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Postharvest quality of 'Emerald' blueberry cultivated in a subtropical region

Abstract – The objective of this work was to evaluate the qualitative attributes, at harvest and postharvest, of 'Emerald' blueberries grown in a subtropical climate region, without winter chilling, in Brazil. Fruit were harvested in the municipality of Piracicaba, in the state of São Paulo, in two harvest peaks, in August and October, and evaluated for their qualitative attributes at harvest and for their physical, chemical, and biochemical attributes at postharvest. The fruit were maintained at ambient conditions, at 22°C and 70% relative humidity, and evaluated on the day of harvest and every three days until the twelfth day of storage. The blueberries harvested in August were larger and rounder, and those harvested in October had a more intense blue coloration and higher concentrations of phenolic compounds, pH, and soluble solids, in addition to a higher total soluble solids and titratable acidity ratio. During storage, an increase was observed in the contents of anthocyanins, quercetins, and total phenolic compounds, as well as in antioxidant activity, besides a decrease in fruit acidity and firmness. Regardless of the harvest month, blueberries grown in a subtropical region of Brazil have a good postharvest shelf life up to 12 days at ambient temperature, with satisfactory fruit quality levels.

Index terms: *Vaccinium* spp., anthocyanins, antioxidant capacity, phenolic compounds, shelf life.

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Qualidade pós-colheita de mirtilos 'Emerald' cultivados em região subtropical

Resumo – O objetivo deste trabalho foi avaliar os aspectos qualitativos, na colheita e na pós-colheita, de mirtilos 'Emerald' cultivados em região de clima subtropical, sem frio hibernal, no Brasil. Os frutos foram colhidos no município de Piracicaba, no estado de São Paulo, em dois picos de colheita, em agosto e outubro, e avaliados quanto aos seus atributos qualitativos na colheita e aos seus atributos físicos, químicos e bioquímicos na pós-colheita. Os frutos foram mantidos em condições de temperatura ambiente, a 22°C e 70% de umidade relativa, e analisados no dia da colheita e a cada três dias até o décimo-segundo dia de armazenamento. Os mirtilos colhidos em agosto foram maiores e mais arredondados, e os colhidos em outubro apresentaram coloração azul mais intensa e maiores concentrações de compostos fenólicos, pH e sólidos solúveis, além de maior relação sólidos solúveis totais e acidez titulável. Durante o armazenamento, observou-se aumento no conteúdo de antocianinas, quercetinas e compostos fenólicos totais, bem como na atividade antioxidante, além de redução na acidez e na firmeza dos frutos. Independentemente do mês de colheita, os mirtilos cultivados em região subtropical no Brasil apresentam boa durabilidade pós-colheita por até 12 dias em temperatura ambiente, com níveis satisfatórios de qualidade dos frutos.

Termos para indexação: *Vaccinium* spp., antocianinas, capacidade antioxidante, compostos fenólicos, vida útil.

Introduction

Blueberries (*Vaccinium* spp.) are considered a functional food (Dunford, 2022) and a source of a wide diversity and a high content of bioactive components (Miller et al., 2019), which are responsible for boosting longevity in other species (Peng et al., 2012; Wang et al., 2018). Blueberries also stand out due to their antioxidant capacity, explained by their contents of flavonoids, including anthocyanins and quercetins, which help prevent several chronic diseases, such as cancer, cardiovascular problems, and cognitive deterioration (Tiwary & Hussain, 2021).

However, the acceptance of blueberries by the consumers may be influenced by other fruit attributes such as soluble solids contents, acidity, coloration, firmness, size, shape, and shelf life, which define sensory characteristics and vary mainly due to the used genetic material (cultivars), weather conditions, and cultivation site and periods (Cerezo et al., 2020).

One of the first available in the market, the Emerald cultivar is a southern highbush blueberry selected by University of Florida (Florida, USA) for its low cold requirement (temperatures below 7.2°C), early production, and large fruit size. When grown in Florida, its harvest extends from mid-April to mid-May (Kovaleski et al., 2015).

In regions with a subtropical or tropical climate, however, the cultivation of blueberries is relatively recent, although there are studies reporting the high quality of these fruit when produced in warm climates, such as those of Brazil (Rodrigues et al., 2011; Souza et al., 2014). Despite these results, it is still necessary to correlate the quality of fruit postharvest with the environmental conditions of the cultivation site, which play a major role in the physical and chemical aspects of blueberries (Cerezo et al., 2020). Understanding how these attributes change during fruit shelf life is also important for the blueberry industry.

