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CERCETARI PRIVIND CONȚINUTUL BIOCHIMIC AL FRUCTELOR LA UNELE DESCENDENȚE HIBRIDE DE AFIN

RESEARCHES ON THE BIOCHEMICAL CONTENT OF FRUITS IN SOME BLUEBERRY HYBRID PROGENY

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Abstract

Breeding highbush blueberry (*Vaccinium corymbosum* L.) is a goal for many researchers, as many blueberry cultivars are cultivated worldwide mainly due to their biochemical composition that can reduce the risk of many diseases. The study was carried out over a period of three years to evaluate fruit size, average weight per fruit, firmness, but also the total content of bioactive compounds, such as polyphenols, flavonoids, anthocyanins, tannins and carotenoids, along with vitamin content. C, total sugar, extracted from frozen blueberries. Three blueberry cultivars ('Delicia', 'Northblue' and 'Duke'), an advanced selection ('4/6') and their hybrid progeny ('Delicia x Duke', 'Delicia x Northblue', ' Delicia x 4/6') were evaluated. The plants were grown at the Research Institute for Fruit Growing, Pitesti, Romania in open field studies in a randomized block with three replications (5 plants/genotype/replication). The research carried out showed the following: average weight/plant recorded values between 1.42 g (hybrid 16-12-10) and 2.47 g ('4/6'), fruit firmness showed variations from 13.9 N .('Northblue') to 29.37 N ('Delicia'), soluble dry matter 11.4°Brix (16-12-15) and 17.01°Brix (16-20-22), polyphenols oscillated from 114.98 (16-12-19) to 1,652 mg GAE/100g (16-20-12), vitamin C had a lower level of 2.3% and the upper level of 16.86% (16 - 9-10). These results indicate the importance of the blueberry species for its breeding and its role in health and nutrition.

Cuvinte cheie: *Vaccinium corymbosum L.,* genotipuri, compoziție biochimică,
Key words: *Vaccinium corymbosum L.,* cultivars, biochemical composition.

1. Introduction

The breeding of highbush blueberry (*Vaccinium* Genus, *Ericaceae* Family, *Ericales* Order) has expanded in the last decades. Two researches, Elizabeth White and Dr. Frederick Coville tried the breeding from wild to domesticated blueberry (Ha).

At the beginning of the 1900s, Dr. Frederick V. Coville began the activity of breeding the blueberry, obtaining the first hybrid in 1908. He studied the requirements of this particular one in relation to the pH of the soil, the effect of chilling temperature, and its improvement. In his research work he collaborated with Elizabeth White and they made many hybrid combinations, obtaining many varieties that are still used in commercial blueberry crops: 'Bluecrop', 'Weymouth', 'Blueray', 'Rubel', 'Berkeley', 'Coville', 'Jersey'. The main growing crops of *Vaccinium corymbosum* are in the United States, but it is gradually spreading throughout the world (Kaiser, 2009). Blueberry is interesting fruit for potential health benefits due to their bioactive compounds (polyphenols, flavonoids, anthocyanins, tannins and carotenoids, along with vitamin content. C, total sugar) (Sinelli et al., 2008).

The aim of this work was to examine the biochemical potential of 35 blueberry hybrids obtained from 'Delicia x Duke', 'Delicia x Northblue', 'Delicia x 4/6'.

2. Material and methods

The plant material analyzed was composed of the 4 genitors and their progenies (a total of 39 blueberry progenies and cultivars) harvested in the in an open field trial in randomized block design with three repetitions plots (5 plants/ genotype/ repetition) between 2019-2022, at the Research Institute for Fruit Growing Pitești-Mărăcineni (RIFG), in South of Romania at 44°54’12” Northern latitude, and 24°52’18” Eastern longitude, 284 m altitude.

The origin of the genitors was that the 'Delicia' cv. obtained from open polination of 'Patriot' cv., 'Duke' cv. obtained from (Ivanhoe × Earliblue) × (E30 ×Eu), 'Northblue' cv. obtained from MN 360 (310 × US3) – (G × Ashworth) × US3, and the advanced selection '4/6' obtained from open polination of 'Spartan' cv. (Mladin et al., 2008).

Also the hybrids were harvested at the full ripe berry stage and they were divided visually in homogenous classes for maturation stage. 'Delicia x Duke' and 'Delicia x Northblue' ripening to the begining July – three weeks of July, 'Delicia x 4/6' ripening to the end of June to 10 July.

