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EVALUAREA CALITĂȚII NUTRIȚIONALE ȘI A COMPUȘILOR BIOACTIVI DIN FRUCTELE DE *LONICERA CAERULEA*

EVALUATION OF NUTRITIONAL QUALITY AND BIOACTIVE COMPOUNDS OF *LONICERA CAERULEA*

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Abstract

This study evaluates and compares the nutritional quality and bioactive compounds of berry fruits from *Lonicera caerulea* L. (blue honeysuckle) grown in Romania. These berries are known for their rich content of vitamins, minerals, and bioactive compounds, which contribute to their potential health benefits. The study was carried out over a period of two years to evaluate fruit size, average weight per fruit, firmness, but also the total content of bioactive compounds, such as polyphenols, flavonoids, anthocyanins, tannins, carotenoids and vitamin C, total sugar, extracted from fresh berries. The aim of the study was to compare the fruit quality, chemical composition of berries from new introduced in the Institute's collection of blue honeysuckle: 'Wojtek', 'HoneyBee', 'Jugana', 'Docz Velika', 'Bakczarskij Velikan', and 'Kami', which was used as a control. The research carried out showed the following results: average weight per plant recorded values between 0.52 g ('Bakczarskij Velikan') and 1.03 g ('Honey Bee'); fruit firmness showed variations from 6.37 N ('Docz Velika') to 15.07 N ('Bakczarskij Velikan'); total soluble solids ranged from 11.37°Brix ('Honey Bee') to 13.33°Brix ('Kami'); polyphenol content oscillated from 9,977.24 mg GAE/100g ('Kami') to 8,538.30 mg GAE/100g ('Honey Bee'); and vitamin C levels ranged from 619.69% ('Kami') to 247.23% ('Wojtek'). These results indicate the importance of the *Lonicera* cultivars for their role in health and nutrition.

Cuvinte cheie: soi, compoziție biochimică, lonicera.
Key words: cultivars, biochemical composition, lonicera.

1. Introduction

Lonicera caerulea L., commonly known as haskap berry or blue honeysuckle, is native to parts of Eastern Asia and Europe, with strong cultural and practical significance in regions such as Russia, China, and Japan. It is a member of the *Caprifoliaceae* family and is well-known for its edible berries, which are rich in antioxidants, vitamins, and nutrients (Rehder, 1903; Celli et al., 2014; Lauritzen et al., 2015; Gołba, et al., 2020). Many of these species are utilized as ornamental and medicinal. The fruits produced by these edible shrubs are known by various names, including blue honeysuckle, haskap, haskap berry, honeyberries, and zimolost (in Russian). Among the *Lonicera* species, blue honeysuckle (*Lonicera caerulea* L. sensu lato) is the most widespread (Pojarkova, A. I., 1958). It has a circumboreal distribution, meaning it is found across the northern regions of the globe, ranging from North America and the mountains of Southern Europe through the Middle East and Northern Asia to Japan. The increasing awareness among consumers about the importance of healthy eating and consuming foods with health-promoting properties has spurred the search for and characterization of new species for such purposes (Plekhanova,1999). One notable group of plants gaining attention in this context belongs to the genus *Lonicera* (Lamoureux et al., 2011). This includes varieties such as *Lonicera caerulea* var. *edulis*, *Lonicera caerulea* var. *kamtschatica*, *Lonicera caerulea* var. *altaica*, *Lonicera caerulea* var. *byarnikovae*, and *Lonicera caerulea* var. *emphyllocalyx*, along with their hybrids. Collectively, these are known as *Lonicera caerulea* L., and are commonly referred to as haskap, blue honeysuckle, honeyberry, or sweet berry honeysuckle (Chmiel et al., 2014).

The fruits of *Lonicera caerulea* L. are comparable to other well-known fruits such as strawberries, blueberries, blackberries, and blackcurrants. These fruits are highly valued in the human diet due to their rich content of bioactive compounds, which are associated with numerous health benefits. Consequently, *Lonicera caerulea* L. is emerging as a significant addition to the superfruit category, offering potential advantages for health-conscious consumers (Chang et al., 2019).

