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Influence of production and conservation conditions on some physical and chemical properties of blueberries

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Abstract: This work studied the effect of production mode (organic versus conventional) and storage conditions on some physical and chemical properties of blueberry from different cultivars, namely Duke, Bluecrop, and Ozarkblue. The physical properties evaluated were caliber, color and texture and the chemical characteristics analyzed were moisture content, total soluble solids and acidity. Furthermore, the effect of storage on these properties was also evaluated. The results showed that blueberries cultivar Duke was bigger, with a more intense coloration, and presented a harder and more elastic texture, when compared with the other cultivars at study. With respect to production mode, it was found that the blueberries produced in organic farming were not so acid or sweet, but had a more intense blue color. The storage conditions did not show an important influence on the chemical properties of blueberry, but influenced the both color and texture.

Keywords: blueberry, conservation, color, organic farming, texture

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1 Introduction

Vaccinium is a genus of terrestrial shrubs belonging to the family *Ericaceae* and holds approximately 450 species, from which the most relevant species include *Cyanococcus*, *Oxycoccus*, *Vitis-Idaea*, *Myrtillus*, and *Vaccinium* (Song and Hancock, 2012). Original from North America the blueberry has been consumed by man since the sixteenth century, documented, and is popularly known as longevity fruit. It is berry with a bluish color, which is quite small, being, however, much appreciated for its exotic flavor (Dourte et al., 2010; Hummel et al., 2012).

Blueberry is considered as one of the richest sources of bioactive compounds, comparing to other fruits, and consequently has a positive effect in protecting against many disorders, and particularly degenerative diseases, like memory loss, cancer, heart disease, vision problems and ageing (Shi et al., 2008). Blueberry cultivation has suffered a marked expansion, mainly due to an increase in fruit demand, and stimulates the interest both of producers and researchers due to its beneficial health characteristics, which are keys for the choice of consumers. The area under blueberry cultivation has more than doubled in Florida during the last 10 years and the worldwide production of blueberries has increased 152% in the last two decades. Hence, in the last two decades, the worldwide area planted with blueberries has largely increased, also possibly due to the greater availability of genetic material, which has allowed the diversification of the geographical zones suitable for the cultivation of this crop (Retamales et al., 2015).

It has been shown that yield is greater when the harvest is carried out with the fruit completely blue, i.e., at full maturation, instead of being harvested at an early ripening stage suitable for export. In fact, when the fruit is allowed to mature on the bush, its diameter and weight have increased (Lobos et al., 2014; Ribera et al., 2010).

Conventional agriculture includes practices such as burning of crop residues, the reversal of topsoil, mobilization for weed control and preparation of the seedbed. These techniques promote soil compaction, erosion, increased carbon dioxide and contamination of waterways with sediment, fertilizers and pesticides. Conventional agriculture practices have led to environmental damage and degradation of ecosystems, which posed a serious threat to the quality of life of all living beings (Sandhu et al., 2010). Organic farming aims to introduce external elements in the agro system in order to avoid the indiscriminate use of pesticides, which are destabilizing factors of the ecosystem. Hence, in recent years, there has been a significant increase in consumer demand for foods produced in organic farming in opposition to conventional farming. On the basis of this aspects related to the quality of the food produced using less aggressive cultivation techniques and on the other hand greater awareness of the general public about environmental issues and care in preserving ecosystems are demand (Zielinska et al., 2015). No doubt that organic agriculture is very significant and constitutes a rapidly growing segment of the food supply chain (Tertuliano et al., 2012).

Blueberries are commercialized in different ways and food preparations, apart from the fresh form. However, fresh fruits quickly deteriorate after they are picked and have a shelf life of less than two weeks at 0ºC and 90%-95% humidity after harvesting (Portuguese Standard NP-783, 1985). Hence the conservation is the utmost importance. According to their genotypes and postharvest lives, blueberry cultivars resent different postharvest lives. Abiotic factors, such as climatic conditions, agricultural cultivation, harvesting method, storage conditions, degree of maturity of berries, biochemical composition, etc., have a significant impact on the shelf life of berries (Pavlovski, 2014).