After harvesting the fruit were frozen at -4 °C until to perform the analysis. The indicators studied were recorded on a sample a 20 blueberry fruits.

The average weight of fruits was determined and the results were expressed in g/fruit. The shape index: the height and equatorial diameter of each fruit were measured with a digital caliper (mm), then calculated according to the formula height/fruit diameter (Matiacevich et al., 2013);

The firmness was determined with a penetrometer Bareiss HPE II Fff nondestructive test, with a measuring surface of 0.25 cm². The soluble solids content was determined with digital refractometer PR Series.

The total polyphenols content (TPC) was determined according to the methodology suggested by Matić et al., 2017. The determination of lycopene and β-carotene levels, the total sugar content (TSC), total flavonoids (TFC) content was determined according to the method described in Tudor-Radu et al., 2016. The determination of the anthocyanins (TAC) content was made according to the methodology suggested by Di Stefano and Cravero, 1989. The content of vitamin C was determined according colorimetric method suggested by Omaye.

Statistical analysis was made by IBM SPSS 14 program (SPSS Inc., Chicago, IL, USA). All results were statistically evaluated by analysis of variance (ANOVA). Differences between cultivars were highlighted through Duncan's multiple test range ($p < 0.005$). Graphical representations were performed with Microsoft Office 2007.

3. Results and discussions

The results showed significant differences between all genotypes and all investigated parameters.

Regarding 'Delicia × Duke' hybrids, the mass of the fruit had the highest value in the hybrid 16-12-11 (2.46 g), close to the weight of the fruit in the parents, because both for the 'Delicia' cv., and for the 'Duke' cv., fruit masses over 2 g were obtained. Also, large fruits (over 2 g) were recorded for the hybrids 16-12-9 and 16-12-7 (2.26 g and 2.24 g, respectively). Hybrid 16-12-10 presented the lowest mass of fruits, namely 1.42 g (Fig. 1).

Regarding the fruit shape index, it reached the highest values of 0.75 in hybrids 16-12-7, 16-12-14, 16-12-15, 16-12-16 and 16 -12-30, close to the values of the parents: 0.67 for the 'Delicia' cv. and 0.74 for the 'Duke' cv.

From the determinations made for the firmness of the fruit pulp, it emerged that a single hybrid, which recorded the value of 35.79 N, was superior to the genitor 'Delicia'. A number of 12 descendants, out of the 17, showed higher firmness compared to the 'Duke' cv.The average sugar content of the hybrids showed oscillations between the lower limit of 2.52 mg % in hybrid 16-12-18 and the upper limit of 4.97 mg % in hybrid 16-12-19. Compared to the parents, the 'Delicia' cv. with a content of 5.86% and the 'Duke' cv. with 5.79%, the hybrids showed lower sugar levels. The average lycopene level oscillated between 0.07 mg/100 g in hybrid 16-12-28 and 0.35 mg/100 g in hybrid 16-12-14. There was only one case where the lycopene level of the hybrid exceeded the concentration of the parents, namely hybrid 16-12-14 (Fig. 1).

β-Carotene showed a higher average than lycopene, although the lower limit reached by the hybrids concentration dropped to 0.06 mg/100 g (16-12-19 hybrid) and the upper one rose to 0.31 mg/100 g (16-12-26 hybrid). Compared to the parents, all progeny showed levels well below their β-carotene concentrations (0.5 mg/100 g in 'Delicia' cv. and 0.39 mg/100 g in 'Duke' cv., respectively).

An opposite situation was observed regarding the vitamin C content of the hybrids, the upper limit being 14.86 mg/100 g (hybrid 16-12-24) and the lower limit being 5.73 mg/100 g (hybrid 16 -12-23), while the parents had a content of 3.92 mg/100 g ('Delicia' cv.) and, respectively, 2.30 mg/100 g ('Duke' cv.). Practically, in the case of vitamin C, with only one exception, all the hybrid offspring presented higher concentrations than the parents.

The total content of phenolic compounds (Fig. 2) of the hybrid progeny 'Delicia x Duke' ranged between 154.83 mg EAG/100 g (16-12-13) and 817.86 mg EAG/100 g (16-12- 2. 3). The comparative analysis of the hybrids and the parents indicated that only 2 of the hybrids presented lower polyphenol content than the parents 'Delicia' (415.23 mg EAG/100 g) and 'Duke' (396.51 mg EAG/100 g). The hybrid 16-12-19 (114.98 mg EAG/100 g) and hybrid 16-12-14 (154.83 mg EAG/100 g).

