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Chemical composition of selected cultivars of highbush blueberry fruit (*Vaccinium corymbosum* L.)

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ABSTRACT

The purpose of the study was to compare basic fruit chemical composition of four highbush blueberry cultivars: 'Spartan', 'Bluecrop', 'Jersey' and 'Blueray'. The plants were grown on plantation near Szczecin in the years 2001 – 2003. Basic chemical composition of fruit including total ash, crude fibre, total nitrogen, soluble solids, titratable acidity, dry weight and total polyphenol content was determined. On average, 'Spartan' berries showed the highest total ash, total nitrogen and soluble solids content. 'Bluecrop' berries had the highest total polyphenol content, the berries of 'Jersey' the highest dry weight content and that of 'Blueray' the highest total acid content. The most considerable seasonal variations in fruit chemical composition of the cultivars were observed for soluble solids and titratable acidity was concerned.

INTRODUCTION

Highbush blueberries (*Vaccinium corymbosum* L.) are extensively cultivated in the United States and more recently have become a popular commercial crop in Europe (Kader et al. 1996). In Poland, first attempts of introducing this species in the 1930s were unsuccessful. The progress was attained only in the 1970s. The cultivation area constantly enlarges because of fruit sensory attributes and high marketable price (Mitek et al. 2001).

Highbush blueberries are large fruit with intensive colour (dark-blue), firmness and pleasant sweet taste. For indigenous inhabitants of North America the berries were not only food but also anti-tussive and 'pain-relieving' plant remedy. Blueberries have low calorie content. According to Rejman and Pliszka (1991) 100 g of fresh fruit contains 83.4 g of water, 0.6 g of protein, 0.6 g of fat, 15.0 g of sugars, 0.3 g of ash. Moreover, 0.02 mg of vitamin B_1, 0.02 mg of vitamin B_2, 0.3 mg of vitamin PP, 16 mg of vitamin C, 289 I.E. (International Equivalents) of vitamin A, 16.0 mg of calcium 13.0 mg of phosphorus and 0.8 mg of ferrum.

The berries are recognized to be one of the most valuable fruit due to their high antioxidative activity (Prior et al. 1998, Mainland et al. 2002). Highbush blueberries are an excellent source of phytochemicals that are believed to have significant biological activity (Schmidt et al. 2005). Antioxidative and anticarcinogenic effects *in vitro* of *Vaccinium* genus berries are partly proposed to be due to phenolic compounds in these berries (Häkkinen and Törrönen 2000, Rimando et al. 2004). Blueberry extracts ameliorate age-related declines in neuronal and cognitive function, common in disorders such as Alzheimer disease (Youdim et al. 2000).

Chemical composition of fruits is conditioned both by genetic (cultivar) and environmental factors (weather, agronomic practices). Bearing that in mind, the purpose of the three-year study was to assess season-to-season stability of basic chemical constituents content reflecting nutritive and biological value of selected cultivars of highbush blueberry fruit.

MATERIAL AND METHODS

The fruits of four highbush blueberry cultivars: 'Spartan', 'Bluecrop', 'Jersey' and 'Blueray' were obtained from commercial plantation in the years 2001 – 2003. In 2001 'Bluecrop' and 'Jersey' shrubs were 11 years old while 'Spartan' 8 years old and 'Blueray' 7 years old. Except for 'Bluecrop' cultivar (*in vitro*) other bushes originated from hardwood cuttings. The plants were cultivated according to the recommendations for this species (Smolarz 2000). The plantation was established on typical forest soil with natural humus level (30 cm) where ground water level

maintains at 1m. Additionally conifer sawdust was used to mulch as well as drip irrigation and acidifying by means of drop-sulphur. The ripe berries of 'Ekstra' class (PN-R-75507) were manually collected and packed into cardboard containers (500 g). The bulk sample for each cultivar was ca. 2 kg. After the harvest, the fruit were kept at 10°C for 16 hs and afterwards chemical analyses were performed in duplicate.

Total ash content was determined by combustion of aliquot (ca. 2 g of fruit tissue) at 550-600°C according to Krełowska-Kułas (1993). Crude fibre content was estimated with the Kürschner-Hanak method (Porzucek 1996). Total nitrogen content was determined with the Kjeldahl method according to Krełowska-Kułas (1993). Dry weight content was estimated with a gravimetric method (drying ca. 5 g aliqout of fruit tissue at 105°C to the constant weigh), according to Krełowska-Kułas (1993). Soluble solids content was determined with Abbé refractometer (PN-90/A-75101/02). Organic acid content was determined by titration of a water extract of fruit tissue with 0.1 N NaOH to an end point 8.1 (measured with Orion 720A pH meter, Orion Research Incorporated, Boston, AM, USA) according to PN-90/A-75101/04. Total polyphenol content was estimated in methanol (70%) extracts according to Singleton and Rossi (1965) with the Folin-Ciocalteu reagent. The data are expressed as mg of gallic acid equivalents (GAE) per 100 g of fruit tissue.

