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EVALUATION OF YIELD, MORPHOLOGY AND QUALITY OF FRUITS OF CHERRY SILVERBERRY (*ELAEAGNUS MULTIFLORA* THUNB.) BIOTYPES UNDER CONDITIONS OF NORTH-EASTERN POLAND

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Key words: cherry silverberry, yield, fruit biometry, chemical composition, fatty acids.

Abstract

The study evaluated three biotypes of cherry silverberry (obtained from the Institute for Fruit Growing in Samokhvalovitchy in Belarus) for cultivation under the conditions of north-eastern Poland in comparison to the form reproduced and cultivated at the University of Warmia and Mazury in Olsztyn. It was demonstrated that the natural conditions of Olsztyn permit cultivation of the examined cherry silverberry biotypes, although the yield was not high. The 01-1999 biotype from the Polish selection was characterized by a higher yield and weight of fruit, as well as by a higher fruit weight-to-stone weight ratio in comparison to biotypes selected in Belarus. The fruit of the examined biotypes also significantly differed in their chemical composition. Fruits of the 9-19-1996 biotype were characterized by high dry matter content, low acidity and a high sugar-to-acid ratio. The 9-24-1996 biotype fruits were characterized by the highest content of vitamin C. Both fruits and stones of cherry silverberry contained fat rich in n-3 and n-6 fatty acids. In cherry silverberry fruits, this ratio ranged from 1.2:1 to 1.4:1 in the pulp and from 1.4:1 to 1.8:1 in the stone.

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OCENA PLONOWANIA, MORFOLOGII I JAKOŚCI OWOCÓW BIOTYPÓW OLIWNIKA DŁUGOSZYPUŁKOWEGO (*ELAEAGNUS MULTIFLORA* THUNB.) W WARUNKACH PÓŁNOCNO-WSCHODNIEJ POLSKI

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Słowa kluczowe: oliwnik długoszypułkowy, plon, biometria owoców, skład chemiczny, kwasy tłuszczowe.

Abstrakt

W pracy oceniono przydatność do uprawy w warunkach północno-wschodniej Polski 3 biotypów oliwnika długoszypułkowego otrzymanych z Instytutu Sadownictwa w Samochwałowiczach na Białorusi w porównaniu z formą rozmnożoną i uprawianą w UWM w Olsztynie. Wykazano, że warunki przyrodnicze Olsztyna umożliwiają uprawę badanych biotypów oliwnika wielokwiatowego, jednak plony nie należały do wysokich. Biotyp 01-1999 polskiej selekcji charakteryzował się wyższym plonowaniem oraz masą owoców, a także wyższym stosunkiem masy owocu do masy pestki niż biotypy wyselekcjonowane na Białorusi. Owoce badanych biotypów różniły się istotnie pod względem zawartości składników chemicznych. Owoce biotypu 9-19-1996 charakteryzowały się wysoką zawartością suchej masy, niską kwasowością i wysokim współczynnikiem kwasowocukrowym. Z kolei owoce biotypu 9-24-1996 charakteryzowały się najwyższą zawartością witaminy C. Zarówno owoce, jak i pestki oliwnika odznaczały się tłuszczem bogatym w kwasy tłuszczowe z grupy n-3 i n-6. W owocach oliwnika stosunek ten wynosił od 1,2:1 do 1,4:1 w miąższu oraz od 1,4:1 do 1,8:1 w pestce.

Introduction

Elaeagnus multiflora Thunb. – the cherry silverberry, also known as cherry elaeagnus or goumi, is a representative of the *Elaeagnus* L. genus – *Elaeagnaceae* Juss. family – which also includes the more popular common seabuckthorn – *Hippophaë rhamnoides* L. (SĘKOWSKI 1993, BUGAŁA 2000, SENETA and DOLATOWSKI 2012). The species is gaining increasing recognition as an ornamental plant and as a prospective fruit plant (BIENIEK et al. 2002).

The cherry silverberry is a native plant to China, Korea and Japan (KOŁBASINA 2003, BIENIEK et al. 2005). This is a shrub growing up to 3 m. Its shoots feature scarce thorns. The leaves are typical for *Elaeagnus* – the upper part of the leaf blade is green, while its bottom side is silvery (SENETA and DOLATOWSKI 2012). Since silverberry flowers give off a strong aroma resembling a smell of cinnamon and vanilla, this plant can be used for flavouring cakes

and other meals. They are well-pollinated by insects from the *Apidae* family. RADIUK and RADIUK (1997) report that the self-fertility rate can vary from 0% to 70%. The fruits are ellipsoidal, of a drupe-like type, up to 1 cm long and are set on stems. Their colour is red and they are juicy and sour, with a taste resembling that of red currant. Silverberries ripen at the end of June or at the beginning of July.

The cherry silverberry has low nutritional requirements and it grows best on dry, sandy and poor soils. However, it needs a lot of light to grow. The shrub can grow in one site for 25 years. Interest in the cultivation of this species has increased along with the development of house and allotment gardening. A symbiosis of this plant with ray fungi binding nitrogen from the air makes the silverberry a pioneer plant fertilizing the soil (HRYNIEWICKI 2008). The silverberry has a long vegetation period and it starts to lose leaves only after first ground frosts. Such a late leaf fall can causes shoot freezing in harsh winters. The shoots, even completely frozen, demonstrate good regeneration abilities and grow from the root neck in significant numbers (KAWECKI et al. 2007).