The limits of variation of tannins were reached in hybrids 16-12-16 (127.38 mg EC/100 g) and 16-12-10 (437.33 mg EC/100 g), respectively. As can be seen from table 4.30, only two hybrids showed a higher level of tannins than the 'Duke' variety (16-12-10 and 16-10-23), while 12 hybrids showed a higher level compared to variety 'Delicia'.

The level of flavonoids increased from 61.44 mg EAG/100 g (16-12-13 hybrid) to 185.99 mg EAG/100 g (16-12-18 hybrid). Most of the hybrids showed a higher content than the parents, which had

an average content of 127.61 mg EAG/100 g in the 'Delicia' cv., respectively 125.89 mg EC/100 g in the 'Duke' cv.

For the hybrid progeny 'Delicia × 4/6', the mass of the fruit of the parents exceeded the mass of the hybrids (Fig. 3). Thus, the variety 'Delicia' had 2.44 g, and the elite 4/6 recorded 2.47 g/fruit. Of the 13 analyzed hybrids, only 4 exceeded the average weight of 2 g/fruit, namely: 16-20-3 (2.12 g), 16-20-11 (2 g), 16-20-12 (2, 09 g) and 16-20-26 (2.03 g). The hybrid 16-20-23 reached the lower limit of the fruit mass of 0.82 g. The size index of the hybrids had a minimum value of 0.7 in the hybrids 16-20-11 and 16-20-12 and reached the maximum limit of 0.88 in the 16-20-23 hybrid.

The fruits reached the upper limit of firmness for the variety 'Delicia' (the maternal parent), with a value of 32.62 N. The average limits of the hybrids were between 9 N for the hybrid 16-20-23 and 16.03 for the hybrid 16- 20-3.

The sugar content of the hybrids (ranging from 8.22% in hybrid 16-20-19 and 16.36% in hybrid 16-20-22) exceeded the upper limit of the parents (4.33% in elite 4/6 and 5.86% for the 'Delicia' cv.).

In the case of vitamin C content, the parents had lower limits than the hybrids (the 'Delicia' cv. with 3.92 mg/100 g and the elite 4/6 with 3.55 mg/100 g) (Fig. 4). The hybrid 16-20-11 stands out with the highest vitamin C content, 14.55 mg/100 g.

For lycopene, the upper limit was recorded in the genitor 'Delicia' (0.27 mg/100 g). The hybrid with the highest level of lycopene (0.26 mg/100 g) was 16-20-19, and with the lowest level of lycopene (0.06 mg/100 g) was the hybrid 16-20-4. In the case of β-carotene, only one hybrid had a level higher than the parents (0.5 mg/100 g in the 'Delicia' cv. and 0.42 mg/100 g in elite 4/6), namely, 16-20-19 with 0.64 mg/100 g.

For the hybrids 'Delicia x Northblue' regarding the weight of the fruit, (Fig. 5) the parents had higher values than the offspring, namely 2.44 g for the variety 'Delicia' and 2.2 g for the 'Northblue' cv.. Hybrid 16-9-6 recorded the highest fruit mass (1.87 g) and the lowest fruit mass was recorded in hybrids 16-9-10 and 16-9-11 (1.49 g).

The shape index of the hybrid progeny reached the upper limit in hybrid 16-9-11 with the value of 0.83, and the lower limit was 0.72 in hybrid 16-9-6,

Fruit firmness showed differences between genotypes. The highest values of hybrid fruit firmness were 25.33 N in hybrid 16-9-18, 22.75 N in hybrid 16-9-8 and 22.47 in hybrid 16-9-1. The lowest values of hybrid fruit firmness were 18.55 N in hybrid 16-9-11, 18.6 N in 16-9-6 and 16.68 N in hybrid 16-9-10. The parent 'Delicia' had a higher value than the offspring (32.63 N), and the parent 'Northblue' had a lower value than all the offspring (13.94 N).