Statistical analysis was performed by one-way analysis of variance for each year and then subjected to three years constant model synthesis. The data were evaluated by the Tukey multiple comparison test. Differences at $p < 0.05$ were considered significant.

RESULTS AND DISCUSSION

The three-year observation of blueberry chemical composition showed significant differences between the cultivars tested.

Total ash content averaged from 0.24% per fresh weight (f.w.) in 'Spartan' berries to 0.19% f.w. in 'Blueray' ones (Fig. 1). Ostrowska and Ściążko (1996) obtained similar range of total ash content in blueberries from 0.21% ('Jersey') to 0.24% ('Herbert'). All the cultivars varied significantly in total ash content on dry weight basis preserving the sequence of highest content in 'Spartan' berries followed by 'Bluecrop', 'Jersey' and the lowest for 'Blueray' (Fig. 2).

Blueberries are delicate fruits with low fibre content. According to Andrzejewski (1975), crude fibre level in these berries is lower than that of bilberries or lingonberries and ranges from 0.78 to 1.41%. In the reported studies 'Spartan' and 'Jersey' berries exhibited significantly higher crude fibre content than other cultivars (Figs 3 and 4). On the basis of fresh weight, 'Spartan' and

'Jersey' berries had by 19 and 14%, respectively more fibre than 'Bluecrop' ones and by 32 and 27%, respectively more than 'Blueray' berries.

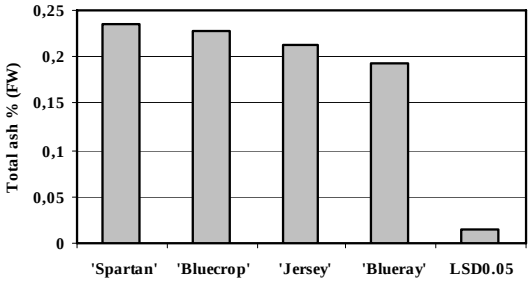

Fig. 1. Total ash content (%) in fresh weight of highbush blueberry fruit

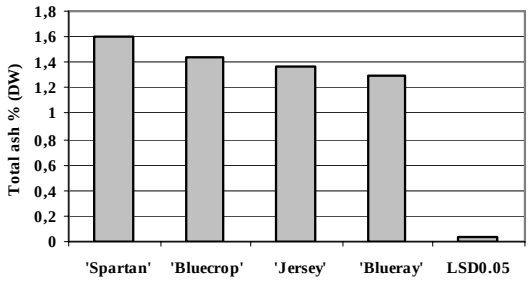

Fig. 2. Total ash content (%) in dry weight of highbush blueberry fruit

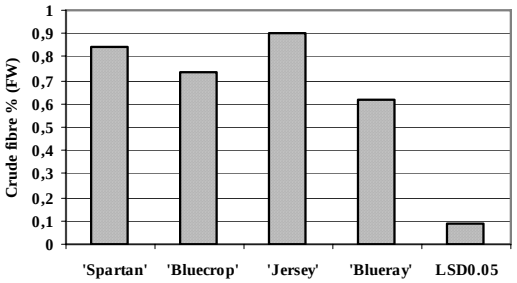

Fig. 3. Crude fibre content (%) in fresh weight of highbush blueberry fruit

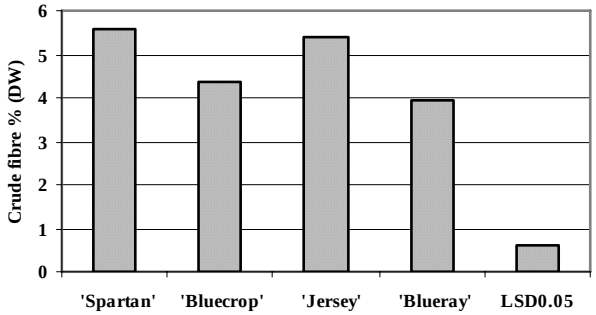

Fig. 4. Crude fibre content (%) in dry weight of highbush blueberry fruit

Average nitrogen content in berries fresh weight in this experiment (0.42-0.33%) was ca. 3 times higher than the one reported by Ostrowska and Ściążko (1996) (0.09-0.12%). 'Spartan' berries showed the highest total nitrogen content. On the basis of fresh weight they surpassed other cultivars by 8 to 21% (Fig. 5) while on the basis of dry weight content by 15 to 23% (Fig. 6). Nitrogen and total ash content in fruits is considerably conditioned by fertilization status of the plants and partially by genetic factors, as well as biochemical and physiological properties of the cultivar.