This work aimed at studying the effect of production mode (organic or conventional) in three blueberry cultivars (Duke, Bluecrop and Ozarkblue) with respect to some biometric attributes (size and weight), some physical properties (color and texture) and some chemical parameters (moisture content, total soluble solids and total acidity). Furthermore, this study was also complemented with the evaluation of the alterations that occur during storage (for a period of up to 14 days) in some of the properties analyzed.

2 Materials and methods

2.1 Samples

In this work, berries from three varieties of Northern Highbush blueberries (cultivars Duke, Bluecrop and Ozarkblue) were studied, all originating from farms located in the North-Centre region of Portugal. The blueberries were produced in conventional agriculture and also in organic farming. The fruits were harvested at full maturity stage in which the berries are usually commercialized, corresponding to complete color development and without loss of turgor. Approximately 500 g of berries was collected for each cultivar, selected randomly from several plants in different parts of the same field.

2.2 Handling and conservation

After harvesting, the samples were transported to the laboratory in appropriate plastic cuvettes protected from light and heat. The properties were evaluated in the fresh samples and also after seven and 14 days of storage under refrigeration at a temperature of 4ºC and 85% to 90% relative humidity (RH). In addition, the cultivar Duke produced in conventional mode were also evaluated the changes in the blueberries when stored at room temperature (around 15ºC to 25ºC and 30 to 60% RH).

2.3 Biometric characteristics

For the determination of the biometric characteristics, weight and size, 30 berries were randomly selected as represent of each sample. The size of each berry was measured with an automated caliper rule (model wqrw4, from Metalworking) and the weight was determined through a precision scale (Laboratory Scale AWS ALX-210 Analytical Balance, from American Weigh).

2.4 Chemical analysis

The moisture content was determined by a Halogen Moisture Analyzer (model HG53 from Mettler Toledo, Columbus, OH-EUA). The operating conditions were as follows: heat source - halogen lamp; drying temperature -120 °C; speed of drying - 3 (intermediate) (Gonçalves et al., 2015). The number of repetitions for each sample was eight independent measurements. For the determination of acidity, the sample preparation followed the Portuguese Standard NP-783 (1985) and the total acidity determination was carried out according to the Portuguese Standard NP-1421 (1977). For the determination of total sugars, the sample was prepared by the same procedure as for acidity. Total sugars were determined as total soluble solids by refractometer and the Brix graduation was measured using a refractometer (model 3T from Atago, Tokyo, Japan). Three replicates were made in all cases.

2.5 Color measurement

The color of blueberries was determined with a colorimeter (Chroma Meter - CR-400, Konica Minolta, Tokyo, Japan) in the CIE Lab color space, though the Cartesian coordinates L*, a* and b*. The L* axis represents Lightness and varies from 0 (corresponding to no lightness, i.e., absolute black), to 100 which is maximum lightness (i.e. absolute white). The other axes are represented by Chromatic coordinates a* and b* and they are at right angles to each other. The a* axis varies from green at one extremity (represented by -a) to red at the other (+a), whereas the b* axis varies from blue at one end (-b), to yellow (+b) at the other. Although in theory there are no extreme values of a* and b*, in practice they can be numbered from -128 to +127. For each sample were examined 55 blueberries.

2.6 Texture analysis

To determine the textural properties, 55 representative berries of each sample were randomly selected. The analyzes were performed with a texturometer (model TA.XT Plus, from Stable Micro Systems, Godaming, Surrey, UK) with the following test conditions: pre-test speed = 1.50 mm s^{-1}, test-speed = 1.00 mm s^{-1}, post-test speed = 10.00 mm s^{-1}, distance = 6 mm, trigger force = 0.05 mm and a load cell of 50 kg. The results were treated with Exponent software TEE (Stable Micro Systems) and from the obtained texture profile (Figure 1) was determined firmness (strength on the highest peak) and elasticity (distance at the highest point).