The average content of sugars was higher in the fruits of the offspring: 7.82% in the hybrid 16-9-11 and 7.43% in the hybrid 16-9-18. The sugar content of the parents varied from 4.61 % in 'Northblue' cv. and 5.86 % in 'Delicia' cv. In the case of vitamin C content, hybrid 16-9-10 reached the maximum limit (13.77 mg/100 g) surpassing the parents, 'Delicia' cv., with 3.92 mg/100 g and 'Northblue' cv., with 2.87 mg/100 g. The minimum limit of vitamin C content was 3.14 mg/100 g recorded in hybrid 16-9-1.

The lycopene level of the hybrids did not exceed that of the parents, 'Delicia' cv., with 0.27 mg/100 g and 'Northblue' cv., with 0.21 mg/100 g. The lycopene level of the hybrids ranged from 0, 04 mg/100 g in hybrid 16-9-1 to 0.12 mg/100 g in 16-9-10. The β-carotene level (Fig. 5) reached the maximum in the parents: 0.5 mg/100 g in the variety 'Delicia' and 0.53 mg/100 g in the 'Northblue' cv. Regarding the level achieved by the hybrids, it ranged from 0.05 mg/100 g in hybrid 16-9-1 to 0.24 mg/100 g in hybrid 16-17-11.

The upper limits of the total content of phenolic compounds (Fig. 6) of the hybrid progeny 'Delicia x Northblue' were recorded by hybrids 16-9-1 with 749.94 mg EAG/100 g and 16-9-11 with 703, 19 mg EAG/100 g. The lower limit, with the value of 281.02 mg EAG/100 g, was recorded in the 16-9-10 hybrid. In the case of parents, 'Delicia' cv. (415.23 mg EAG/100 g) was exceeded by 5 progeny (16-9-1, 16-9-6, 16-9-8, 16-9-11 and 16- 9-18), and 'Northblue' cv. (524.22 mg EAG/100 g) was outperformed by 4 progeny (16-9-1, 16-9-8, 16-9-11 and 16-9-18).

The comparative analysis of the tannin content indicated that the hybrids reached the upper limit of 479.53 mg EAG/100 g at hybrid 16-9-6, surpassing the parents that had a content of 207.09 mg EAG/100 g at cultivar 'Delicia' and 278.28 mg EAG/100 g in cultivar 'Northblue'. The lower limit of hybrids was 110.84 mg EAG/100 g in hybrid 16-9-8.

In the case of flavonoids, hybrid 16-9-11 was noted with the highest content (225.96 mg EC/100 g), and the lowest content was recorded in hybrid 16-9-8 (93.64 mg EC/100 g). The values obtained in the parents were 127.61 mg EC/100 g in the 'Delicia' cv. and 146.68 mg EC/100 g in the 'Northblue' cv.

The maximum variation limits of anthocyanins were reached in hybrids 16-9-6 with 392.91 C3G/100 g and 16-9-8 with 312.91 C3G/100 g, and the minimum limit was 116.41 C3G/ 100 g for the 16-9-11 hybrid. The parents had the limits of 214.85 C3G/100 g for the 'Delicia' cv. and 119.73 C3G/100 g for the 'Northblue' cv.

4. Conclusions

'Delicia × Duke'

In this combination, 'Delicia' cv. presented levels of polyphenols and anthocyanins close to the average value, similar to the content of organic acids, but stood out for the maximum level of lycopene.

The four of the 16 hybrids obtained from these cultivars showed intermediate or higher fruit mass compared to the parents and only 3 hybrids had soluble substance content higher than one of the parents. With two exceptions, the level of polyphenols of the hybrids exceeded the values determined for the parents, and vitamin C was in all cases analyzed significantly more concentrated in the hybrids.

'Delicia x 4/6'

Elite 4/6 had the highest concentration of β-carotene. In both varieties, both fruit acidity and sugar levels are low.

In this case, 8 out of the 12 hybrids showed higher levels of polyphenols than the parents, only 2 hybrids stood out for the high level of anthocyanins, but without exception the hybrids showed vitamin C contents that exceeded the values determined for the parents.

'Delicia x Northblue'

The value of this combination is mainly due to the maximum content of vitamin C and organic acids, as well as the high level of polyphenols in the fruits of the Northblue variety. In addition, for the 'Delicia' cv., the concentration of anthocyanins and total titratable acidity are medium.

In this case, 4 of the 6 hybrids showed slightly higher polyphenol levels compared to the parents. A higher vitamin C content was also determined in a similar number of hybrids and only two progeny were noted for their high level of anthocyanins.