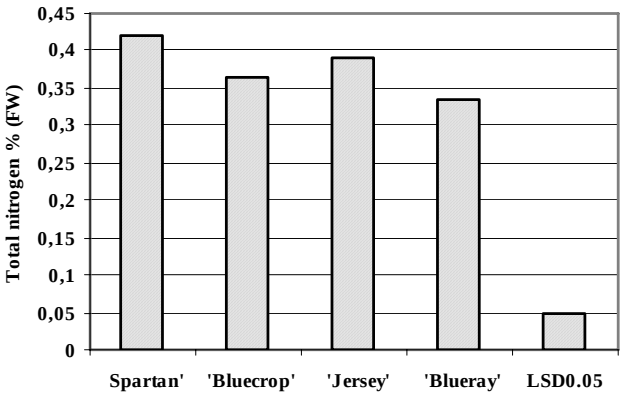

Fig. 5. Total nitrogen content (%) in fresh weight of highbush blueberry fruit

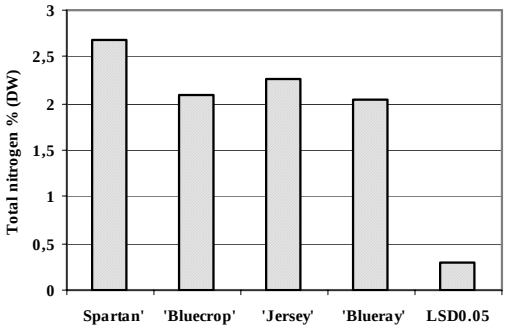

Fig. 6. Total nitrogen content (%) in dry weight of highbush blueberry fruit

There were no statistically significant differences observed between the cultivars regarding mean soluble solids content (Table 1). However, in the year 2001 'Blueray' and 'Jersey' berries and in 2002 'Bluecrop' ones had significantly higher soluble solids content as compared to other cultivars. The greatest divergence in soluble solids content occurred in 2001, from 13.7% ('Blueray') to 11.55% ('Spartan'). Prior et al. (1998) found much wider scope of soluble solids content in particular cultivars of *Vaccinium corymbosum* 10.0-19.0%. Seasonal variation of soluble solids content in particular cultivars observed in this study reveals that the characteristic is more strongly conditioned by environmental than genetic factors.

Table 1. Soluble solids and titratable acidity of highbush blueberry fruit in the years 2001 – 2003

Cultivar	Soluble solids (%)*				Titratable acidity (% citric acid)*			
	2001	2002	2003	$\bar{x}$	2001	2002	2003	$\bar{x}$
'Spartan'	11.55	12.80	12.70	12.35	0.77	0.27	0.57	0.54
'Bluecrop'	12.55	13.55	13.85	13.32	1.13	0.54	0.73	0.80
'Jersey'	13.20	11.70	14.60	13.17	1.05	0.66	0.71	0.81
'Blueray'	13.70	12.40	13.35	13.15	1.07	0.43	1.12	0.87
$LSD_{0.05}$	0.611	0.519	n.s.	n.s.	0.055	0.013	0.032	0.015

*Data are expressed on fresh weight basis

Blueberries are reported to have total acid content 0.51-1.77 g 100 g^{-1} of citric acid (Andrzejewski 1975). In the study, significant differences were found between the cultivars regarding the acidity of berries both in particular years and on average. 'Blueray' berries had the highest mean total acid content (titratable

acidity) (0.87 g 100 g^{-1} of citric acid) whereas 'Spartan' berries the lowest (0.54 g 100 g^{-1} of citric acid). Similarly to soluble solids, total acid content was not a stable feature for the cultivars in particular years of the study. Considerable divergence was noticed from 0.27 'Spartan', 2002 to 1.13 g 100 g^{-1} of citric acid 'Bluecrop', 2001 (Table 1). In 2002 all the cultivars showed the lowest total acid content. In 2001 'Bluecrop', 'Jersey' and 'Spartan' berries exhibited the highest acidity while that of 'Blueray' in 2003.

Water content in blueberries is estimated at 80.1-87.7% (Andrzejewski 1975), 83.2% (Adams 1975). In the experiment average dry weight content ranged from 15.83% ('Jersey') to 14.46% ('Spartan') and 'Spartan' berries had significantly less dry weight content than that of other cultivars (Table 2). Prior et al. (1998) determined much wider scope of dry weight content from 14.9% ('Croatan') to 32.9% ('Jersey'). Moreover 'Spartan' and 'Bluecrop' fruit exhibited rather equalized dry weight level in each year of the study while 'Jersey' and to a lesser degree, 'Blueray' berries, showed more differentiated one.

