. The initial level and the evolution during storage of some biochemical components (soluble dry matter, total sugar, titratable acidity and vitamin C) were determined. It has been shown that in general the blueberry fruit were relatively long shelf life with minimal changes in respiration associated with ripening. These trials evidence that the blueberries generally responded very well to temperatures of 5-10° C, when they resisted 25 days of storage with low losses, which did not affect the appearance and their commercial quality. Particular results were obtained in spaces with a temperature of 10-12°C and a modified atmosphere in which the blueberries of both varieties showed, after 20 days, average total losses of only 1.31%, without changes in appearance and taste of the fruits.

Key words

storage conditions, biochemical components, quantitative and the qualitative losses

In the last years there has been a marked worldwide increase in area planted to blueberries [5], because they are recognized for their contribution to a healthy diet with different beneficial bioactive compounds such as flavonoids, anthocyanins, and others [10, 12], which helps to avoid important diseases including different cancers [20, 21, 22].

The main attributes of blueberries for human health are:

- have the greatest antioxidant capacity of all fruits
- neutralize free radicals that can promote disease and aging in the body
- helps maintain urinary tract health
- maintains the integrity of vision
- maintain brain health
- helps to improve constipation and digestion
- fight against cancer

The quality of the fruit and its maintenance after harvesting is influenced by the date and time of harvesting and by the stage of fruit maturation, but also the interval and temperature storage of the fruit [4, 17].

Storage capacity is dependent on the quality of raw materials for preserving and on conditions during storage [1, 9, 11, 13].

Forney *et al.* (2003) reported that proper storage for blueberries is around 0°C, with a relative humidity from 90 to 95% that provides a storage life of 10–18 days.

The use of controlled atmosphere in fresh produce transportation is widely applied by producers, to assure the quality of the product and avoid spoilage. Ceponis and Cappellini (1985) concluded that respiration rate as well as deterioration decreases for some fruits when under CO₂ levels of about 10% to 20%.

Studies using controlled-atmosphere (CA) storage techniques have indicated that shelf-life extension can be obtained for blue-berry (*Vaccinium* spp.) fruit using combinations of elevated CO₂ and reduced O₂ in the storage environment [6, 7, 14, 16].

The use of modified atmosphere in the packaging and storage of fresh blueberries is widespread in all the countries producing large quantities of these fruits [14, 15, 16].

In our country little research has been done on the preserving the quality of the blueberries after

harvesting. Instead, the influence of storage conditions on the quality of tomatoes [18]), apricots [19]), peaches and nectarines [2, 3] has been studied.

In present study blueberry fruit were chosen for investigation due to their relatively long shelf life, their minimal changes in respiration associated with ripening, and their relative insensitivity to CO₂ levels over the range of those expected to be encountered in the storage system used.

Material and Methods

The experience includes 10 experimental variants. The basis for organizing variants of the storage experience were the variety and conditions of storage. The blueberries introduced in the testing of the crop in 2017, come from Research and Development Institute for Fruit Mărăcineni.

The scheme of the organization of experience with the cultured blueberries storage is shown in Table 1.

Table 1

Experimental scheme to preserve blueberries

Variant	Variety	Storage conditions *)
V1	BLUECROP	20-22°C
V2	-idem-	20-22°C+IR
V3	-idem-	10-12 °C
V4	-idem-	10-12 °C+MA
V5	-idem-	3-5 °C
V6	DELICIA	20-22°C
V7	-idem-	20-22°C+IR
V8	-idem-	10-12 °C
V9	-idem-	10-12 °C+MA
V10	-idem-	3-5 °C

*) Legend: MA= modified atmosphere ; IR= ionizing radiation

Aspects of how to organize the experience are presented in Figure 1.



Fig.1. The mod of the of experiences' organization

In experimentation were taken two varieties of blueberries: Bluecrop and Delicia. The appearance of the two varieties are shown in Figures 2 and 3.



