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Comparison of Some Morphological Features, Quality and Chemical Content of Four Cultivars of Chokeberry Fruits (*Aronia melanocarpa*)

Ireneusz OCHMIAN[1*], Józef GRAJKOWSKI[1], Miłosz SMOLIK[2]

[1]*West Pomeranian University of Technology in Szczecin, Department of Pomology, Słowackiego 17, 71-434 Szczecin, Poland; ireneusz.ochmian@zut.edu.pl (*corresponding author)*

[2]*West Pomeranian University of Technology in Szczecin, Department of Plant Genetics, Breeding and Biotechnology, Słowackiego 17, 71-434 Szczecin, Poland*

Abstract

Two cultivars of chokeberry - 'Nero' and Polish 'Galicjanka' are sold in Poland. Sometimes, there are also present the seedlings of 'Viking' and 'Hugin' cultivars. In the experiment some morphological characteristics, the quality of fruits and chemical composition of four chokeberry cultivars ('Galicjanka', 'Hugin', 'Nero', 'Viking') were compared. Chokeberry plants were grown at the Experimental Station of Pomology Department at the West Pomeranian University of Technology in Szczecin. Fruits collected from 'Hugin' cultivar shrubs were the smallest (100 fruits weight was 32 g) and the least juice was obtained from them (73.6%); however, they were characterised by the highest content of soluble solids (18.7°Bx), titratable acids (1.05 g), polyphenols (2340 mg), especially cyanidin 3-galactoside as well as nitrates (98.5 mg) and nitrites (1.87 mg). The 'Hugin' cultivar was characterised by light-coloured fruits, and, as a result, by light-coloured juice. Fruits of 'Galicjanka' cultivar were the biggest, 100 fruits weight was 111,7 g. In fruits of the 'Nero' and 'Viking' cultivars, the content of individual components was at the lowest level. These cultivars have the largest amount of substances colouring fruits, pulp as well as red and blue juices, are also the darkest and the dark juice was obtained from them. Maceration of fruit pulp resulted in a significant change of colour of the juice obtained, it become darker and had a more intense blue colour.

Keywords: chemical composition, colours, firmness, fruits quality, gloss, maceration, phenolic compounds

Introduction

Chokeberry (black chokeberry) is a species with lower cultivation requirements within *Rosaceae* family and is an indigenous species in eastern North America and East Canada. More recently it is cultivated also in East European countries and Germany (Jeppsson, 2000a, 2000b; Strigl *et al.,* 1995). Black-fruited (*Aronia melanocarpa*), red-fruited (*A. arbutifolia*) and purple-fruited (*A. prunifolia*) chokeberries are three cultivars growing in the wild. In the beginning of the 20th century, chokeberry was transferred to Russian botanic gardens, where it spread in the European part of the country. Health benefits of chokeberry were appreciated quite quickly and plantations were established there (Seidemann, 1993). From there, it spread to the Central and Eastern European countries, where it is currently planted on a large scale (Benvenuti *et al.,* 2004). In Poland, chockeberry shrubs meant for fruit production were introduced in the seventies (Kleparski and Domino, 1990).

The *Aronia* shrubs can grow to a height of 2-3 m, which produce in May to June umbels of some 20-30 small white flowers, ripening to purplish black berries of a diameter of 6-13 mm and a weight of 0.5-2 g (Ara, 2002; Seidemann, 1993). Aronia is cold and hardy to about -30°C and is not sensitive to spring frost due to the late flowering time. The fruit is high in sugar (12-20% soluble solids), has a 0.7 to 1.4% titratable acidity (Jeppsson and Johansson, 2000; Krawiec, 2008; Oszmiański and Sapis, 1988). Chokeberries have a very high content of polyphenols (Benvenuti *et al.*, 2004; Walther and Schnell, 2009), namely phenolic acids, proanthocyanidins, anthocyanins (560-1050 mg, 100 g fresh weight), flavonols and flavanones (Koponen *et al.*, 2007). In comparison with other fruit species, relatively high values of antioxidant capacity were reported in chokeberry fruit (Kulling and Rawel, 2008; Skupień and Oszmiański, 2007). High contents of cyanidin-3-arabinoside, cyanidin-3-galactoside are also typical of chokeberries (Rop *et al.*, 2010), gnthocyanins (Espin *et al.*, 2000; Wilska-Jeszka *et al.*, 1991).