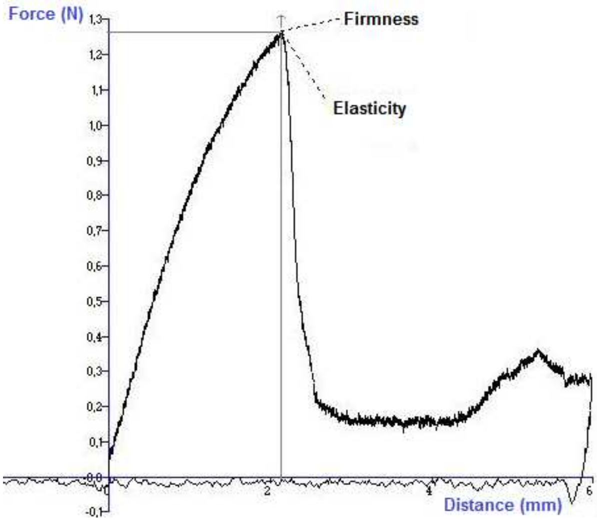

Figure 1 Texture profile analysis for blueberry.

3 Results and discussion

3.1 Biometric characteristics

The results showed that the mass of blueberries varied depending on the cultivar and production mode. At harvest, the berries from cultivar Ozarkblue were heavier than the other cultivars, and particularly when produced in conventional mode (Table 1). This trend for the products was lighter when produced in organic production was observed for the other two varieties studied, although the differences were less significant, particularly in Bluecrop, where the difference was minimal.

When harvested, the blueberries of cultivar Duke had higher average caliber as compared to the other cultivars (Table 1) either in organic farming or conventional production mode. The cultivar that showed a lower average caliber was Bluecrop grown in conventional production. For variety Ozarkblue, blueberries in conventional production had a higher caliber. The average sizes of the berries obtained for Ozarkblue was 0.93 to 1.07 cm, which were values lower than the results of 1.60 cm obtained by Machado and Jesus (2012) for the same cultivar. However, the harvest blueberry gauge values obtained in cultivars were similar to values obtained by Sousa (2007) that ranged 1.01 to 2.25 cm.

Table 1 Biometric characteristics at harvest of the blueberries studied

Sample [(1)]	Mass (g)	Diameter (mm)
DuCo	2.17 ± 0.36^{bB}	1.53 ± 0.15^{cA}
DuOr	1.75 ± 0.36^{aA}	1.51 ± 0.15^{cA}
BlCo	1.77 ± 0.27^{aA}	0.90 ± 0.13^{aA}
BlOr	1.75 ± 0.53^{aA}	1.36 ± 0.21^{bB}
OzCo	2.40 ± 0.92^{cB}	1.07 ± 0.24^{bA}
OzOr	2.05 ± 0.31^{bA}	0.93 ± 0.17^{aA}

Note: (1) Cultivar: Du=Duke, Bl=Bluecrop, Oz=Ozarkblue; Production mode: Co=conventional, Or=organic;

Identical uppercase small letters refer to samples that do not differ according to cultivar for the same production mode (Post Hoc LSD Ficher Test, $p < 0.05$).

Identical uppercase capital letters refer to samples that do not differ according to production mode, for the same cultivar (Post Hoc LSD Ficher Test, $p < 0.05$).

3.2 Chemical analysis

Table 2 showed the chemical properties of the blueberries at harvest. The moisture content was very similar for both production modes, with just slight variations between varieties. The value obtained for cultivar Bluecrop (around 75% corresponding to 25% of dry matter) was higher than that 16% dry matter reported by Skupien (2006). In the study of Kalt and McDonald (1996), dry matter values obtained for blueberry in fresh state were around 13.8%.

Table 2 Chemical properties at harvest of the blueberries studied

Sample [(1)]	Moisture content (%)	Total soluble solids (ºBrix)	Total Acidity (mg citric acid 100 g^{-1})	Maturation index [(2)]
DuCo	78.31 ± 3.59^{bA}	11.26 ± 0.75^{aB}	0.07 ± 0.00^{aB}	160.86
DuOr	79.05 ± 2.11^{bA}	6.86 ± 0.29^{aA}	0.04 ± 0.00^{aA}	167.15
BlCo	76.82 ± 3.48^{aA}	10.96 ± 1.67^{aA}	0.07 ± 0.01^{aA}	156.57
BlOr	75.80 ± 3.08^{aA}	11.80 ± 0.80^{bA}	0.08 ± 0.01^{bA}	147.50
OzCo	81.24 ± 2.34^{cA}	15.39 ± 1.06^{bB}	0.10 ± 0.01^{bB}	153.90
OzOr	81.00 ± 4.31^{cA}	12.66 ± 0.34^{bA}	0.08 ± 0.00^{bA}	158.25