The objective of this work was to evaluate the qualitative attributes, at harvest and postharvest, of 'Emerald' blueberries grown in a subtropical climate region, without winter chilling, in Brazil.

Materials and Methods

The experiment was carried out in a commercial blueberry orchard, in a private propriety called Chácara Catavento, located in the municipality of Piracicaba, in the state of São Paulo, Brazil (22°43'30"S, 47°38'56"W, at 550 m of altitude). The climate of the region is Cwa, without winter chilling (Alvares et al., 2013).

The evaluated 'Emerald' blueberries were obtained from three-year-old plants, cultivated in a semi-protected environment, under arches covered with a low-density polyethylene sheet, in 10 L pots with a substrate based on pine bark. Ripe fruit, with a dark-purple coloration and the presence of epicuticular wax in the peel, were harvested in two harvest peaks: August (winter) and October (spring). The mean climate conditions during fruiting and harvest for the two harvest peaks were, respectively: 19.5 and 26.3 MJ m^{-2} per day of global solar radiation, 20.6 and 25.1°C, and 73.9 and 71% relative humidity (Figure 1).

After harvest, the fruits were stored in a cold chamber, with an ambient temperature of 22±1ºC and a relative humidity of 70±5%, for 12 days.

The experimental design was completely randomized in a 2×5 factorial arrangement, with two harvest peaks (August and October) and five numbers of days after harvesting (0, 3, 6, 9, and 12), with four replicates, totaling 500 fruits for evaluation. The following fruit attributes were analyzed on the day of harvest: fresh mass (in grams per fruit), on a precision scale; length and diameter (in millimeters), by measuring the longitudinal length and equatorial diameter of seven fruit per replicate using a digital caliper; and shape, considered the ratio between longitudinal length and equatorial diameter, with values closer to 1 and to 0 indicating rounder and flatter fruits, respectively.

To understand how these attributes change during fruit shelf life, other analyses were carried out on the day of harvest and every 3 days up to 12 days of storage.

Peel coloration was evaluated using the CR-400 colorimeter (Konica Minolta, Osaka, Japan), with obtained values in the CIE L, a* and b* standard coordinates, from which chromaticity and hue angle were calculated (Lindbloom, 2022).

Total anthocyanins and quercetins were quantified according to Lees & Francis (1972), with modifications. For extraction, 10 g of frozen fresh sample were used, to which 30 mL of the extracting solution with 95% ethanol and 1.5 N HCl (85:15 v/v) were added. After 12 hours, at 4ºC and protected from light, the samples were filtered using filter paper and washed with the extracting solution to separate any residues from the

whole pigment of the sample. An aliquot of 1.5 mL of the filtered extract was collected, and the volume was completed to 50 mL with the extracting solution. After 2 hours at room temperature, absorbance was read in a spectrophotometer at the wavelengths of 535 and 374 nm for anthocyanins and quercetins, respectively. The results were expressed in milligrams of total anthocyanins or quercetins per gram of fresh fruit.

Total phenolic compounds were quantified according to the method of Singleton & Rossi (1965), with modifications. The extract was obtained from 0.5 g of the sample ground in 9.5 mL methanol p.a. and then centrifuged at 4,629 x *g*, at 5°C, for 10 min. An aliquot of 0.15 mL supernatant was added to 0.05 mL methanol p.a., 1.5 mL distilled water, and 0.1 mL Folin-Ciocalteu reagent at 10% (v:v). After 5 min, 0.2 mL anhydrous sodium carbonate at 20% (v:v) was added to the solution, which was kept for 2 hours at room temperature for the reaction to occur. Sample absorbance was read in a spectrophotometer at the wavelength of 765 nm. Gallic acid (0.1 mg mL^{-1}) was used as a standard, and the results were expressed in gram of gallic acid per gram of fresh fruit.