Table 2. Dry weight and total polyphenol content in the fruit of highbush blueberry cultivars in the years 2001 − 2003

Cultivar	Dry weight (%)				Total polyphenol (mg 100 g^{-1})*			
	2001	2002	2003	$\bar{x}$	2001	2002	2003	$\bar{x}$
'Spartan'	14.57	14.67	14.13	14.46	320.9	233.6	221.9	258.8
'Bluecrop'	15.51	15.70	15.50	15.50	306.4	313.5	300.7	306.9
'Jersey'	16.79	14.34	16.36	15.83	211.8	199.7	170.7	194.1
'Blueray'	15.80	14.91	14.97	15.23	208.6	229.5	179.5	205.9
$LSD_{0.05}$	0.827	0.736	n.s.	0.961	n.s.	39.25	63.21	37.31

*Data are expressed on fresh weight basis

Berries are rich in phenolic compounds which exhibit a wide range of biological effects, including antioxidant and anticarcinogenic properties (Zheng and Wang 2003). The authors determined total phenolic content in 'Serra' cultivar 4.12 mg g^{-1}. Ehlenfeldt and Prior (2001) estimated 1.79 mg g^{-1} as mean total polyphenol content for 87 highbush blueberry and species-introgressed highbush blueberry cultivars. Similar results were obtained by Łata et al. (2005) 1769.4 and 1724.1 μg g^{-1} for 'Bluecrop' berries in 2001 and 2002 year, respectively. Ścibisz et al. (2003) surveyed much higher levels of phenolics in blueberries 497.4 mg 100 g^{-1} ('Earlyblue') 227.7 mg 100 g^{-1} ('Bluecrop'). The differences in the reported data partially result from varied analytical methods employed by the authors. In the present study, on average, 'Bluecrop' fruit presented the highest content of total polyphenol (306.9 mg 100 g^{-1}) compared to the other cultivars (Table 2). The

lowest content was determined in ‘Blueray’ and ‘Jersey’ berries (205.9 and 194.1 mg 100 g^{-1}, respectively). In the analysed years ‘Spartan’ fruit were found to have the most unstable phenolics content (in 2001 they had ~100 mg 100 g^{-1} more than in 2003) whereas ‘Bluecrop’ berries the most stable (the maximal difference was ca. 13 mg 100 g^{-1}).

CONCLUSIONS

1. ‘Spartan’ berries showed, on average, the highest content of total ash and total nitrogen in fresh and dry weight. These berries presented also the highest soluble solids and the lowest total acid and dry weight content.
2. ‘Bluecrop’ berries exhibited the highest total polyphenol content.
3. The berries of ‘Jersey’ cultivar presented the highest dry weight content and the lowest total polyphenol content.
4. ‘Blueray’ berries displayed the lowest total ash; crude fibre and total nitrogen content both on fresh and dry weight basis. Moreover these berries had the lowest soluble solids content.
5. On dry weight basis, lesser differences were found between the cultivars regarding total ash and total nitrogen content and more substantial in crude fibre content.
6. The influence of environmental factors evinced in considerable changes of year-to-year soluble solids content and titratable acidity of fruit of particular cultivars. ‘Bluecrop’ and ‘Spartan’ berries showed stable dry weight content. Moreover ‘Bluecrop’ berries had the most equalized total polyphenol content while ‘Spartan’ berries the least.

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SKŁAD CHEMICZNY OWOCÓW WYBRANYCH ODMIAN BORÓWKI WYSOKIEJ (*VACCINIUM CORYMBOSUM* L.)

Streszczenie: Celem badań było porównanie składu chemicznego owoców czterech odmian borówki wysokiej: ‘Spartan’, ‘Bluecrop’, ‘Jersey’ i ‘Blueray’. Rośliny były uprawiane na plantacji w pobliżu Szczecina, w latach 2001 – 2003. W owocach oznaczano zawartość podstawowych składników chemicznych: popiołu ogółem, błonnika surowego, azotu całkowitego, ekstraktu, kwasów ogółem, suchej masy i polifenoli ogółem. Pod względem średnich wartości, jagody odmiany ‘Spartan’ wykazywały największą zawartość popiołu ogólnego, azotu ogólnego i ekstraktu. Borówki odmiany ‘Bluecrop’ miały najwyższą zawartość suchej masy, a odmiany ‘Blueray’ największą kwasowość. Największe zmiany w składzie chemicznym owoców badanych odmian w poszczególnych sezonach, obserwowano w odniesieniu do zawartości ekstraktu i kwasowości.

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