Our results obtained in this research are related to the knowledge of the important quality factors from 4 cultivars and their hybrid progenies harvested in Romania. It is proposed to create new valuable cultivars of *Vaccinium corymbosum L.* from these hybrids that had the most important the biochemical content.

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Figures

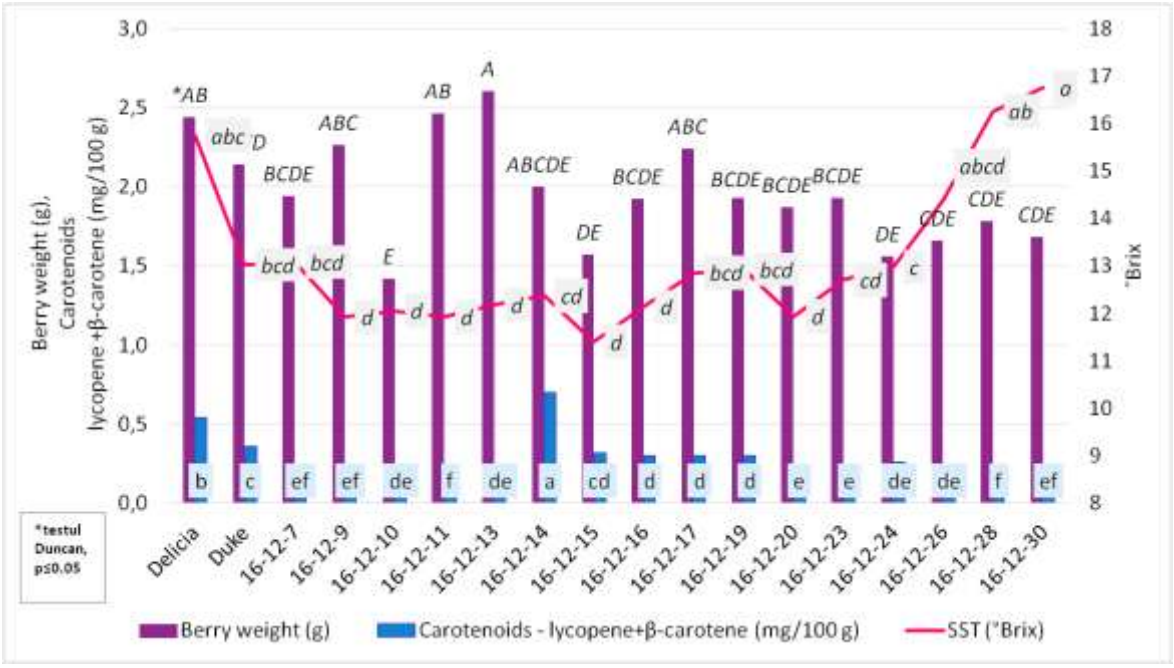

Fig. 1 The influence of the genotype on some biometric and biochemical indicators in the hybrid combination 'Delicia × Duke'