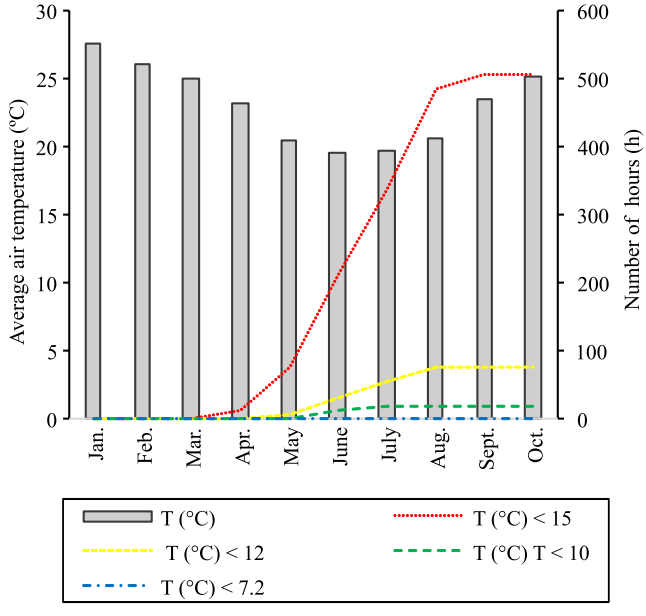

Figure 1. Average air temperature and total number of chill hours below 15, 12, 10, and 7.2°C during the experimental period in the municipality of Piracicaba, in the state of São Paulo, Brazil. T, temperature. Source: Universidade de São Paulo (2022).

Antioxidant activity was quantified by scavenging the following two free radicals: 2'-azino-bis 3-ethylbenzothiazoline-6-sulfonic acid (ABTS) and 2,2-diphenyl-1-picrylhydrazyl (DPPH) according to Re et al. (1999) and Brand-Williams et al. (1995), respectively. To determine the scavenging of the ABTS radical, absorbance reduction was read at 734 nm, 6 min after the extract was added, being expressed in percentage of absorbance reduction. For DPPH, the scavenged radicals were read at 515 nm after 50 min of extract addition; the results were also expressed in percentage of absorbance reduction.

Other evaluated fruit quality parameters were: firmness (in Newton), determined by the flattening method, as described in Calbo & Nery (1995); soluble solids (SS) content (in ºBrix), using the PR-101 digital palette refractometer (Atago, Tokyo, Japan), with two reads per replicate, following the methodology of AOAC International (AOAC, 2010); pH and titratable acidity (TA, in percentage of citric acid) as in AOAC (2010); and ratio between TSS and TA.

All data were subjected to the analysis of variance, and means were compared by Tukey's test at 5% probability. To characterize the cultivar in relation to the evaluated variables, the multivariate analysis based on the principal components analysis (PCA) was performed, using a biplot chart. The SAS, version 9.3, statistical software (SAS Institute Inc., Cary, NC, USA) was used.

Results and Discussion

In the first harvest peak, in August, the harvested fruit showed higher values for fresh mass and diameter (41 and 24% higher, respectively) and lower values for shape than those harvested in October, the second harvest peak (Table 1), being, therefore, larger and flatter.

The higher fresh mass of the fruits harvested in August could be attributed to their greater diameter. According to Handa et al. (2012), the increase in fruit diameter occurs for two reasons: initial growth, which is driven by successive cell divisions; and growth flow, which occurs by the expansion of cell volume (Table 2). This expansion is caused by the higher accumulation of photoassimilates in the vacuole of fruit cells, which makes their water potential very negative, allowing water to enter through osmosis, consequently

increasing cell volume (Beauvoit et al., 2014). Zorenc et al. (2016) also reported higher fresh mass values in the first weeks of harvest, with a decrease over the weeks in the same harvest, which could be explained by the availability of the photoassimilates responsible for fruit expansion.

Compared with the literature, the mean fresh mass of the blueberries harvested in August was 41% higher than that of the same cultivar evaluated in Watkinsville, Georgia, USA (Ogden & van Iersel, 2009), highlighting the quality of the fruit produced in regions without chilling, such as in the municipality of Piracicaba, in São Paulo, Brazil.

Regarding coloration, there was no difference in chromaticity between months of harvest, and the values obtained were close to the central axis of the LCH system of colors, i.e., they were low, indicating a grayish tone (Table 2). However, hue angle and luminosity presented the highest values in August, indicating that the fruit from the first harvest peak had a lighter blue tone (Tables 2 and 3). The blueberries from the second harvest peak had a higher pigmentation and, therefore, were a darker blue, as confirmed by the

Table 1. Analysis of the profile of 'Emerald' blueberries (*Vaccinium* spp.) cultivated in a subtropical region, in Brazil, and stored at 22°C and 70% relative humidity for 12 days[(1)].