Note:(1)Cultivar: Du=Duke, Bl=Bluecrop, Oz=Ozarkblue; Production mode: Co=conventional, Or=organic

(2) Maturation index = total soluble solids / acidity

Identical uppercase small letters refer to samples that do not differ according to cultivar for the same production mode (Post Hoc LSD Ficher Test, $p < 0.05$).

Identical uppercase capital letters refer to samples that do not differ according to production mode, for the same cultivar (Post Hoc LSD Ficher Test, $p < 0.05$).

Table 2 also showed that the concentration of soluble solids (in ºBrix, equivalent to g sucrose per 100 g sample) for the different samples analyzed right after harvest. The cultivar Ozarkblue produced in conventional mode presented the highest sugar concentration (15.39%). For the cultivar Duke, the major difference was observed between both production modes, which being 6.86% average for organic farming and 11.26% average for conventional mode. The mean values of acidity varied between 0.04 and 0.10 mg citric 100 g^{-1} acid (Table 2). Kalt and McDonald (1996) obtained at harvest for blueberries of cultivar Duke 0.05 mg citric acid 100 g^{-1}, which was similar to the results obtained in this study for the same cultivar. Also Zheng et al. (2003) found acidity values around 0.08 mg citric acid 100 g^{-1} for blueberries at harvest. Table 2 also showed the values of the maturation index, calculated as the ratio between the total soluble solids and the acidity. The results showed that all samples evaluated a relatively similar maturation stage, with maturation index varying from 147.50 to 167.15, respectively for cultivars Bluecrop and Duke, both in organic mode. The results also highlighted that for the same cultivar produced in both production modes, the values were very similar and that the berries from cultivar Duke were those in a more advance maturation stage.

The results in Table 3 showed that the effect of room temperature storage was not much different than that of cold storage in respect to the variation of the moisture content along conservation for seven or 14 days. The results also showed, in for cultivar Ozarkblue, a trend for a loss in moisture along conservation due to loss of moisture to the surrounding atmosphere inside the refrigerator. Table 3 also showed the evolution of total soluble solids content during storage. Again in this case the trends were not fully established. Still, for cultivar Ozarkblue a decreasing trend was observed during storage, as suggested by Zheng et al. (2003). As regards the effect of conservation on the acidity was not marked (Table 3). Blueberry cultivar Ozarkblue appeared to exhibit a slight tendency of decreasing acidity along storage time. The same trend was observed by Zheng et al. (2003), which revealed a reduction in the acidity over the 35 days of storage after harvest.

Table 3 Moisture, total soluble solids and acidity of the blueberries along storage