The fruit is resistant to cold, pests, various soil acidities, and diseases. However, its main attraction is mostly associated with its health properties. It is noted for its anticancer, anti-inflammatory, and antioxidant activities, which are important factors in improving human health. These features stem from the diverse content of phytochemicals in honeysuckle berries, including high concentrations of phytochemicals such as hydroxycinnamic acids, hydroxybenzoic acids, flavanols, flavones, isoflavones, flavonols, flavanones, and anthocyanins, as well as iridoids, present in exceptional amounts in the fruit. The content and health properties of the fruit have been identified to depend on cultivar, genotype, and the place of harvesting. The fruit has great potential to minimize the negative effects of UV radiation, diabetes mellitus, and neurodegenerative diseases, and to exert hepatoprotective and cardioprotective activity.

The aim of the study was to to comprehensively compare the yield, fruit quality, chemical composition, and fruit color of berries from blue honeysuckle (*Lonicera caerulea* L.): 'Wojtek', 'HoneyBee', 'Jugana', 'Docz Velikana', 'Aurora', 'Bakczarskij Velikan', and 'Kami', which was used as a control.

2. Material and methods

The plant material analyzed was composed of the 7 cultivars harvested in the in an open field trial from *Lonicera* germplasm collection with three repetitions plots (5 plants/ genotype/ repetition) between 2023-2024, at the Research Institute for Fruit Growing Pitești Romania (ICDP).

The predominan soil type in the field trials was medium-textured and heavy-clay soil with medium to low humus content. The cultivation system consisted of raised beds, 60 cm wide, covered with plastic film and equipped with two irrigation tubes beneath the plastic mulch. Before planting, Complex 12-11-18+20%SO3 was applied as the base fertilization. Subsequent fertilization of the plantation was carried out by fertigation with nutrient doses determined based on soil analyses and the anticipated yield.

The average weight of the fruits was measured and reported in grams per fruit (g/fruit). The shape index was calculated by measuring the height and equatorial diameter of each fruit with a digital caliper (in millimeters), and then using the formula height/fruit diameter (Matiacevich et al., 2013).

Firmness was assessed using a Bareiss HPE II Fff penetrometer with a nondestructive test method and a measuring surface of 0.25 cm². The soluble solids content was determined using a digital refractometer from the PR Series.

The total polyphenols content (TPC) was measured according to the methodology suggested by Matić et al., 2017. *Lycopene and β-carotene levels*, along with *total sugar content* (TSC) and *total flavonoids content* (TFC), were determined using the method described by Tudor-Radu et al., 2016. *The total anthocyanins content* (TAC) was determined using the methodology suggested by Di Stefano and Cravero, 1989. *Vitamin C content* was measured using the colorimetric method suggested by Omaye.

The DPPH method was developed by Blois in 1958 to determine antioxidant activity, using a stable free radical of 2,2-diphenyl-1-picrylhydrazyl (DPPH). In general, the DPPH method has been and continues to be used to evaluate the antioxidant properties of naturally occurring chemical compounds (Villano D et al., 2007).

Statistical analyses were performed using IBM SPSS Statistics version 14 (SPSS Inc., Chicago, IL, USA). All data were analyzed using one-way analysis of variance (ANOVA) to assess differences between groups. Post hoc comparisons between cultivars were conducted using Duncan's multiple range test, with statistical significance set at p<0.005p < 0.005p<0.005. Graphical representations of the results were generated using Microsoft Office Excel 2007. Genetic distances between cultivars were determined using Minitab software, version 18 (Minitab Inc., State College, PA, USA), based on the Euclidean distance formula. The Euclidean distance (d_{ik}) between two cultivars (i and k) was calculated as the square root of the sum of the squared differences between corresponding traits: dik=√(∑_j 〖(X_{ij}-X_{kj}))² where X_{ij} and X_{kj} represent the trait values for cultivar *i* and cultivar *k*, respectively, at the *j*-the trait.

3. Results and discussions

For the phenological development of *Lonicera* cultivars, bud swelling begins on February 16 for the 'Jugana' cultivar and concludes with the 'Honey Bee' cultivar on February 22. Flowering starts on March 10 for both the 'Jugana' and 'Docz Velikana' cultivars and ends on March 23 with the 'Honey Bee' cultivar. Mass flowering begins on March 18 for the 'Kami' cultivar. Harvest maturity occurs between May 2 for the 'Kami' cultivar until May 12 for the both 'Docz Velikana' and 'Honey Bee' cultivars (Table 1).

Significant differences were observed among all genotypes for the investigated parameters.