Treatment	Fresh mass (g)	Diameter (mm)	Length (mm)	Shape -
Months of harvest				
August	1.99A	18.1A	11.1A	0.62B
October	1.16B	13.7B	9.5A	0.71A

[(1)]Means followed by equal letters do not differ from each other by Tukey's test, at 5% probability. (n=4).

Table 2. F-test in analyses of variance for storage period (day), harvest peak (month of harvest), and day × month interaction on the physical, chemical, and biochemical attributes of 'Emerald' blueberries (*Vaccinium* spp.) stored at 22°C and 70% relative humidity for 12 days.

Variable	Day	Month	Day × month	CV (%)
Firmness (N)	*	ns	*	11.64
Luminosity (L)(1)	ns	*	*	0.68
Chromaticity (C*)	*	ns	ns	18.17
Hue angle (Hº)	ns	*	ns	14.18
Soluble solids (°Brix)	ns	*	ns	3.03
pH[(1)]	*	*	*	2.67
Titrable acidity (% citric acid)[(2)]	*	*	*	5.16
TSS/TA ratio[(3)]	*	*	*	12.73
Total anthocyanins (mg g^{-1})	*	*	ns	11.73
Total quercetins (mg g^{-1})[(1)]	*	*	ns	2.46
Phenolic compounds (mg g^{-1})	*	ns	ns	7.39
DPPH (% of reduction)	*	*	*	7.67
ABTS (% of reduction)	*	ns	*	10.47
Fresh mass (g)	-	*	-	1.75
Diameter (mm)	-	*	-	9.40
Length (mm)	-	ns	-	12.04
Shape	-	*	-	10.24

[(1)] Data transformed by log x. [(2)]Data transformed by $x^{0.5}$. [(3)]Data transformed by x^{-1}. (n=4). TSS, total soluble solids; and TA, titratable acidity. *Significant between treatments at 5% probability. [ns]Nonsignificant.

Table 3. Postharvest characterization of 'Emerald' blueberries (*Vaccinium* spp.) cultivated in a subtropical region, in Brazil, and stored at 22°C and 70% relative humidity for 12 days[(1)].

Treatment	Chromaticity -	Hue angle -	Anthocyanins (mg g^{-1})	Quercetins (mg g^{-1})	Phenolic compounds (mg g^{-1})	SS (°Brix)
Months of harvest						
August	1.7A	199.28A	0.83B	0.32B	6.79A	10.3B
October	1.7A	168.10B	0.98A	0.37A	6.75A	11.8A
Days after harvest						
0	1.2c	198.96a	0.48c	0.26d	5.94d	11.5a
3	1.5bc	179.79a	0.66b	0.29cd	6.16cd	11.0a
6	1.8ab	179.81a	0.81b	0.33c	6.83bc	11.0a
9	2.0a	179.40a	1.22a	0.40b	7.33ab	11.0a
12	2.0a	181.50a	1.35a	0.45a	7.58a	11.0a

[(1)]Means followed by equal letters, in the columns, do not differ from each other by Tukey's test, at 5% probability. SS, soluble solids.

quantification of anthocyanin content, which was 18% higher in October.

The 'Emerald' blueberries presented a good color preservation postharvest. There was a small increase in saturation (Table 1) and, therefore, an increase in the purity of the blue tone in both months of harvest and a color darkening (reduction in luminosity) only in August (Table 3).

Blueberry coloration is directly related to the biosynthesis of anthocyanins, which, similarly to quercetins, are phenolic compounds highly influenced by fruit metabolism postharvest (Radünz et al., 2022). In the present work, blueberries stored for a longer period presented a higher content of anthocyanins, quercetins, and total phenols (Table 1). Since the evaluated blueberries were stored at room temperature and without any postharvest treatment, it is likely that there was an increase in their respiratory activity, which favored an increase in the route of shikimic acid and a decrease in acidity, preliminary reactions to the biosynthesis of those phenolic compounds. The phenols produced by the studied blueberries were probably continuously stored in the cell vacuole, allowing the observed increase in the contents of anthocyanins, quercetins, and total phenols over the experimental period.