Fig.2. Appearance of blueberries variety Bluecrop



Fig.3. Appearance of blueberries variety Delicia

Before placing the storage, biometric measurements were made, having regard to: average weight of the fruit, height, diameter and index form.

There have been determined the initial level and the evolution during storage of some biochemical components: soluble dry matter, total sugar, titratable acidity and vitamin C.

Results

The results regarding the biometric data are shown in Table 2, which shows that the blueberries of Delicia variety were larger and heavier on average 0.29 g/fruit than the variety Bluecrop.

Table 2

Biometric data of blueberries					
No.	Variety	Height (mm)	Diameter (mm)	Shape index	Average weight (g/fruit.)
1	BLUECROP	10.6	13.2	0.80	1.46
2	DELICIA	11.9	14.8	0.80	1.75

The data on the evolution of the blueberries losses during storage in different conditions are presented in Table 3.

The storage duration of the blueberries was, for both varieties, 5 days when stored at a temperature of 20-22° C, 20 days for storage at 10- 12° C and 25 days when the temperature was 3-5° C.

At ambient temperature the blueberries were recorded after 5 days of storage the mass losses from 8.67% to 10.84%, losses by impairment of 0.91% to 2.96% and total losses of 11.63% to 11.75%, depending on variety. Lower losses by impairment were recorded for V1 variants of the Bluecrop variety, while in the V6 variant with blueberries of the Delicia variety the level of weight losses was lower. Finally,

both varieties had very close values of total losses, with an average of 11.69%.

Under additional ambient air ionization conditions, blueberries recorded, after the same interval of 5 days of storage, mass losses of 11.89-13.51%, losses by impairment of 1.02-2.52% and total losses of 12.91-16.03% depending on the variety. Under these conditions, V7 variant of variety Delicia showed less mass, spoilage and total losses than V2 variant of variety Bluecrop. The total average losses were 14.47%, with approx. three percentage points higher than at blueberries kept in environment without air ionization, particularly because of the higher mass losses produced by the own ventilation of the equipment ionization.

Table 3

Losses during storage of blueberries varieties

Variant	Variety	Storage conditions (°C)	Storage durations (days)	Mass losses (%)	Losses by impairment (%)	Total losses (%)
V1	BLUECROP	20-22°	5	10,84	0,91	11,75
V2	- idem-	20-22°+ IR	5	13,51	2,52	16,03
V3	- idem-	10-12 °C	20	3,89	1,75	5,64
V4	- idem-	10-12 °C+ MA	20	0,15	1,35	1,50
V5	-idem-	3-5 °C	25	7,20	0,13	7,33
V6	DELICIA	20-22°	5	8,67	2,96	11,63
V7	-idem-	20-22°+ IR	5	11,89	1,02	12,91
V8	-idem-	10-12 °C	20	3,68	1,39	5,07
V9	-idem-	10-12 °C+ MA	20	0,07	1,05	1,12
V10	-idem-	3-5 °C	25	6,97	0,56	7,53
Overall average		20-22°	5	9,76	1,93	11,69
		20-22°+ IR	5	12,70	1,77	14,47
		10-12 °C	20	3,79	1,57	5,36
		10-12 °C+ MA	20	0,11	1,20	1,31
		3-5 °C	25	7,09	0,34	7,43

The appearance of the blueberries Delicia variety kept for 5 days in hot space with ionized air is shown in Figure 4.



Fig. 4. Storage the blueberries (V6 Delicia variety) at natural temperature (20-22°C) with ionization

At a temperature of 10-12°C blueberries recorded, after 20 days of storing, mass losses of 3.68% to 3.89%, 1.39-1.75% spoilage losses and 5.07-5.64% total losses in function of variety.

Under these refrigeration thermal conditions, the variants V3 and V8 of the two varieties showed mass losses, losses by impairment and total losses close

and low level, the total losses being at the average value of 5.36% (below 10% considered acceptable from the point of view of maintaining the commercial and consumer characteristics).