The fruit color reflects the type and quantity of color compounds. It is an important feature of their quality and attractiveness, and consumers search for products of intensive and natural color for a given article. It is also a characteristic feature of a variety. The aronia juice color is wine red to dark purple. Anthocyanins are red pigments present mostly in berry fruits. They give an attractive color to preserves and thus, they are frequently applied in the coloring of groceries. They are natural pigments and their addition to food does not raise consumer concern. Moreover, they have pro-healthy properties (Konczak and Zhang, 2004).

Anthocyanin pigments are sensitive to the action of external factors, such as light, high temperature, acidity, and the presence of oxygen. In order to describe color quality, CIE L*a*b* system is frequently applied. It is a system of color description that was elaborated by the International Commission on Illumination (Commission Internationale d'Eclairage) in 1976.

Chokeberry fruits are used in the production of jams, preserves, juices, cordials and as a natural colorant of food products (Jeppsson and Niklas, 1998; Plocharski and Zbroszczyk, 1989). Chokeberries are small, dark violet fruits but - because of their astringency - are not favoured as 'table fruits'. In Poland, chokeberries are grown mainly for juice production. Although chokeberry fruits belong to the so-called soft fruits, they are exceptionally durable and resistant to damage in transportation. They may be stored in a cold store even for a few weeks after crop, without losing their biological value.

Some cultivars are bred of true black chokeberry (*Aronia melanocarpa*) and some are hybrid cultivars ('Stewart', 'Burka', 'Titan') (e.g. *Aronia* × *Sorbus*) (Jeppsson, 2000b; Jeppsson and Johansson, 2000). The more important cultivars include 'Nero' (the Czech Republic), 'Rubina' (crossing from Russian and Finnish plants), 'Viking' and 'Kurkumäcki' (Finland), 'Hugin' (Sweden), 'Fertödi' (Hungary) and 'Aron' (Denmark) (Strigl *at al*., 1995).

Generally, in Poland, two cultivars of chokeberry are sold, namely: 'Nero' and Polish 'Galicjanka.' Sometimes, there are also present the seedlings of 'Viking' and 'Hugin' cultivars. Seedlings of different origin are sold, that generally do not differ in terms of appearance and use value. Plants of undefined variety, of which commercial plantations were established, were sold for years. Due to this fact, numerous planters are of the opinion that cultivars offered by arborists do not significantly differ among each other. This was the reason for the initial genetic study performed in order to describe the range of genetic variability exist between selected genotypes of *Aronia* (Smolik *et al*., 2011). The aim of the study was to compare some morphological features, quality, and chemical content of four cultivars of chokeberry fruits.

Materials and methods

Materials

Four cultivars of black chokeberry (*Aronia melanocarpa* (Michx.) Elliot.): including 'Galicjanka', 'Hugin', 'Nero' and Viking' were used in this study. Chokeberry plants were grown in the Experimental Station of the West Pomeranian University of Technology in Szczecin in Rajkowo and Ostoja near Szczecin (north-west Poland). The plantation was established on grey-brown podsolic soil originated from medium boulder clay. The experiment was carried out in 2007. The fertilization with nitrogen in two doses, 40 kg N·ha^{-1} each, was used whereas, phosphorus and potassium fertilization was not applied because the soil was abundant in these elements (7.3 mg·100 g^{-1} and 48.0 mg·100 g^{-1}, respectively). The pH was neutral (6.8-7.1). From florescence to harvest, drip irrigation was performed according to tensiometer indications. Because *Aronia melanocarpa* plants are resistant to pathogen diseases 'by nature' no chemical protection was applied. The fruits were collected in full ripeness stage in September.