Besides a higher content of anthocyanins, the fruit harvested in October also presented a higher content of quercetins (Table 3), another flavonoid strongly present in 'Emerald' blueberries and of great functional importance. There was a mean gain of 2.8 and 1.7 times in anthocyanin and quercetin contents, respectively, from the day of harvest to the last day of analysis.

The higher contents of anthocyanins and quercetins in the second harvest peak might have been a consequence of other changes, especially in TA and SS, which were observed in the cell medium, responsible for the way of expression and stability of both compounds. Furthermore, the blueberries harvested in October showed a higher pH and a greater

Table 4. Postharvest characterization and antioxidant capacity of 'Emerald' blueberries (*Vaccinium* spp.) cultivated in a subtropical region, in Brazil, and stored at 22°C and 70% relative humidity for 12 days[1].

Months of harvest	Number of days				
	0	3	6	9	12
			Luminosity[2]		
August	32.1Aa	30.4Ab	31.7Aab	30.8Aab	30.5Ab
October	28.6Ba	29.0Aa	28.8Ba	28.9Ba	28.9Ba
			Reduced DPPH (%)		
August	47.5Ad	52.0Ac	52.8Ac	60.3Ab	66.6Aa
October	38.4Bb	39.9Bb	47.4Ba	47.4Ba	49.0Ba
			Reduced ABTS (%)		
August	32.4Ad	31.4Bd	36.7Bc	49.3Ab	54.0Aa
October	32.9Ac	35.4Ac	44.2Ab	43.2Bb	49.8Ba
			Firmness (N)		
August	2.22Aa	2.83Aa	2.39Aa	2.09Aa	1.27Ab
October	2.70Aa	1.95Aab	2.10Aab	2.16Aab	1.88Ab
			pH[2]		
August	2.55Bb	2.62Bb	2.54Bb	2.85Ba	3.00Ba
October	3.15Ac	3.53Ab	3.88Aa	3.83Aa	4.10Aa
			Titratable acidity (TA, % citric acid)[2]		
August	1.73Aa	1.46Ab	1.41Abc	1.16Acd	1.02Ad
October	1.04Ba	0.54Bb	0.42Bbc	0.43Bbc	0.36Bc
			TSS/TA ratio[2]		
August	6.2Bc	7.1Bc	7.5Bbc	8.6Bab	10.0Ba
October	11.6Ab	21.8Aa	28.9Aa	26.8Aa	32.7Aa

[1]Means followed by equal uppercase letters do not differ from each other for month, and means followed by equal lowercase letters do not differ from each other for days, by Tukey's test, at 5% probability. [2]Transformed data. TSS, total soluble solids.

increase in pH over the evaluated period (Table 4), as well as a higher SS content. Since the reduction in H^+ protons in the cell medium causes the flavylium cation of anthocyanins to lose protons and form blue quinoidal bases, the higher the pH, the higher the loss of protons and the higher the stability of the blue-toned anthocyanins (Albarici et al., 2006). Tierno & Ruiz de Galarreta (2016) added that higher sugar contents reduce water activity, generating a balance in favor of the flavylium cations.

The antioxidant activity of the Emerald cultivar, cultivated in a subtropical region without chilling, is considered intermediary, inhibiting 40–70% of reactive oxygen species when analyzed by the DPPH and ABTS methods (Table 4). Throughout postharvest, there was an increase in free-radical scavenging, indicating that fruit stored for a longer period still show a great antioxidant capacity. An increase in phenolic content was also observed throughout the days (Table 3), probably since the studied compounds stand out among those with antioxidant properties in fruits and vegetables (Russo et al., 2018) and there was a high correlation between the studied variables in the multivariate analysis (Figure 2).

The contents of total phenolic compounds and of the DPPH and ABTS radicals used to quantify antioxidant activity increased in 28, 26, and 37%, respectively, during storage (Tables 1 and 3), similarly to that of flavonoids. Therefore, throughout the study period, there was an accumulation of all quantified phenolic compounds and an increase in antioxidant activity, indicating that older fruit have a higher nutritional value than the freshly picked ones. When comparing months of harvest, no difference was observed in total phenolic contents and, differently from expected, antioxidant activity was higher in August.