The appearance of the blueberries of the two varieties kept for 20 days under refrigeration conditions is shown in Figure 5.



Fig. 5. Storage the blueberries by refrigeration (10-12 °C)
a- V3 – variety Bluecrop b- V8 – variety Delicia

The accumulation of an increased concentration of CO₂ in modified atmosphere conditions carried out in the sealed containers located in an ambient temperature of 10-12 °C, resulted in recording, after 20 days of storage, of 0.07% to 0.15% mass losses, of 1.05-1.35% spoilage losses and total losses of 1.12-1.50%, depending on the variety.

The CO₂ concentration has been maintained around 10% for the all duration of the blueberries storage. In these conditions, both variants with modified atmosphere (V4 and V9) recorded minimal losses due to tight volume of the air and the reduced proportion of diseases that have developed.

Although the differences between the two variants are reduced, the V9 variant with fruit of the Delicia variety showed the smallest mass and total losses of the whole blueberries experience. At the same time, it was ascertained that both the appearance of the fruits and their taste were not affected in any way by the duration and the conditions of preservation.

The appearance of the Delicia variety blueberries kept for 20 days under refrigeration conditions and modified atmosphere is shown in Figure 6.



Fig. 6. Storage the blueberries by refrigeration (10-12 °C) and AM- V9-Delicia variety

The blueberries kept for 25 day at temperature of 3-5°C recorded 6.97-7.20% mass losses, 0.13-0.56% spoilage losses and 7.33-7.53% total losses, depending on the variety. Under these cold conditions, the variants V5 and V10 of the two varieties exhibited mass losses, spoilage losses and total losses very close, the losses due to spoiling being the lowest in the whole

experience and the total losses being at the average value of 7.43% (below 10%, considered acceptable in terms of maintaining commercial and consumer attributes). The appearance of the bells of the two varieties kept for 25 days under refrigeration is shown in Figure 7.

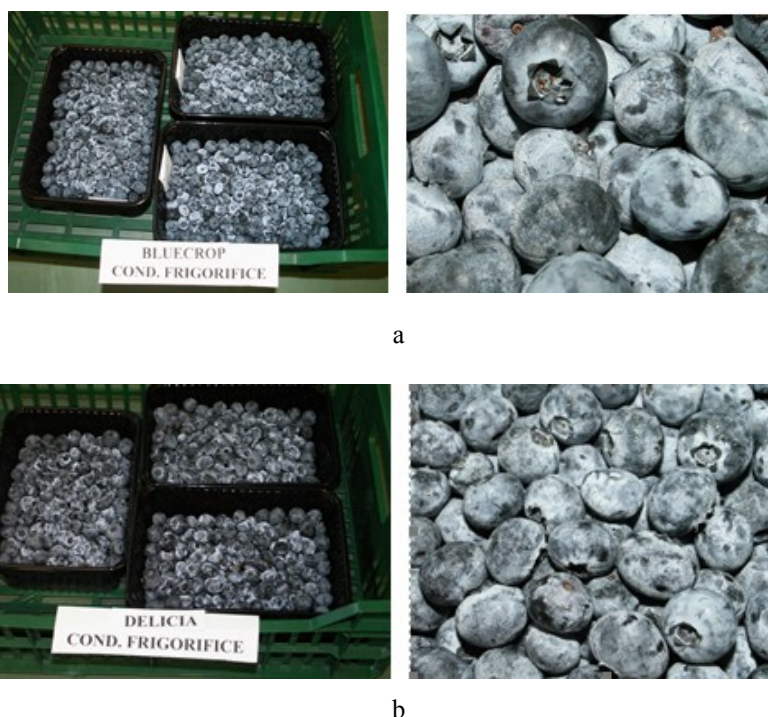


Fig. 7. . Storage the blueberries by refrigeration (3-5 °C)
a-V5 –variety Bluecrop b-V10-variety Delicia

With regard to the depreciation caused by the diseases during the storage, a great resistance to diseases of the blueberries was registered, which generally maintained their qualitative qualities.