Regarding fruit mass, the highest value was recorded for the 'Honey Bee' cultivar at 1.03 g, followed by the 'Wojtek' cultivar at 0.90 g. The 'Bakczarskij Velikan' cultivar had the lowest fruit mass, at 0.52 g. Your results for 'Wojtek' (0.90 g) align with findings from previous research, including Gawroński (2014) and Molina et al. (2019), which reported that 'Wojtek' produced significantly larger fruits compared to other cultivars tested in those studies. This suggests that 'Wojtek' has consistent performance in terms of fruit size across different geographical locations and growing conditions. The Polish and Slovenian studies (such as those by Gawroński and Molina) serve as valuable benchmarks, confirming that 'Wojtek' consistently exhibits larger fruit size, which supports its attractiveness for growers seeking high-yielding, larger-berried cultivars (Table 2).

For the fruit shape index no significant differences were observed between genotypes, with values ranging from 2.49 for the 'Docz Velikana' cultivar to 1.82 for the 'Wojtek' cultivar (Table 2).

In terms of fruit pulp firmness, the 'Bakczarskij Velikan' cultivar exhibited the highest value at 15.07 N, while the 'Docz Velikana' cultivar had the lowest firmness at 6.37 N (Table 2).

No significant differences were observed between genotypes for total soluble solids, with values ranging from 13.33°Brix in the 'Kami' cultivar to 11.37°Brix in the 'Honey Bee' cultivar (Table 2).

The average sugar content of the genotypes exhibited fluctuations, with a minimum of 47.19 mg% in the 'Honey Bee' cultivar and a maximum of 78.66 mg% in the 'Kami' hybrid cultivar (Table 4).

Regarding lycopene and β-carotene content, the average lycopene levels were higher than those of β-carotene. Lycopene content ranged from 2.61 mg/100 g in the 'Docz Velikana' cultivar to 1.49 mg/100 g in the 'Kami' cultivar. In contrast, β-carotene levels varied from 1.26 mg/100 g in the 'Kami' cultivar to 0.47 mg/100 g in the 'Docz Velikana' cultivar (Table 4).

Regarding vitamin C content, the highest value was recorded in the 'Kami' cultivar at 619.69 mg/100 g, while the lowest was observed in the 'Wojtek' cultivar at 247.23 mg/100 g (Table 4).

The total content of phenolic compounds ranged from 9,977.24 mg GAE/100 g for the 'Kami' cultivar to 8,538.30 mg GAE/100 g for the 'Honey Bee' cultivar (Table 3).

Significant variation was observed in tannin content, with values reaching 994.22 mg EC/100 g for the 'Docz Velikana' cultivar and 802.42 mg EC/100 g for the 'Kami' cultivar (Table 3).

The flavonoid content increased from 311.68 mg GAE/100 g in the 'Aurora' cultivar to 421.38 mg GAE/100 g in the 'Bakczarskij Velikan' cultivar (Table 3).

The maximum variation limits of anthocyanins were recorded in the 'Wojtek' cultivar with 17.19 C3G/100 g, and the 'Docz Velikana' cultivar with 2.99 C3G/100 g (Table 3).

The dendrogram analysis identified six distinct groups based on genetic relationships. The groups are as follows:

The first group includes the cultivars 'Jugana' and 'Kami'.

The second group includes the cultivars 'Jugana' and 'Honey Bee'.

The third group includes the cultivars 'Jugana' and 'Wojtek'.

The fourth group includes the cultivars 'Kami' and 'Aurora'.

The fifth group includes the cultivars 'Jugana' and 'Docz Velikana'.

The sixth group includes the cultivars 'Docz Velikana' and 'Bakczarskij Velikan'.

The greatest genetic similarity was observed between the 'Docz Velikana' and 'Bakczarskij Velikan' cultivars, while the largest differences were found between the 'Jugana' and 'Kami' cultivars. The centroid method is a technique used in cluster analysis to measure the distance between two clusters. This method involves calculating the center of mass (centroid) for each cluster and then determining the distance between these centroids. The Euclidean distance is used to quantify the distance between centroids. The smallest Euclidean distance was observed between the centroids of the 'Bakczarskij Velikan' and 'Aurora' cultivars, indicating that these two cultivars are closest to each other in the feature space used for clustering analysis.

Conversely, the largest Euclidean distance was found between the centroids of the 'Kami' and 'Bakczarskij Velikan' cultivars, suggesting that these cultivars are the most distant from each other in the same feature space.