Despite the high correlation between phenolic compounds and antioxidant activity, it is believed that other compounds that were not evaluated here also show antioxidant capacity in 'Emerald' blueberries, especially since the fruit harvested in August had a greater antioxidant activity quantified by scavenging of the DPPH radical. Some authors reported a moderate correlation between phenols and antioxidant capacity when using the ABTS, DPPH, and ferric reducing antioxidant power (FRAP) methods, emphasizing the assumption that phenolic content alone does not allow a precise indication of the antioxidant activity

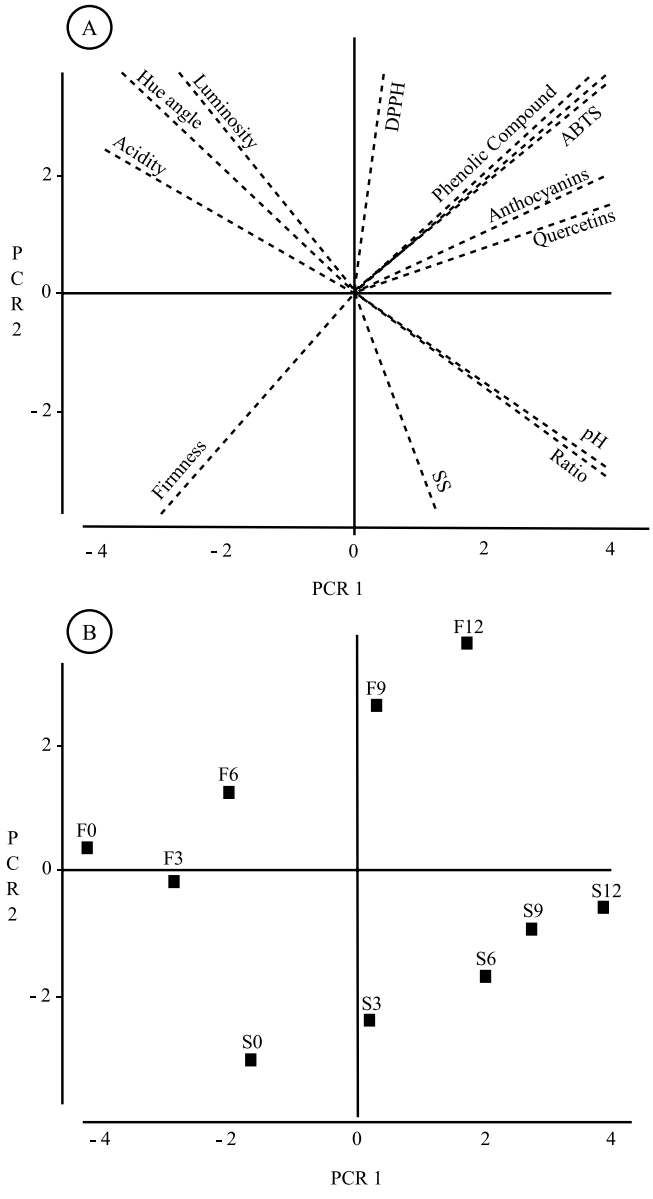

Figure 2. Principal components analysis for the physical, chemical, and biochemical attributes of 'Emerald' blueberries (*Vaccinium* spp.) cultivated in a subtropical region, without chilling, in Brazil, and stored at 22°C and 70% relative humidity for 12 days, showing: analyzed variables (A) and days of evaluation (B). F0, F3, F6, F9, and F12, 0, 3, 6, 9, and 12 days after harvest in August, respectively; and S0, S3, S6, S9, and S12, 0, 3, 6, 9, and 12 days after harvest in October. PCR1 and PCR2 explain 58 and 33% of the total variation of the data, respectively. DPPH, 2,2-diphenyl-1-picrylhydrazyl; ABTS, 2'-azino-bis 3-ethylbenzothiazoline-6-sulfonic acid; Ratio, ratio between total soluble solids and titratable acidity; and SS, soluble solids.

of blueberries (Giovanelli & Buratti, 2009; Rodrigues et al., 2011). Another point that might have resulted in the higher scavenging of reactive oxygen species by the DPPH radical in August was the lower temperature in the preceding months (Figure 1), which might have caused less stress to the blueberries. These findings are in alignment with those observed for other vegetables in conditions similar to those of the present work (Guassi Signorelli et al., 2021).