Thus, even at temperatures of 20-22°C, the blueberries presented, after 5 days of keeping, reduced spoilage losses (with an average of 1.93%). Under the above-mentioned conditions, the depreciations were, most often, at the fruit level, without the development of zones or outbreaks of mass depreciation.

Of the pathological agents encountered more often were the gray rot (*Botrytis cinerea*) and the mummification of the fruits (*Monilinia vaccinii-corymbosi*), which mainly affected blueberries during storage.

Aspects of the blueberries with depreciations by impairment are shown in Figure 8.



Fig. 8. Depreciation caused by pathogens during the storage of

The results regarding the initial level and evolution of some chemical components during storage of the blueberries are shown in Table 4.

Table 4

Initial level and evolution of chemical components during storage of blueberries

Variant	Variety	Storage conditions (°C)	Dry substance (%)	Acidity (%)	Total sugar (%)	C Vitamin (mg/100g)
-	BLUECROP	initial	10,4	0,96	4,08	14,17
V1	- idem-	20-22°	14,1	0,58	7,90	21,95
V2	- idem-	20-22°+ IR	12,6	0,64	7,25	22,07
V3	- idem-	10-12 °C	14,1	0,77	4,95	19,61
V4	-idem-	10-12 °C+ MA	12,9	0,84	4,61	21,07
V5	- idem-	3-5 °C	12,7	0,84	4,51	14,67
-	DELICIA	initial	12,0	1,29	5,13	16,98
V6	-idem-	20-22°	13,3	1,16	7,90	18,94
V7	-idem-	20-22°+ IR	13,1	0,90	7,33	20,06
V8	-idem-	10-12 °C	14,2	1,16	5,32	18,45
V9	- idem-	10-12 °C+ MA	13,0	1,22	5,21	19,22
V10	- idem-	3-5 °C	11,7	1,19	5,32	15,62
Overall average		initial	11,2	1,13	4,60	15,58
		20-22°	13,7	0,87	7,90	20,45
		20-22°+ IR	12,9	0,77	7,29	21,07
		10-12 °C	14,2	0,97	5,13	19,03
		10-12 °C+ MA	13,0	1,03	4,91	20,15
		3-5 °C	12,2	1,02	4,92	15,15

From the data presented in the table, shows that initially, in placing in storage, the blueberries had a content of 10.4 to 12.0% soluble solids, titratable acidity from 0.96 to 1.29%, from 4.08 to 5.13% total sugar and 14.17 to-16.98 mg/100g vitamin C, depending on the variety. The variety Delicia was located at all components before the Bluecrop variety, having more dry substance, acidity, total sugars and vitamin C than it did.

Dry substance content of the blueberries presented during storage under various conditions constant increases, but in different proportions depending on the variant. The highest increases were recorded in both varieties for refrigeration storage (V3 and V8), followed by storage in environmental conditions (V1 and V6), the only decrease being determined in the variants of cold storage of the variety Delicia (V10).

From the average data obtained, it appears that, the cold, the air ionization and the modified atmosphere in general decreased to a small extent the increase of the SU content, compared to the reference temperature of the environment and refrigeration, which led to higher increases of SU in the cranberries so preserved.

The acidity of the blueberries has decreased in all storage variants compared to the initial values, but in varying proportions, depending on the variety, duration and storage conditions. The lowest decrease in acidity occurred in the cold storage + AM variants and in the cold storage of the blueberries of both varieties

(V4 and V5 in the Bluecrop variety and V9 and V10 in the Delicia variety).

However, a sharp decrease in acidity was recorded in the variants of both storage varieties at ambient temperature with air ionization (V2 and V7) and in V1 variant of Bluecrop variety, stored at ambient temperature. Thus, fruit acidity decreases by keeping in warm more than at lower temperatures.