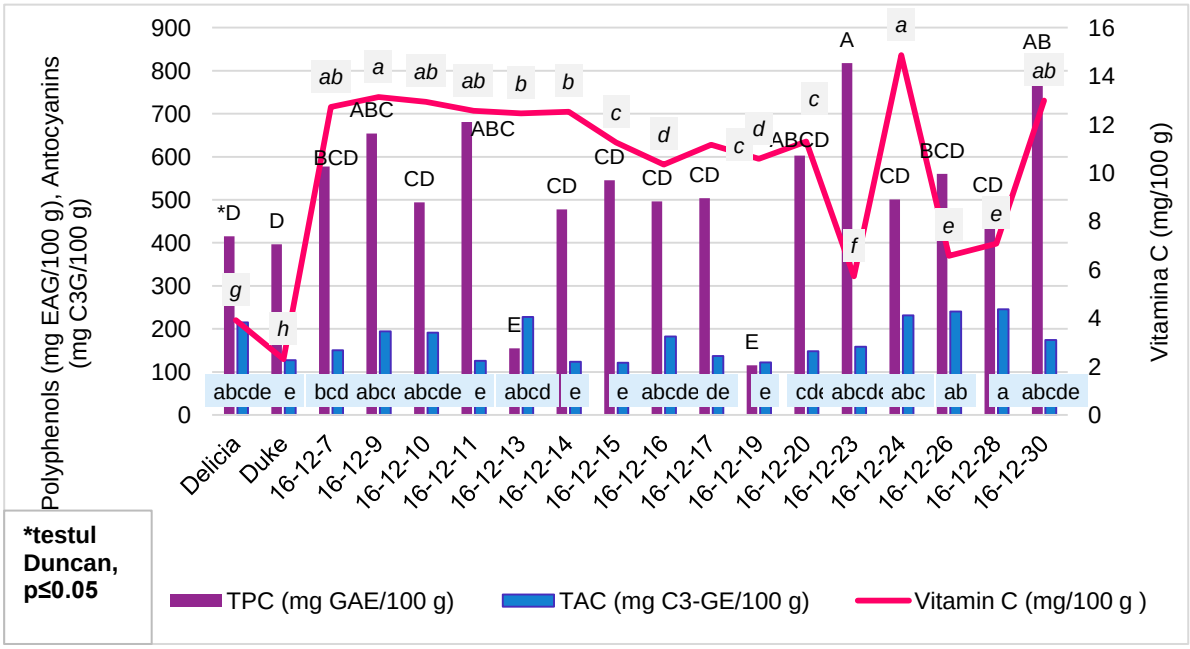

Fig. 2 The influence of the genotype on some biochemical indicators in the hybrid combination 'Delicia × Duke'

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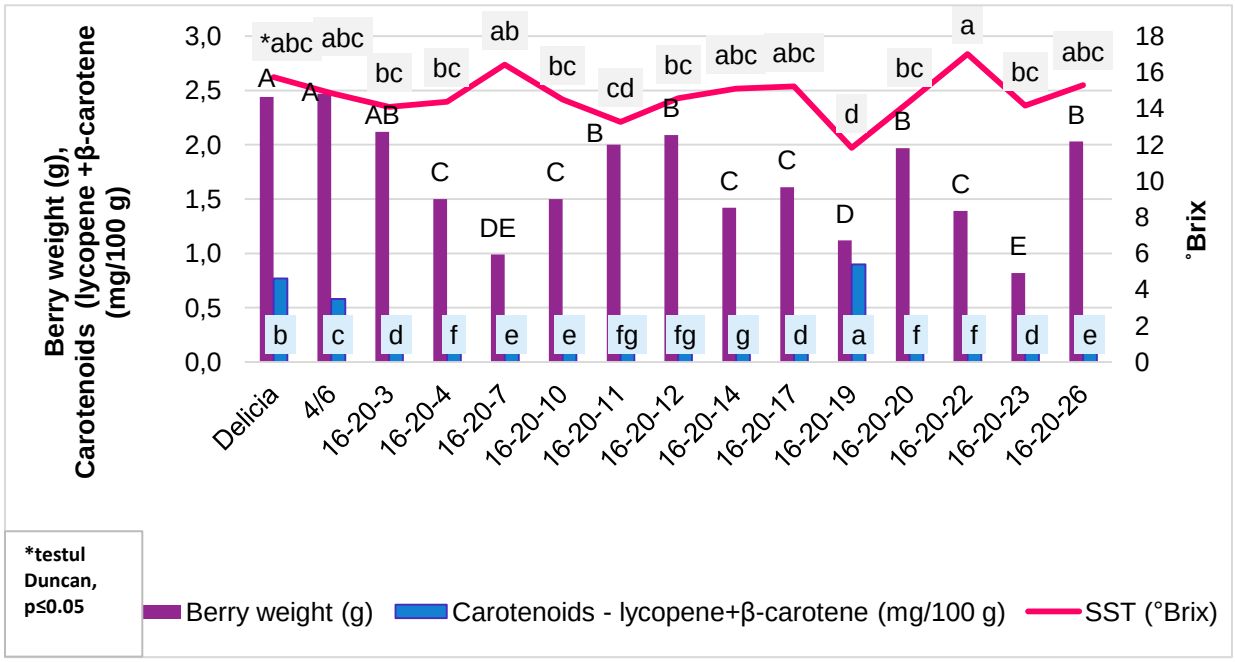

Fig. 3 The influence of the genotype on some biometric and biochemical indicators in the hybrid combination 'Delicia × 4/6'