In practical terms, the distances between centroids can be used to assess the quality of the clusters and determine whether adjustments are needed in the number of clusters or the methodology used for clustering. These distances can also inform decisions on how to treat or analyze additional data associated with each cluster (Fig. 1).

4. Conclusions

This study characterized the profiles of major bioactive compounds, DPPH antioxidant capacity, and biometric traits in berries from seven blue honeysuckle (*L. caerulea*) cultivars. The 'Aurora' cultivar stood out for having the highest total phenolics, suggesting significant potential health benefits. In contrast, the 'Docz Velikana' cultivar exhibited the highest total tannin content, indicating strong antioxidant properties and possible health-promoting effects.

Broadly, 'Wojtek' cultivar was noted for its high total anthocyanin content, contributing to its vibrant color and potential antioxidant activity. Additionally, it had the highest levels of total sugars, which enhance its sweeter taste, likely due to its relatively low organic acid content.

'Kami' emerged as a rich source of carotenoids, total sugars, and vitamin C, highlighting its nutritional value.

These findings underscore the variability in bioactive compounds and nutritional characteristics among different blue honeysuckle cultivars, which could influence their health-promoting properties and culinary applications. All cultivars demonstrated high antioxidant activity as assessed by DPPH assays, with relatively minor variations in this property compared to other measured traits.

Overall, the results suggest that berries from these seven blue honeysuckle cultivars are promising food sources with health-promoting properties. Variations in bioactive compound levels and antioxidant activity are primarily determined by genotype.

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Tables and Figures

Table 1. Phenological data

Cultivar	Bud swelling start	Flowering start	Mass flowering	Harvest maturity
Wojtek	18 February	21 March	30 March	12 May
HoneyBee	22 February	23 March	31 March	12 May
Jugana	16 February	10 March	20 March	05 May
Docz Velikana	17 February	10 March	21 March	05 May
Bakczarskij Velikan	19 February	11 March	21 March	04 May
Kami	20 February	11 March	18 March	02 May

Table 2. Biometric traits

Genotype	Berry weight (g)	Size index	Fruit firmness (N)	TSS °Brix
Jugana	$0.76±0.3^{ab}$	$2.05±0.45^{a}$	$11.27±5.83^{abc}$	$12.07±1.27^{a}$
Docz Velika	$0.81±0.06^{ab}$	$2.49±0.22^{a}$	$6.37±1.16^{c}$	$12.11±0.89^{a}$
Bakczarskij Velikan	$0.52±0.12^{b}$	$2.08±0.12^{a}$	$15.07±1.36^{a}$	$12.41±1.7^{a}$
Kami	$0.68±0.03^{ab}$	$2.33±6.02^{a}$	$11.7±1.82^{ab}$	$13.33±2.68^{a}$
HoneyBee	$1.03±0.33^{a}$	$2.14±0.34^{a}$	$10.53±1.75^{abc}$	$11.37±0.35^{a}$
Wojtek	$0.90±0.16^{a}$	$1.82±0.65^{a}$	$10.13±2.73^{abc}$	$11.43±0.93^{a}$
Aurora	$0.81±0.04^{ab}$	$2.11±0.03^{a}$	$8.33±1.23^{bc}$	$12.8±1.9^{a}$

Table 3. Biochemical compounds

Genotype	TPC, mg GAE/100 g	TFC, mg CE/100 g	TTC, mg GAE/100 g	TAC, mg C3GE/100 g
Jugana	$9066.19±392.31^{ab}$	$393.61±2.64^{c}$	$876.27±12.71^{c}$	$4.99±0.15^{d}$
Docz Velika	$8954.88±377.42^{ab}$	$421.13±5.71^{a}$	$994.22±11.31^{a}$	$2.99±0.37^{f}$
Bakczarskij Velikan	$8992.5±111.89^{ab}$	$421.38±2.9^{a}$	$960.07±13.23^{b}$	$5.02±0.82^{d}$
Kami	$9977.24±1035.88^{a}$	$321.97±5.01^{d}$	$802.42±11.46^{e}$	$6.59±0.08^{c}$
HoneyBee	$8538.3±320.82^{b}$	$325.66±8.32^{d}$	$805.45±11.85^{e}$	$11.54±0.1^{b}$
Wojtek	$9367.06±439.82^{ab}$	$388.37±2.85^{c}$	$952.64±13.28^{b}$	$17.19±0.09^{a}$
Aurora	$9880.27±1153.17^{a}$	$311.68±3.14^{d}$	$830.89±11.86^{c}$	$3.85±0.02^{e}$