Sample (1)	0 DAH (2)	7 DAH (2)	14 DAH (2)
	Moisture content (%)		
DuCoRe	$78.31 \pm 3.59^{aA\alpha}$	$83.26 \pm 4.98^{\alpha}$	$81.91 \pm 4.43^{\alpha}$
DuCoTa	$78.31 \pm 3.59^{aA\alpha}$	$82.55 \pm 7.02^{\alpha}$	$82.54 \pm 5.29^{\alpha}$
DuOrRe	$79.05 \pm 2.11^{aA\alpha}$	$83.62 \pm 3.71^{\beta}$	$78.08 \pm 4.81^{\alpha}$
OzCoRe	$81.24 \pm 2.34^{bA\alpha}$	$80.05 \pm 1.83^{\alpha}$	$79.10 \pm 2.78^{\alpha}$
OzOrRe	$81.00 \pm 4.31^{bA\beta}$	$79.59 \pm 4.49^{\beta}$	$73.36 \pm 1.89^{\alpha}$
	Total soluble solids (ºBrix)		
DuCoRe	$11.26 \pm 0.75^{aB\alpha}$	$12.14 \pm 1.42^{\beta}$	$14.07 \pm 0.94^{\gamma}$
DuCoTa	$11.26 \pm 0.75^{aB\alpha}$	$12.12 \pm 0.63^{\beta}$	$13.23 \pm 0.42^{\gamma}$
DuOrRe	$6.86 \pm 0.29^{aA\alpha}$	$10.08 \pm 0.62^{\beta}$	$10.11 \pm 0.65^{\beta}$
OzCoRe	$15.39 \pm 1.06^{bB\gamma}$	$12.97 \pm 0.70^{\alpha}$	$14.04 \pm 0.32^{\beta}$
OzOrRe	$12.66 \pm 0.34^{bA\beta}$	$10.63 \pm 0.06^{\alpha}$	$10.56 \pm 0.50^{\alpha}$
	Acidity (mg citric acid 100 g^{-1})		
DuCoRe	$0.07 \pm 0.00^{aA\alpha}$	$0.08 \pm 0.01^{\alpha}$	$0.09 \pm 0.01^{\alpha}$
DuCoTa	$0.07 \pm 0.01^{aA\beta}$	$0.08 \pm 0.00^{\beta}$	$0.04 \pm 0.00^{\alpha}$
DuOrRe	$0.04 \pm 0.00^{aA\alpha}$	$0.06 \pm 0.00^{\beta}$	$0.06 \pm 0.00^{\beta}$
OzCoRe	$0.10 \pm 0.01^{bA\gamma}$	$0.08 \pm 0.00^{\alpha}$	$0.09 \pm 0.00^{\beta}$
OzOrRe	$0.08 \pm 0.00^{bA\beta}$	$0.07 \pm 0.00^{\alpha}$	$0.07 \pm 0.00^{\alpha}$

Note: (1)Cultivar: Du=Duke, Bl=Bluecrop, Oz=Ozarkblue; Production mode: Co=conventional, Or=organic; Conservation: Re=refrigeration, Ta=ambient temperature.

(2)DAH=days after harvest.

Note: Identical uppercase small letters refer to samples that do not differ according to cultivar for the same production mode (Post Hoc LSD Ficher Test, $p < 0.05$).

Identical uppercase capital letters refer to samples that do not differ according to production mode, for the same cultivar (Post Hoc LSD Ficher Test, $p < 0.05$).

Identical uppercase Greek letters refer to samples that do not differ according to storage time, in the same line (Post Hoc LSD Ficher Test, $p < 0.05$).

3.3 Color

Table 4 presented the values for the color coordinate L*, lightness, at harvest and after seven and 14 days of storage. At harvest, samples Ozarkblue were less dark, with higher values of L* (around 40), while cultivars Duke and Bluecrop exhibited similar values of L* (around 35). Along storage, lightness tended to decrease slightly, indicating that the blueberries became darker. The values of L* obtained by Zheng et al. (2003) and Rocha (2009), ranged from 31 at harvesting to 28.5 after 30 days of storage, thus confirming a tendency for decrease along time.

Table 4 Variation of color coordinates (L*, a* and b*) of the blueberries along storage