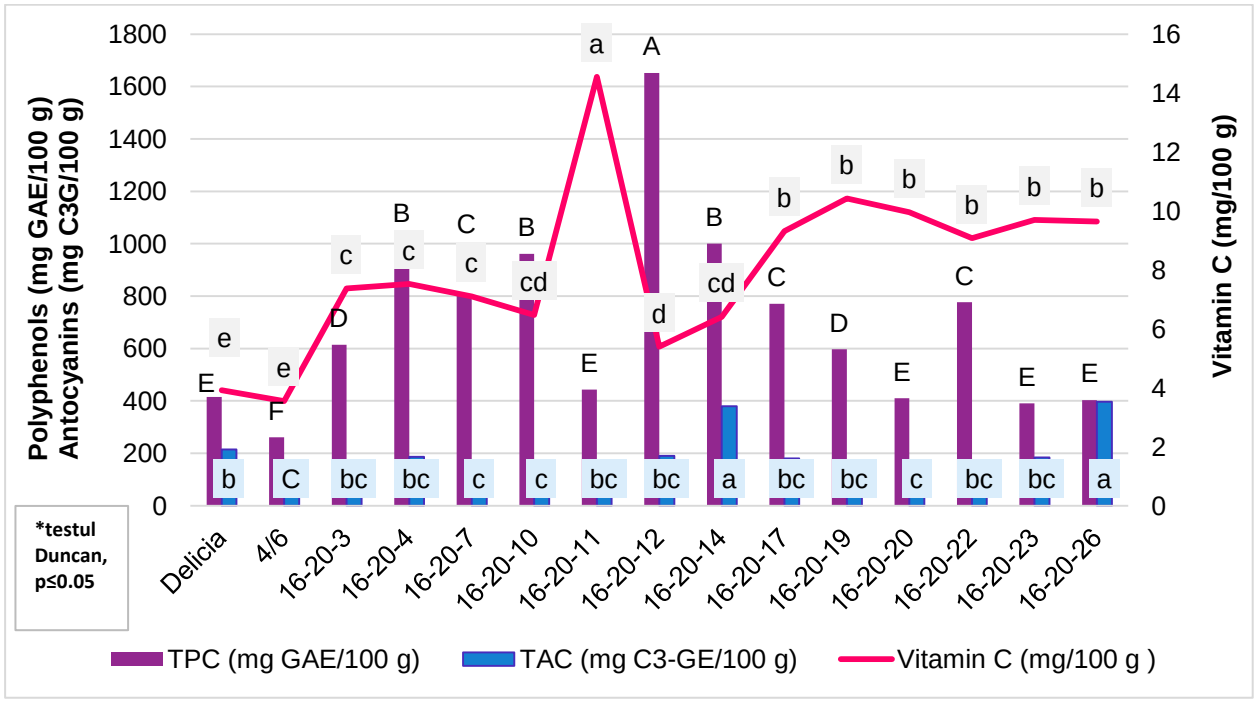

Fig. 4 The influence of the genotype on some biochemical indicators in the hybrid combination 'Delicia × 4/6'

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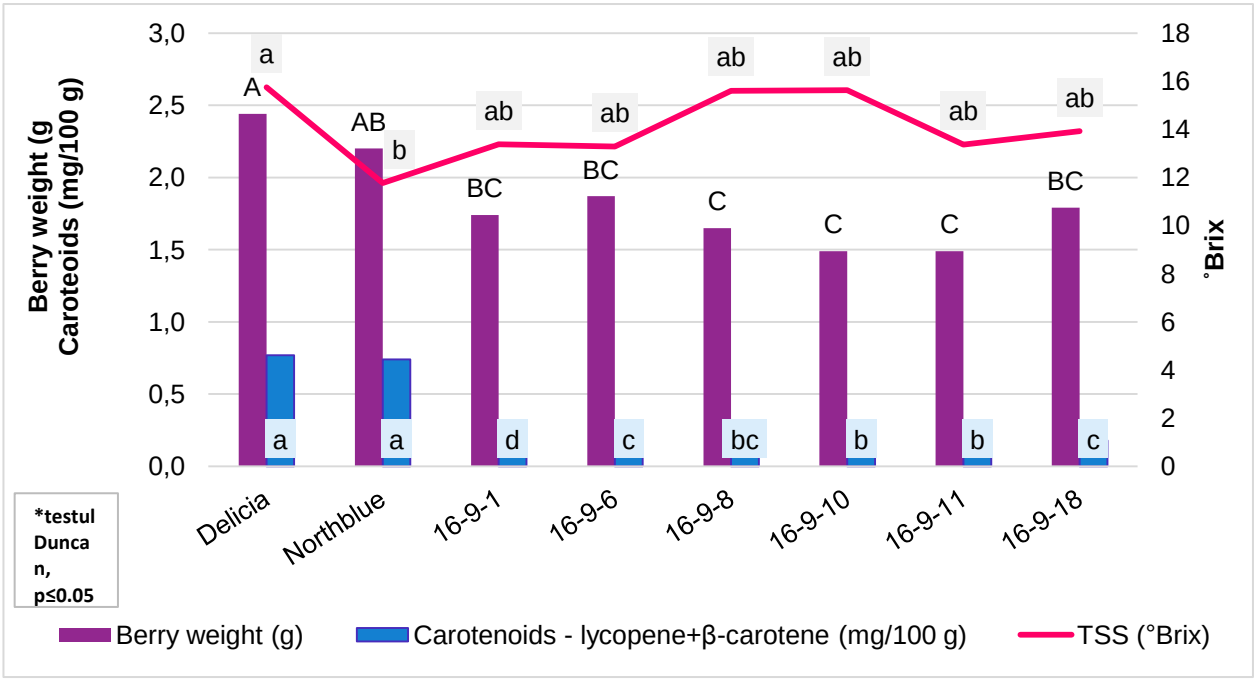