Table 4. Biochemical compounds

Genotype	mg licopen/100 g	mg β - caroten/100 g	Sugars g GE/100 g	Vitamin C mg/100 g	DPPH %
Jugana	$2.04±0.02^{d}$	$1.04±0.02^{b}$	$60.44±0.06^{c}$	$276.68±0.43^{c}$	$73.42±3.72^{a}$
Docz Velika	$2.61±0.02^{a}$	$0.47±0.03^{e}$	$54.55±0.07^{e}$	$307.2±0.38^{b}$	$68.7±5.01^{ab}$
Bakczarskij Velikan	$2.11±0.01^{c}$	$0.98±0.02^{c}$	$54.77±0.07^{d}$	$278.5±0.42^{c}$	$68.69±2.71^{ab}$
Kami	$1.49±0.01^{e}$	$1.26±0.01^{a}$	$78.66±0.13^{a}$	$619.69±5.67^{a}$	$60.24±1.69^{cd}$
Honeybee	$2.13±0.02^{c}$	$0.87±0.03^{d}$	$47.19±0.06^{g}$	$263.9±1.15^{d}$	$56.45±0.74^{d}$
Wojtek	$2.32±0.02^{b}$	$0.87±0.03^{d}$	$49.69±0.07^{f}$	$247.23±0.49^{f}$	$68.79±3.66^{ab}$
Aurora	$2.05±0.01^{d}$	$0.98±0.02^{c}$	$68±0.19^{b}$	$257.79±0.71^{e}$	$65.82±5.94^{bc}$

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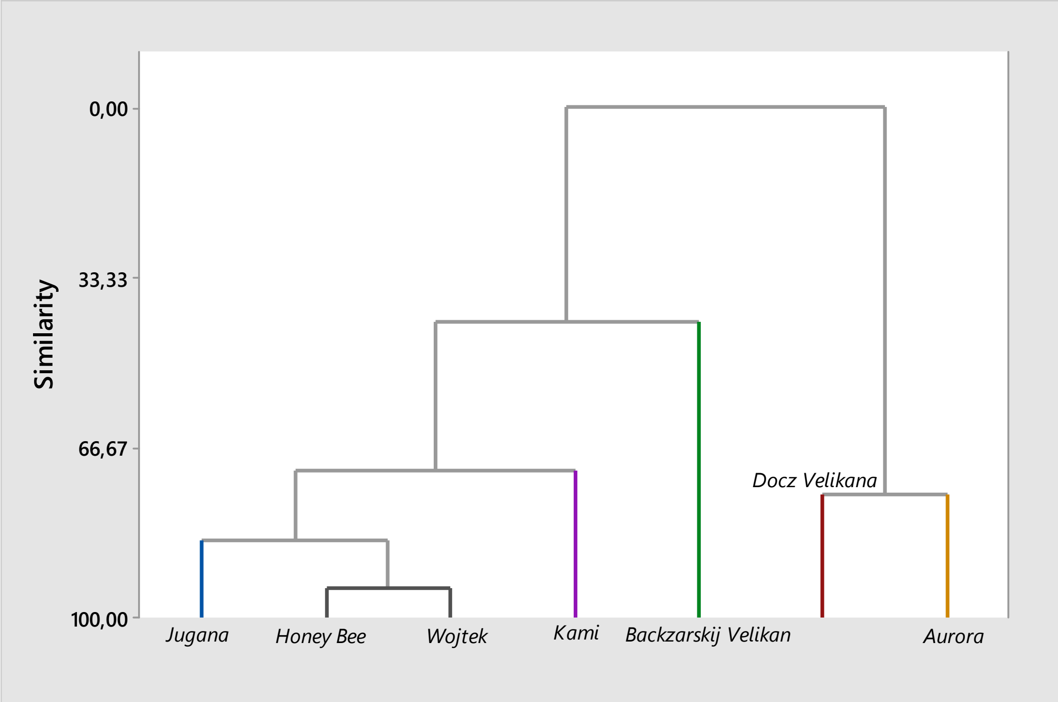

Fig. 1. Dendogram of bioactive compounds