Methods

Physical features of fruits were measured on fresh berries immediately after the harvest. Dry weight, soluble solids, titratable acidity, total sugar, reducing sugar, nitrate and nitrite content, were performed on fresh fruits packed in polyethylene bags and stored overnight at 5°C. The weight of 100 fruit was expressed in grams. The fruit diameter and firmness was measured by means of nondestructive device FirmTech2 combined with a computer (BioWorks, USA). The firmness of 100 randomly selected berries from every replicate was expressed as a gram-force causing fruit surface to bend 1mm. For juice extraction efficiency fruit were homogenized with a blender and heated up to 50°C. Then, after cooling, 1.5 ml of pectinase (Rapidaza Super) per 500 g of pulp were added. The pulp was left to stand in a room temperature for 1 hour. Afterward, the pulp was pressed for 10 min at the final pressure of 300 kPa by means of a laboratory hydraulic press (Oszmiański and Wojdylo, 2005).

Dry weight of fruit was determined with a gravimetric method (drying an aliquot ~5 g of fruit tissue at 105°C to constant weight) according to Polish standard (PN) - (PN-90/A-75101/03).

Soluble solids content was determined with a digital refractometer PAL-1 (Atago, Japan).

Titratable acidity was determined by titration of a water solution of chokeberry homogenate with 0.1 N NaOH to an end point of pH 8.1 (measured with an multimeter Elmetron CX-732) according to PN-90/A-75101/04.

Total sugar and reducing sugar content was determined according to the Loof-Schoorl method.

Sucrose content was calculated according to the relationship: sucrose = (total sugar – reducing sugar) × 0.95. Nitrate and nitrite content was measured with a RQflex 10 requantometer (Merck) and expressed as mg per 100 g fruit juice.

Total polyphenol content in the methanol (70%) extracts was estimated according to Singleton and Rossi (1965) with the Folin-Ciocalteu reagent. The data is expressed as mg of gallic acid equivalents (GAE) per 100 g of fruit tissue.

Phenolics composition of blueberries was determined in fruit samples that were kept frozen (-32°C) in polyethylene bags (250-300 g) until analyzed. The 2 g aliquots of fruit (after thawing) were extracted three times with ~8 mL of 80% MeOH acidified with a glacial acetic acid (1 ml of 100% acetic acid per 1 l 80% MeOH) in an ultrasonic bath for 15 min. The samples were filtered and transferred to the flasks and made up to the final volume 25 ml. Further, the extracts were centrifuged twice at 12,000 *g* and 20 μl of supernatants were injected into the HPLC system. The HPLC apparatus consisted of a Merck-Hitachi L-7455 diode array detector (DAD) and quaternary pump L-7100 equipped with D-7000 HSM Multisolvent Delivery System (Merck-Hitachi, Tokyo, Japan). The separation was performed on a Cadenza CD C18 (75 × 4.6 mm, 5 mm) column (Imtakt, Japan). Column oven temperature was set at 30°C. The mobile phase was composed of solvent A (4.5% formic acid, pH 2.2) and solvent B (acetonitrile). The program began with a linear gradient from 0% B to 21% B (0-30 min), followed by washing and reconditioning the column. The flow rate was 1 ml min^{-1} and the runs were monitored at the following wavelengths: phenolic acids at 320 nm, flavonol glycosides (quercetin and kaempferol derivatives) and luteolin at 360 nm, and anthocyanin glycosides at 520 nm (Fig. 1). The Photo Diode Array spectra were measured over the wavelength range 200-600 nm in steps of 2 nm. Retention times and spectra were compared to those of pure standards within 200-600 nm. Standards of anthocyanidin glycosides were obtained from Polyphenols Laboratories (Norway), flavonols, and phenolic acids from Extrasynthese (France).

Greening index determined using Chlorophyll Meter SPAD- 502 (Minolta) in SPAD units in autumn, a measurement of leaf surface was performed by means of a DIAS scanner connected to a computer.