The initial total sugar content was higher for Delicia variety than for the Bluecrop variety. The value of the total sugar content increased during the maintenance of blueberries in almost all cases, the volume of these increases being different depending on the storage variant.

The highest increases in the total sugar content occurred in the variants of keeping in the ambient temperature of both varieties (V1 and V2 of Bluecrop variety and V6 and V7 of Delicia variety), and the lowest increases occurred in refrigeration and chilling + AM variants (V4 and V5 for Bluecrop and V9 and V10 for Delicia). Thus, by keeping at ambient temperature, blueberries sweetened more and more rapidly than those kept at a lower temperature, whose total sugar content grew the least

The initial content of vitamin C shows an advantage of 2.81 percentage points in favor of the Delicia variety. The evolution of the vitamin C content was different, showing both increases and decreases during the maintenance of blueberries, depending on the storage variant. The two varieties had similar developments under similar storage conditions. The highest increases in vitamin C were determined in the

V2 and V7 variants of storage at ambient temperature + ionization of the two varieties.

The smallest increase in vitamin C content was produced in variant V5 of Bluecrop refrigerated storage variety, the V10 variant of the Delicia variety, presenting in these conditions even a reduction of the vitamin C content compared to the initial value. From the average data obtained, it can be stated that under all conditions of storage tested, the vitamin C content of blueberries increased on average by approx. 30%, except for refrigeration, which led to a 3% decrease in vitamin C fruit content.

Conclusions

From the observations made during the keeping of the blueberries under different conditions, it was obvious that the blueberries generally responded very well to temperatures of 5-10° C, when they resisted 20-25 days of storage with low losses, which did not affect the appearance and their commercial quality.

Particular results were obtained in spaces with a temperature of 10-12°C and a modified atmosphere in which the blueberries of both varieties showed, after 20 days, average total losses of only 1.31%, without changes in appearance and taste of the fruits.

Initially, when placed in storage, the blueberries had a content of 10.4 to 12.0% soluble solids, from 0.96 to 1.29%, titratable acidity, from 4.08 to 5.13% total sugar and 14.17 to 16.98 mg/100g vitamin C, depending on the variety. The variety Delicia was located at all components before the Bluecrop variety, having more dry substance, acidity, total sugars and vitamin C than the variety Bluecrop. During the storage, the values of these biochemical components showed both increases and decreases, depending on variety and variant of storage.