When comparing months of harvest, there were no differences regarding firmness, a qualitative attribute that determines the shelf-life period of blueberries. However, in both months, firmness values were reduced during storage, indicating fruit softening (Table 4), which may be related to water loss, a reduction in pectins and pectates, and an increase in enzymatic activities (Liu et al., 2019). Despite this, the 'Emerald' blueberries, produced in a subtropical region without chilling, remained suitable for commercialization and consumption until 12 days after harvest. This is an important result, since, for 'Snowchaser' blueberries, belonging to the same group as 'Emerald', this period was of only 6 days (Jimenes et al., 2018). The fact that, in the present study, the fruit were manually harvested and directly placed in packaging for transport also helped to extend shelf life, since blueberries are extremely susceptible to mechanical damage, which leads to loss of firmness, decreasing fruit quality and shelf life (Xu et al., 2015). In addition, since there was no effect of month of harvest on fruit firmness, if the point of harvest (equal for both periods) is respected throughout harvest, this attribute will not be damaged during postharvest.

SS contents, pH, and the TSS/TA ratio were higher in the fruit harvested in October (Tables 1 and 3). The obtained values are indicative that the fruit from this month were sweeter and less acidic, and, therefore, had a milder flavor. During the evaluated period, SS contents remained the same, whereas pH and the TSS/TA ratio increased and acidity decreased, which is characteristic of small fruit.

The higher SS contents and pH of the fruit harvested in October might be related to the temperature of the production environment, which interferes in fruit composition (Musacchi & Serra, 2018). The accumulation of SS increases as environmental temperature increases, as long as it does not exceed 30°C (Kullaj, 2016). In present work, the temperatures during fruit ripening before the first harvest were lower than those before the second one (Figure 1), which probably affected the obtained results.

During fruit maturation, temperature also has a strong influence on the concentration of organic acids (Kullaj, 2016). In addition to increasing fruit respiration, which consumes organic acids as a substrate, higher temperatures also increase the activities of the malic enzyme, decarboxylating malic acid and pyruvate (Costa et al., 2012). Therefore, the fruit that ripened at higher temperatures, i.e., that were harvested in October, presented a lower TA and a higher pH. However, during the storage days for both periods of harvest, TA values decreased and pH values increased, which can be attributed to the fact that blueberries use organic acids after harvest as a substrate in their respiratory process.

In the PCA, the two principal components (PCR1 and PCR2) were capable of explaining 91% of the total variation of results, that is, 58 and 33%, respectively (Figure 2). Therefore, days after harvest were better characterized by PCR1, with the leftmost values referring to day 0 (harvest) or the beginning of postharvest, and the rightmost values referring to the end of postharvest. However, the months of harvest peak were better characterized by PCR2, with the values for the evaluations in August and October staying above and below the axis, respectively.

According to PCR1, on the day of harvest, the fruit showed a higher acidity and firmness (variables of higher importance). However, at the end of postharvest, the fruit were characterized by a higher content of anthocyanins, quercetins, phenolic compounds, ABTS, and chromaticity (also variables of higher importance). Therefore, for the two harvest periods, the postharvest characteristics were moving to the right and upwards, which reinforces the previously obtained results, showing increases in phenolic compounds, anthocyanins, quercetins, and antioxidant activity during the storage period. According to PCR2, the harvest in August resulted in fruit with a higher DPPH radical scavenging and a lower content of total SS; therefore, fruit harvested in October had a greater TSS/TA ratio and a lower antioxidant capacity.

The PCA also allowed correlating variables among each other. The values obtained for anthocyanins and quercetins were highly related, as were those for

phenolic compounds, chromaticity, and ABTS radical scavenging. Furthermore, firmness was opposed to all these attributes, evidencing the changes in fruit quality throughout the evaluation days.

Conclusions

1. Regardless of the harvest month (August and October), 'Emerald' blueberries (*Vaccinium* spp.) grown in a subtropical region, in Brazil, show a good post-harvest shelf life up to 12 days at room temperature, with satisfactory fruit quality levels.

2. 'Emerald' blueberries cultivated in a subtropical region with a mild winter present a more intense fruit coloration and biochemical attributes with higher values when harvested in October, the second harvest peak.

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