Fruit color and shine, juice and pulp color were measured in a transmitted mode through Konica Minolta CM-700d spectrophotometer in 1 cm-thick glass trays. Measurements were conducted in CIE L*a*b* system, through a 10° observer type and D65 illuminant. Statistical analysis was done by using Statistica software package version 8.1 (Statsoft, Poland). The data were subjected to one-way analysis of variance. Values of p<0.05 according to Duncan multiple comparison test for physical features estimation were considered significant.

Results and discussion

On the basis of the results obtained. different sizes of chokeberry fruit cultivars were observed (Tab. 1). Fruits of 'Galicjanka' variety had the highest weight of 100 fruits and the longest diameter. Fruits picked up from 'Hugin' variety bushes were significantly smaller. The weight of 100 fruits amounted to only 32 g. whereas the fruits of 'Galicjanka' variety was 111.7 g.

According to Jeppsson (2000 b and a) the fruits of Galicjanka', 'Nero' and 'Viking' cultivars may be considered large fruits. These cultivars weighed from 65 to almost 95 g. In specific years of research by Kawecki and Tomaszewska (2006), the weight of cropped fruits ranged from 84 to 98 g. In turn Smolarz and Chlebowska (1997) and Strik *et al*. (2003) obtained fruits that weighed about 280 g.

A relationship between the fruit size and ripeness was observed. Small fruits of 'Hugin' variety were the ripest. These fruits showed also the lowest juice efficiency. Similar amount of juice was obtained from the other fruit cultivars -'Galicjanka' and 'Nero'. They equaled 76.8% and 78.9%. respectively. Fruit efficiency from control plants achieved by Skupień *et al*. (2008) obtained in an experience reached 86%.

Tab. 1. Size ripeness and juice efficiency of chokeberry cultivars under study

Characteristics[a]	Cultivars			
	'Galicjanka'	'Hugin'	'Nero'	'Viking'
Weight of 100 fruits (g)	111.7c[a]	32.0a	91.7b	99.5bc
Fruit size (mm) min-max	12.9-16.4	6.1-7.2	12.1-15.8	12.8-16.2
Mean	14.9c	6.6a	14.1b	14.4bc
Firmness (G · mm^{-1}) min-max	309-548	384-674	338-586	327-572
Mean	411a	489c	445b	453b
Juice extraction efficiency (%)	76.8b	73.6a	78.9b	77.2b

[a] Mean values marked with the same letter do not differ significantly at p = 0.05 according to Duncan's multiple range test

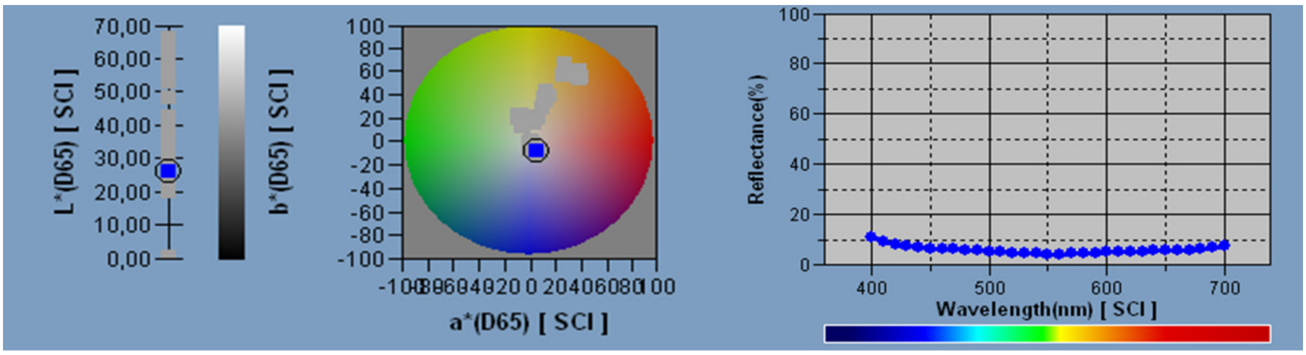

Fig. 1. CIE L*a*b* chromaticity diagram - L* (100 white, 0 black) a* (-100 yellow, +100 blue) b* (-100 red , +100 green)