References

1. Allan-Wojta P.M., Forney C. F., Carbyn S. E., Nicholas K. U., 2001. Microstructural indicators of quality-related characteristics of blueberries: an integrated approach. *Lebensmittel-Wissenschaft & Technologie*, vol. 20, pp. 23–32
2. Alexe Constanta, Vintila M., Popescu Simona, Dumitru Liana-Melania, Lamureanu Gh., Chira Lenuta, 2013. Behaviour of Delta cultivar nectarines during the valorization process according to the fertilization of the culture. *Scientific Papers, Series B. Horticulture*, vol. LVII, USAMV Bucuresti
3. Alexe Constanta, Vintila M., Popescu Simona, Dumitru Liana –Melania, Lamureanu Gh., Chira Lenuta, 2014. Quality assessment of Southland cultivar peaches according to certain technological factors of culture and storage. *Scientific Papers, Series B. Horticulture*, vol. LVIII, USAMV Bucuresti
4. Basiouny F. M., Chen Y., 1988. Effects of harvest date, maturity and storage intervals on postharvest quality of rabbiteye blueberry (*Vaccinium ashei* Reade). *Proceedings of the Florida State Horticultural Society*, vol. 101, pp. 281–284.
5. Brazelton C., 2009. World Blueberry Acreage and Production Report. United States Highbush Blueberry Council – Industry Relations Committee. Folsom, California.
6. Ceponis M. J., Cappellini R. A., 1985. Reducing decay in fresh blueberries with controlled atmospheres,” *HortScience*, vol. 20, pp. 228–229
7. Chiabrando V., Giacalone G., Rolle L., 2009. Mechanical behaviour and quality traits of highbush blueberry during postharvest storage. *Journal of the Science of Food and Agriculture*, vol. 89, no. 6, pp. 989–992
8. Forney C.F., Jordan, M.A., Nicholas, K.U., 2003. Effects of CO₂ on physical, chemical, and quality changes in ‘Burlington’ blueberries. *Acta Hort.* 600:587-593
9. Giongo L., Poncetta P., Lorett, P., Costa F., 2013. Texture profiling of blueberries (*Vaccinium* spp.) during fruit development, ripening and storage. *Postharvest Biology and Technology*, vol. 76, pp. 34–39
10. Lila M.A., 2004. Anthocyanins and human health: an in vitro investigative approach. *Journal of Biomedicine and Biotechnology*, vol. 2004, no. 5, pp. 306–313
11. Nunes M.C.N., Emond J.P., Brecht J. K. , 2004. Quality curves for highbush blueberries as a function of the storage temperature. *Small Fruits Review*, vol. 3, no. 3-4, pp. 423–440
12. Retamales, J.B., Hancock, J.F. 2012. Blueberries. CABI (Cambridge, USA). First Ed. 323p.
13. Sargent S.A., Brech J.K., Forney C. F., 2006. Blueberry harvest and postharvest operations: quality maintenance and food safety. *Blueberries for Growers, Gardeners, Promoters* Eds., pp. 139–151, Painter Printing, DeLeon Springs, Fla, USA
14. Schotsmans W., Molan A., MacKay B., 2007. Controlled atmosphere storage of rabbiteye blueberries enhances postharvest quality aspects. *Postharvest Biology and Technology*, vol. 44, no. 3, pp. 277–285
15. Silva J. L., Marroquin E., Matta F. B., Garner J. O. Jr., Stojanovic J., 2005. Physicochemical, carbohydrate and sensory characteristics of highbush and rabbiteye blueberry cultivars. *Journal of the Science of Food and Agriculture*, vol. 85, no. 11, pp. 1815–1821
16. Skog L. J., Chu C. L., 2000. Ozone technology for shelf life extension of fruits and vegetables. *Proceedings of the Fourth Conference on Postharvest*, R. Ben-Aire and S. Philosoph-Hadas, Eds., vol. 2 of *Acta Horticulturae* 553, pp. 285–291, ISHS.
17. Swift J. E., 2010. Effects of frozen storage and harvest time on the textural and sensory properties of rabbiteye blueberries (*Vaccinium virgatum* Aiton) [M.S. thesis], NCSU, Raleigh, NC, USA

18. Veringă Daniela, 2017. Identifying of some tomato varieties for industrialization with resistance to storage, *Journal of Horticulture, Forestry and Biotechnology*, vol. 21(2) Banat University of Agricultural Sciences and Veterinary Medicine Timisoara, pp.64-68.
19. Veringă Daniela, Mohora Angela, Lămureanu Gh., 2017. Preliminary results regarding maintaining of the quality after harvesting of the apricots. *Scientific papers, Series Horticulture*, vol. 60, 2017, USAMV Iasi
20. Wang Y., Chang C. F., Chou J., 2005. Dietary supplementation with blueberries, spinach, or spirulina reduces ischemic brain damage. *Experimental Neurology*, vol. 193, no. 1, pp. 75–84
21. International Agency for Research on Cancer, 2003. *IARC Handbooks of Cancer Prevention. Volume 8: Fruit and Vegetables*, International Agency for Research on Cancer, Lyon, France.
22. World Cancer Research Fund/American Institute for Cancer Research, Food, Nutrition, Physical Activity, and the Prevention of Cancer: A Global Perspective, American Institute for Cancer Research, Washington DC, USA, 2007.