Sample (1)	0 DAH (2)	7 DAH (2)	14 DAH (2)
		L* (lightness)	
DuCoRe	33.15 ± 2.69$^{aA\beta}$	30.64 ± 2.04$^{\alpha}$	31.08 ± 2.77$^{\alpha}$
DuCoTa	33.15 ± 2.69$^{aA\beta}$	31.58 ± 2.28$^{\alpha}$	31.78 ± 2.26$^{\alpha}$
DuOrRe	34.39 ± 2.07$^{aA\alpha}$	36.02 ± 2.29$^{\alpha}$	35.74 ± 4.79$^{\alpha}$
BlCo	33.82 ± 4.19^{aA}	-	-
BlOr	35.59 ± 1.88^{aA}	-	-
OzCoRe	38.56 ± 2.50$^{bA\beta}$	35.40 ± 2.86$^{\alpha}$	34.17 ± 3.07$^{\alpha}$
OzOrRe	39.66 ± 2.05$^{bA\beta}$	37.10 ± 3.37$^{\alpha}$	35.85 ± 3.27$^{\alpha}$
		a* (greenness/redness)	
DuCoRe	0.54 ± 1.33$^{bB\alpha}$	0.39 ± 0.61$^{\alpha}$	0.73 ± 1.59$^{\alpha}$
DuCoTa	0.54 ± 1.33$^{aB\alpha}$	0.00 ± 0.40$^{\alpha}$	0.08 ± 0.53$^{\alpha}$
DuOrRe	-0.21 ± 0.29$^{aA\alpha}$	-0.56 ± 0.24$^{\alpha}$	-0.11 ± 1.46$^{\alpha}$
BlCo	0.53 ± 0.94^{bA}	-	-
BlOr	0.60 ± 1.18^{cA}	-	-
OzCoRe	0.34 ± 0.52$^{aB\alpha}$	0.60 ± 0.74$^{\alpha}$	-0.05 ± 0.58$^{\alpha}$
OzOrRe	-0.05 ± 0.52$^{bA\alpha}$	1.95 ± 2.43$^{\beta}$	1.27 ± 1.40$^{\beta}$
		b* (blueness)	
DuCoRe	-5.84 ± 1.27$^{bA\alpha}$	-4.70 ± 1.01$^{\alpha}$	-5.04 ± 1.42$^{\alpha}$
DuCoTa	-5.84 ± 1.27$^{bA\alpha}$	-4.93 ± 1.34$^{\alpha}$	-4.80 ± 1.06$^{\alpha}$
DuOrRe	-6.61 ± 0.89$^{bA\alpha}$	-7.31 ± 1.02$^{\alpha}$	-7.43 ± 2.08$^{\alpha}$
BlCo	-6.16 ± 1.87^{bB}	-	-
BlOr	-8.21 ± 0.90^{aA}	-	-
OzCoRe	-8.01 ± 0.88$^{aA\alpha}$	-7.14 ± 1.20$^{\alpha}$	-6.31 ± 1.31$^{\alpha}$
OzOrRe	-7.01 ± 0.87$^{aB\alpha}$	-6.35 ± 1.83$^{\alpha}$	-6.65 ± 0.98$^{\alpha}$

Note: (1) Cultivar: Du=Duke, Bl=Bluecrop, Oz=Ozarkblue; Production mode: Co=conventional, Or=organic; Conservation: Re=refrigeration, Ta=ambient temperature.

(2)DAH=days after harvest.

Identical uppercase small letters refer to samples that do not differ according to cultivar for the same production mode (Post Hoc LSD Ficher Test, $p < 0.05$).

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Identical uppercase Greek letters refer to samples that do not differ according to storage time, in the same line (Post Hoc LSD Ficher Test, $p < 0.05$).

The color coordinate a* showed in the present case values were very close to zero, either positive or negative but around zero (Table 4), thus indicating that there was neither a predominance of green nor of red (i.e. it is positioned in the gray area, of undefined color). Because all values were very similar and the standard deviations were of the same magnitude of the value itself (as a consequence of having positive and negative values), no comparisons could be made among the cultivars or along drying, because the results were similar in all cases. In the study by Zheng et al. (2003) the values of a* coordinate were as follows: 0.46 at harvesting; -1.85 at seven days after harvest; and -1.62 at 14 days after harvest, thus confirming that the balance between greenness/redness was not significant for blueberry color.

Table 4 also showed the values for color coordinate b*, which represented blue color when negative and yellow when positive. In the present case the values were negative, confirming the blue color of the berries. At harvest, the intensity of blue was higher for cultivar Bluecrop in organic farming (-8.21) and Ozarkblue in conventional mode (-8.01). Cultivar Duke showed less intense blue coloration. Regarding the effect of storage, a slight trend to diminish the blue color was observed in most cases. In a study by Rocha (2009), the author concluded that, under similar conditions, the coordinate b* values were -0.36 and -2.23. Zheng et al. (2003) found at harvest values of b* of -4.68, a result was similar to the values observed in this study.

3.4 Texture

At harvest the values of firmness range between 1.31 and 1.70 N (Table 5), which were similar to those found in the study by Kalt and McDonald (1996) for mature blueberries, about 2 N.