The analysis of the chokeberry cultivars under study indicated different fruit chemical content (Tab. 2 and 3). Generally the highest content of a majority of the discussed ingredients was present in the fruits of the 'Hugin' variety (Tab. 2). The chemical content of the fruits of 'Nero' and 'Viking' cultivars was similar and the content of specific ingredients was on a lower level.

In the case of these cultivars, the dry matter content constituted 15.7% and 15.3% and in the fruits of the 'Hugin' variety it equaled as much as 19.5%. The dry matter content of berries ranges from 17% to 30% (Lehmann, 1990; Skupień and Oszmiański, 2007). The soluble solid content was on a similar level. In the fruits of 'Nero' and 'Viking' cultivars it amounted to 14.4°Bx and 14.2°Bx respectively. The highest content (18.7°Bx) characterized the fruits of the 'Hugin' variety. The soluble solid content in chokeberries depends upon numerous factors: weather. environmental conditions. crop period. and variety. and it amounts from 12.4 to 18.3% (Jeppsson 2000 a and b; Strik *et al*., 2003).

Chokeberry fruits have generally a low organic acid content that equals from 1 to 1.5% (Lehmann, 1990; Tanaka and Tanaka, 2001; Skupień *et al*., 2008). The main acids identified were L-malic acid and citric acid. The fruits under study were characterized by a lower organic acid content; in the 'Galicjanka' variety, it was at the level of 0.75 g in 100 grams of fruits.

No significant differences in the total and reduced sugar content were detected (Tab. 2). The total sugar content estimated in this experiment (6.2-10.8 g in 100 grams of fruits) was similar to the data reported by Kleparski and Domino (1990). The level of reduced sugar in the analyzed fruits ranged from 8.83 g ('Viking') to 12.48 g ('Hugin'). The content of reducing sugar in fresh chokeberries was found to be between 16-18% (Strigl *et al*., 1995). According to Seidemann (1993) the sum of glucose and fructose was determined to lie between 13.0-17.6 g·100 g^{-1} FW.

The highest level of harmful nitrates and nitrites was detected in the fruits of 'Hugin' variety (Tab. 2). The nitrate content was more than twice higher than in the fruits of 'Nero' variety and the nitrite content was three times higher than in the fruits of 'Viking' variety. In Poland and other countries there is a lack of regulations on permissible nitrate content in fruits (except for bananas). According to the Polish Ministry of Agriculture (Dz. U. 2003) the permissible nitrate content in vegetables meant for feeding babies and young children should not exceed 200 mg $NaNO_3$ kg^{-1}.

A scientifically confirmed positive influence of polyphenols on health demands strives to maintain these compounds both in fruits and preserves as efficiently as possible. In the case of chokeberry the juice is also to be considered. Chromatographic (HPLC) and GAE analyses showed that chokeberry fruits are a rich source of polyphenols especially those of 'Hugin' variety. Total polyphenols (GAE) amounted to 2340 mg gallic acid per 100 g (Tab. 2) and that determined by means of the HPLC equaled 1329 mg (Tab. 3). The total polyphenols of freshly produced products were in the range of 6144-6188 mg·l^{-1} and the anthocyanin content (HPLC) between 1035-1160 mg·l^{-1} (Würth *et al.,* 2010). Jakobek *et al*. (2007) obtained a higher amount of total phenol for chokeberry (7194 mg·kg^{-1}). The total phenolic content of *Aronia* berries cultivar 'Nero' has been determined to range from 3440-3760 mg·100 g^{-1} of DW (Hudec *et al*., 2006; Kolesnikov and Gins, 2001) to 4210 mg 100 g^{-1} of DW of berries cultivar 'Viking' (Kähkönen *et al*., 1999, 2001).