Fig. 5 The influence of the genotype on some biometric and biochemical indicators in the hybrid combination 'Delicia × Northblue'

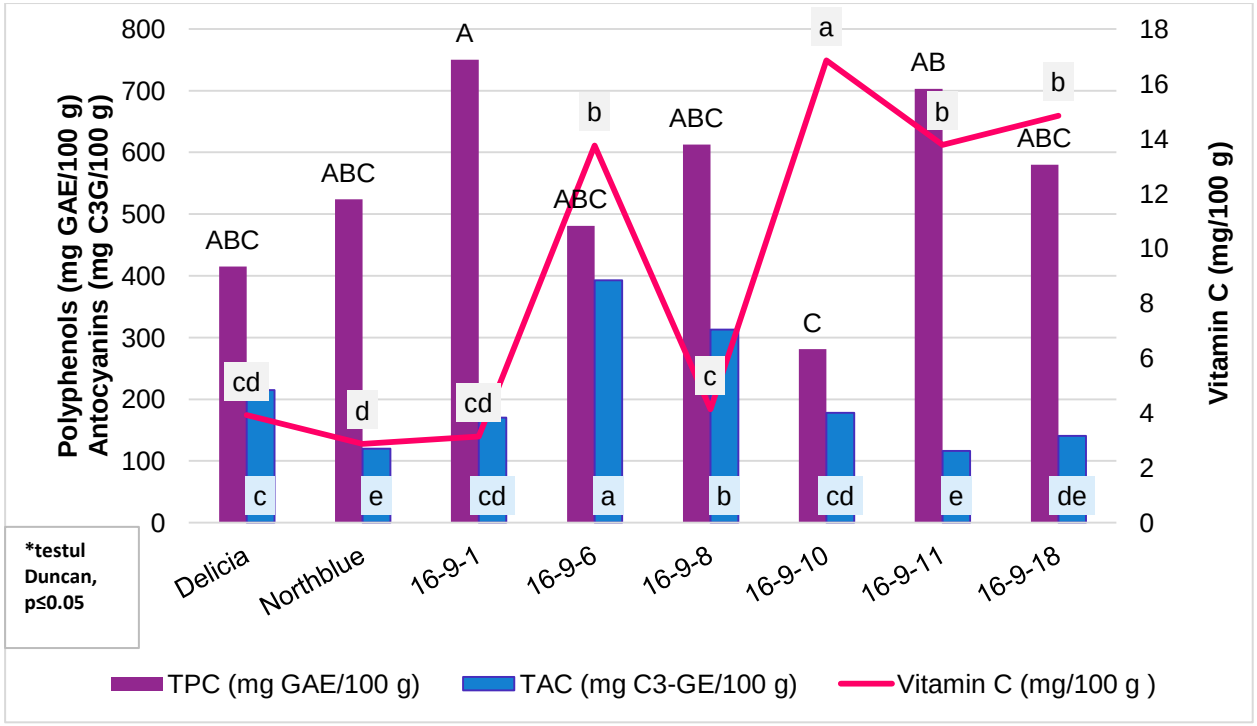

Fig. 6 The influence of the genotype on some biochemical indicators in the hybrid combination 'Delicia × Northblue'