Although the differences were very small, cultivar Duke presented higher values for firmness (Table 5), indicating that these berries were slightly harder. As to the effect of storage, increasing storage time increased firmness in all cases. Table 5 also showed the elasticity of the blueberries evaluated at harvest and after storage. Once again the differences seemed quite small, but a trend for less elasticity was still observed for cultivar Ozarkblue (2.02 and 2.19 mm, respectively for organic and conventional production modes). Elasticity seemed to increase along storage, and this trend was also observed for all samples at study.

Table 5 Firmness and elasticity of the blueberries upon harvesting and along storage

Sample (1)	0 DAH (2)	7 DAH (2)	14 DAH (2)
		Firmness (N)	
DuCoRe	$1.70 \pm 0.16^{bA\alpha}$	$1.90 \pm 0.20^{\beta}$	$1.99 \pm 0.28^{\beta}$
DuCoTa	$1.70 \pm 0.17^{bA\beta}$	$1.31 \pm 0.32^{\alpha}$	$1.34 \pm 0.37^{\alpha}$
DuOrRe	$1.63 \pm 0.25^{bA\alpha}$	$1.86 \pm 0.26^{\beta}$	$1.89 \pm 0.44^{\beta}$
BlCo	1.46 ± 0.23^{aA}	-	-
BlOr	1.31 ± 0.22^{aA}	-	-
OzCoRe	$1.40 \pm 0.25^{aA\alpha}$	$1.53 \pm 0.34^{\alpha}$	$1.50 \pm 0.45^{\alpha}$
OzOrRe	$1.36 \pm 0.17^{aA\alpha}$	$1.71 \pm 0.33^{\beta}$	$1.57 \pm 0.48^{\alpha\beta}$
Sample (1)		Elasticity (mm)	
DuCoRe	$2.89 \pm 0.42^{aA\alpha}$	$3.15 \pm 0.45^{\beta}$	$3.15 \pm 0.68^{\beta}$
DuCoTa	$2.89 \pm 0.42^{aA\alpha}$	$2.83 \pm 0.50^{\alpha}$	$2.99 \pm 0.77^{\alpha}$
DuOrRe	$2.44 \pm 0.38^{aA\alpha}$	$3.04 \pm 0.46^{\alpha\beta}$	$4.08 \pm 0.63^{\beta}$
BlCo	2.49 ± 0.46^{aA}	-	-
BlOr	2.93 ± 0.42^{aA}	-	-
OzCoRe	$2.19 \pm 0.45^{aA\alpha}$	$2.32 \pm 0.39^{\alpha\beta}$	$2.99 \pm 0.71^{\beta}$
OzOrRe	$2.02 \pm 0.36^{aA\alpha}$	$1.97 \pm 0.26^{\alpha}$	$2.43 \pm 0.61^{\alpha}$

Note: (1)Cultivar: Du=Duke, Bl=Bluecrop, Oz=Ozarkblue; Production mode: Co=conventional, Or=organic; Conservation: Re=refrigeration, Ta=ambient temperature.

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Identical uppercase Greek letters refer to samples that do not differ according to storage time, in the same line (Post Hoc LSD Ficher Test, $p < 0.05$).

4 Conclusions

This study allowed to conclude that the blueberries from cultivar Duke were on average bigger when compared with the other cultivars at study, and that they also had a more intense darker blue color. With respect to the textural parameters, the berries from cultivar Duke showed to be harder and more elastic. The cultivars that presented at harvest the highest quantity of sugars was cultivar Ozarkblue, which produced in conventional mode and for the same cultivar acidity showed a trend for decreasing along storage time, with the statistical differences. With respect to the production mode it concluded that the fruits produced in organic farming had lower acidity and also total soluble solids. However, they were bluish and less elastic when compared with those from conventional mode. The storage temperature (cold or room temperature) was not found to expressively influence the chemical properties of blueberry as confirmed by the results of the statistical tests, but, contrarily, influenced the physical properties in a way that the blueberries stored under refrigeration had a statistically significant less intense color and a firmer, less elastic texture.

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