Cyanidin 3-galactoside constituted a majority of the polyphenols determined (Tab. 3). It made up 50% of the determined phenolic compounds in all the cultivars under study. This compound was determined at a similar level in the previous research (Ochmian *et al*., 2009). Also other authors confirm a high cyanidin 3-galactoside content in the analyzed chokeberry fruits (Jeppsson and Johansson, 2000) which amounted from 237 mg (Zheng and Wang, 2003) to 990 mg (Wu *et al*., 2004).

The color of the analyzed fruits and juices obtained thereof was measured in a transmitted mode determined by means of the photocolorimetric method conducted in CIE L*a*b* system (Tab. 4 and 5).

The a*-value providing information of the position in the color gamut between green and red (Fig. 1) measured

Tab. 2. Chemical composition of chokeberry fruit

Traits / Cultivars	'Galicjanka'	'Hugin'	'Nero'	'Viking'
Dry weight (%)	17.80b[a]	19.50c	15.70a	15.30a
Soluble solids (°Bx)	16.60b	18.70c	14.40a	14.20a
Titratable acidity (g citric acid 100·g^{-1})	0.75a	1.05b	0.85a	0.80a
Total sugar (g 100·g^{-1})	12.92a	13.79a	10.25a	9.16a
Reducing sugar (g 100·g^{-1})	12.16a	12.48a	9.88a	8.83a
Nitrate (mg·kg^{-1})	62.70a	98.50b	45.20a	53.80a
Nitrite (mg·kg^{-1})	1.24b	1.87c	0.84a	0.62a
Total polyphenol (mg gallic acid per 100g)	2185b	2340c	1950a	1845a

[a] Explanation was displayed in Tab. 1

Tab. 3. Phenolic compounds pattern of chokeberry fruit (mg·100 g^{-1})

Items \ Cultivars	'Galicjanka'	'Hugin'	'Nero'	'Viking'
Chlorogenic acid	84.0	96.6	75.2	72.0
Neochlorogenic acid	79.1	59.3	67.8	62.2
Nonidentified phenolic acid (r.t. 16.4 min)	13.9	18.0	8.4	7.1
Nonidentified phenolic acid (r.t. 35.4 min)	87.3	116.1	85.6	72.5
Quercetin 3-rutinoside	5.5	3.9	3.9	6.1
Quercetin 3-galactoside	9.9	7.9	6.6	9.1
Quercetin 3-glucoside	7.1	11.3	6.4	4.4
Quercetin 3-vicianoside	3.3	4.3	3.1	2.6
Quercetin 3-robinobioside	5.7	11.3	2.1	1.1
Cyanidin 3-galactoside	512.9	636.0	436.3	417.3
Cyanidin 3-glucoside	18.2	27.2	10.7	7.8
Cyanidin 3-arabinoside	249.5	299.4	133.8	128.0
Cyanidin 3-xyloside	33.2	38.2	30.4	29.0
Total	1109.4b[a]	1329.5c	870.3a	819.2a

[a] Explanation was displayed in Tab. 1

Tab. 4. Fruit and pulp color and gloss of the chokeberry cultivars under study

Cultivars	Fruit color			Gloss fruits	Pulp color		
	L*	a*	b*		L*	a*	b*
'Galicjanka'	18.94b[a]	4.46ab	-1.32a	3.81c	24.90a	13.94b	-4.87a
'Hugin'	21.59c	2.44a	-4.59ab	2.34b	35.84c	9.48a	-7.59b
'Nero'	16.62a	5.47ab	-6.04bc	0.68a	30.05b	22.00c	-10.61b
'Viking'	16.14a	7.51b	-8.89c	0.73a	31.11b	21.08c	-10.84b
Mean	18.32A	4.97a	-5.21a		30.48B	16.63b	-8.48a

[a] Explanation was displayed in Tab. 1

Tab. 5. Juice and pomace color after maceration period of the chokeberry cultivars under study

Cultivars	Juice color						Pomace color					
	1 h after maceration			12 h after maceration			1 h after maceration			12 h after maceration		
	L*	a*	b*	L*	a*	b*	L*	a*	b*	L*	a*	b*
'Galicjanka'	13.8	3.68	-11.66	9.41	9.38	-19.15	15.78	6.16	-11.73	12.54	8.53	-13.18
'Hugin'	17.06	4.37	-14.12	11.83	8.64	-21.63	14.95	6.21	-12.84	11.97	7.11	-16.51
'Nero'	14.63	4.51	-16.63	7.13	10.1	-23.55	14.13	5.19	-12.98	11.48	5.76	-17.49
'Viking'	14.89	4.64	-16.33	6.96	11.37	-24.04	14.34	4.93	-13.15	12.73	5.49	-18.44
Mean	15.10B[a]	4.30a	-15.19a	8.83A	9.87b	-22.09b	14.80B	5.62a	-12.68a	12.18A	6.72a	-16.41b

[a] Explanation was displayed Tab. 1

Tab. 6. Characteristic of leaves of the four chokeberry cultivars

Characteristics Cultivars	Leaf area (cm^2)	Length of leaf (mm)	Leaf width (mm)
'Galicjanka'	16.5a[a]	62a	43b
'Hugin'	12.8a	83b	35a
'Nero'	34.4b	87b	53c
'Viking'	32.8b	84b	52c

[a] Explanation was displayed in Tab. 1

on the fruit surface ranged from 2.44 ('Hugin') to 7.51 ('Viking'). This parameter value determined for the pulp was significantly higher for all the cultivars and amounted to 16.63 (Tab. 4). Both juice and pulp color determined by the a*-parameter after 1 hour of maceration was alike and it had a similar value as the fruit surface (juice 4.30 pomace 5.62 skin 4.97). The process of 12-hour maceration changed the a*-parameter value in particular in the juice to 9.87. The color of a 5% concentrate from the chokeberry juice defined by the a*-parameter was much more intense and amounted to 63.8 (Gonzalez-Molina *et al.*, 2008).

The fruit surface color defined by the b* parameter indicated the location on the axis between yellow and blue colors amounted to -5.21. whereas in the pulp, it was -8.48 (Tab. 4). Values of b* were even higher in the process of maceration and they amounted to -15.19 after 1 hour and -22.09 after 12 hours. The highest value was observed in the samples consisting of fruits of 'Nero' and 'Viking' cultivars (Tab. 5).

Tab. 7. Colour and greening index of the leaves of four chokeberry cultivars

Cultivars	Leaf color						Green index (SPAD)
	upper leaf			underside of the leaf			
	L*	a*	b*	L*	a*	b*	
'Galicjanka'	34.93a[a]	-23.57a	-1.26a	50.88a	-3.26a	8.71a	58.3a
'Hugin'	33.30a	-34.37b	-2.33b	52.96b	-4.66b	10.92b	73.1b
'Nero'	34.04a	-37.50b	-1.57a	52.05b	-4.55b	10.48b	70.6b
'Viking'	34.15a	-38.38b	-1.12a	52.78b	-4.04b	11.32b	72.4b
Mean	34.11A[a]	-33.46a	-1.57a	52.17B	-4.13b	10.36b	

[a] Explanation was displayed in Tab. 1

It implies that 'Nero' and 'Viking' cultivars contain the highest quantity of fruit and pulp red- and blue-coloring substances. These cultivars have the darkest fruits which undoubtedly influence obtaining a dark juice. It is marked by the L* parameter the value range of which is from 0 (black) to 100 (white). The 'Hugin' variety is characterized by bright fruits and as a result-bright juice. Another experience showed that a 5%-concentrate of chokeberry juice was significantly fairer where L* parameter equaled 43.1 (Gonzalez-Molina *et al*., 2008). In turn L* parameter of blackcurrant juice in comparison to the proper results was lower (the juice was darker) and amounted to 5.84 (Kalisz and Wolniak, 2007). Specific parameters (L* 16, a* 2.5, b* 1) of bilberry fruits *(Vaccinium myrtillus)* had similar values in an experiment conducted by Pasławska *et al*. (2010). For a few cultivars of apple trees the value of L* coefficient ranged 35-50 for the blushed apple peel and 65-80 for the primary color (Rybczyński and Dobrzański, 2004).

To describe the cultivars under analysis more fully, a few parameters characterising the leaves were also presented. It was found that the leaves of the 'Viking' and 'Nero' cultivars were the largest (Tab. 6); they were characterised by a much larger surface area (32.8 and 34.4 cm^2 respectively), they were also the broadest and the longest. Leaves of the 'Hugin' cultivar are equally long; however, they are narrow, which makes their shape lanceolate. In this way, these leaves have the smallest surface area, almost three times smaller than the leaves of the 'Viking' and 'Nero' cultivars. The leaves of cultivated cultivars are larger than those from wildly growing shrubs occurring in Russia; the length of leaves ranged from 41 to 55 mm and the width ranged from 23 to 34 mm (Skvortsov and Maitulina, 1982).

The colour of the leaves was also measured. Generally, the upper part of leaves is darker compared to the bottom, parameter L* - top 34.11, bottom 52.17 (Tab. 7). In researches of Ozgur *et al.* (2011) fresh leaves of leek were brighter - L* 66.95. The upper leaf surface is also definitely greener (parameter a* -33.46) than the bottom of the leaf (a* -4.13). The lowest value of this parameter was found on leaves of the 'Galicjanka' cultivar (a* -23.57), which also had the lowest greening index (SPAD 58.3). In other cultivars, both parameter a* and the greening index were at a similar level. The greening index is highly correlated with the content of chlorophyll, which is responsible for the green colour (Gregorczyk and Raczyńska, 1997). This is confirmed by the results obtained, leaves with the highest greening index were the greenest.

Conclusions

The data presented show differences in the quality and chemical composition of fruits and some morphological characteristics of both fruits and leaves of the cultivars being under analysis. Fruits collected from 'Hugin' cultivar shrubs are the smallest, which undoubtedly had an influence on the smallest amount of juice obtained from these fruits. Despite the low juice efficiency, fruits of the 'Hugin' variety generally had the highest content of the majority of the ingredients under analysis, both as regards the beneficial ones: soluble solids, titratable acids, polyphenol and harmful ones: nitrates and nitrites. The level of harmful nitrates is still on the allowable level. The chemical composition of fruits of the 'Nero' and 'Viking' cultivars, which was similar in the content of individual components, is at the lowest level. Chromatographic analyses (HPLC) and GAE showed that chokeberry fruits are a rich source of polyphenols, especially the 'Hugin' cultivar. In the fruits under analysis, there was the largest amount of cyanidin-3-galactoside from among all polyphenols, which were determined - it constituted 50% of phenolic compounds. Beneficial health effects of polyphenols are an argument for looking for fruits rich in these compounds. The 'Nero' and 'Viking' cultivars have the largest amount of substances colouring fruits, pulp as well as red and blue juices. Fruits of these cultivars are also the darkest and the dark juice was obtained from them. The 'Hugin' cultivar was characterised by light-coloured fruits, and, as a result, by light-coloured juice. Maceration of fruit pulp resulted in a significant change of the colour of the juice obtained, it become darker and has a more intense blue colour. Shrubs of the 'Hugin' cultivar had long leaves; however, they are narrow and lanceolate. In this way, these leaves had the smallest surface area, almost three times smaller than the leaves of the 'Viking' and 'Nero' cultivars.

On the basis of these few characteristics which have been discussed above, it can be concluded that the 'Viking' and 'Nero' cultivars are very similar both in respect of morphological features of their fruits and leaves and their chemical composition. The 'Hugin' cultivar, on the other hand, is fundamentally different from the other three cultivars. This is also confirmed by previously performed initially genetic investigations.

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