The first variety of the cherry silverberry, 'Sachaliński pierwyj'®, was cultivated in the Far Eastern Research Institute of Agriculture in Russia and registered and entered in 1999 into the State Register of Breeding Achievements Approved for Use. Other varieties were also cultivated later in Russia, such as 'Moneron'® and 'Taisa'® (2002), 'Kril'on'® (2006), 'Szikotan'® (2009), 'Juznyj'® (2009), 'Kunaszir'®(2011), 'Cunai' (2015) and 'Paramushir' (2016) (State Register of Breeding Achievements Approved for Use, 2016). The variety cultivated in Europe and in the USA is 'Sweet Scarlet'. Research in Poland started in 1995 at the Department of Horticulture in Olsztyn with three-year old cherry silverberries obtained from the Institute for Fruit Growing in Samokhvalovitchy in Belarus. The research focused on the ability of the cherry silverberry to germinate after the application of various stratification methods (KAWECKI et al. 2004). Currently, research is being conducted on more than ten seedlings in order to select the best forms that could be introduced into cultivation in Poland. This species is already being introduced into cultivation in Russia, Ukraine and the USA (BACZYŁO and SZAŁKIEWICZ 1996, SZAŁKIEWICZ and KAWECKI 2003). Its fruits, because of their rich chemical composition, reveal therapeutic and preventive values (BIENIEK et al. 2002, ISACZKIN et al. 2003). As results from the previous research concerning the chemical composition of the cherry silverberry fruit, they are rich in carotene, phenolic compounds, amino acids as well as macro and microelements (SZAŁKIEWICZ and KAWECKI 2003). The research conducted by LEE et al. (2010) demonstrated that the substances found in fruits of this species had antioxidant, anti-inflammatory and anti-proliferative effects and could be of

crucial importance in treating colon cancer. Fruits of this plant can be used in home processing to prepare juice, compote, jam or jelly and other food products. They demonstrate a toning effect and improve blood circulation, while fresh and processed fruit are recommended in abdominal pain. Leaves can be used as compresses for slow-healing wounds (KAWECKI et al. 2007).

The aim of the study was to evaluate usability for cultivation in conditions of north-eastern Poland of three biotypes of the cherry silverberry obtained from the Institute for Fruit Growing in Samokhvalovitchy in Belarus in comparison to the form reproduced and cultivated at the University of Warmia and Mazury in Olsztyn.

Materials and Methods

The experiment was established in 2007 in the Experimental Garden of the University of Warmia and Mazury in Olsztyn (north-eastern Poland, latitude: 53°50 N, 20°31 E). The climate of Olsztyn is typical for lakeland areas, determined by local elements of the environment, i.e. the land form and numerous lakes and forests. The research concerned 3 vegetatively propagated biotypes: 9-19-1996, 9-24-1996, 9-34-1996, obtained from the Institute for Fruit Growing in Samokhvalovitchy from the breeding farm E-2 (SZAŁKIEWICZ and KAWECKI 2003). The comparison of the biotypes also included evaluation of the 01-1999 biotype, obtained from seeds originating from a shrub cultivated in Olsztyn from 1999. The plants were planted in Albic Luvisolx (Arenic) soil, deeply flattened, produced from clays of pH in KCl 6.8 (*World reference...* 2014), in 4 x 2 m spacing. The shrubs started to fructify in the third year after planting. In 2012–2015, plant yield, morphological features and the chemical composition of the fruits were examined.

To describe the morphological features of fruits and stones, 100 fruits of each biotype were randomly selected. The research was conducted on fruits collected from plants in the consumption ripeness stage, when the fruits were fully red, it was usually the first week of July. For chemical analyzes, samples of about 0.4 kg of fresh fruit of each biotype were harvested. Immediately after harvesting, the seeds were extracted from fruits and fresh material, both fruit pulp and seeds, was analyzed for chemical composition.

Biochemical examinations of fruits included the following analyses:

– determination of the content of organic acid (*Przetwory owocowe...* PN-90/A-75101/04),

– determination of the content of sugars (*Przetwory owocowe...* PN-90 A-75101/07),

– determination of the content of dry matter (*Przetwory owocowe...* PN-90/A-75101/03),

– determination of the content of vitamin C (*Przetwory owocowe...* PN-90 A-75101/11),

– determination of fatty acids (*Analiza estrów metylowych...* PN-EN ISO 5508).

The results of chemical composition analysis were expressed as mg: 100 g^{-1} of fresh mass (vitamin C) or as % of fresh mass (organic acids, total saccharides, monosaccharides) and presented as an arithmetic mean of three parallel tests an statistically analysed with the use of a univariate analysis of variance. The significance of differences was calculated with Duncan's test at the significance level of 0.05 (for yield and morphological features of fruits) and of 0.01 (for chemical composition of fruits). Calculations were performed using Statistica 10.0 software. Percentage contents of fatty acids in the silverberry fruit pulp and stone are shown in the graphs on which the standard deviation was noted.

Results and Discussion

Mean yields of the examined cherry silverberry biotypes from the period of 2012–2015 ranged from 0.36 kg for the 9-34-1996 biotype to 1.32 kg for the 01-1999 biotype. These were relatively low yields and, as results from the statistical analysis, they were significantly varied (Table 1). The studies were conducted on plants after the fifth year of planting, since few fruits set in the fourth year. According to SZAŁKIEWICZ and KAWECKI (2003), most seedlings start yielding in fourth year after planting. In the research by those authors, the first trade yield in the berry plants experimental field of the Institute for Fruit Growing in Samokhvalovitchy in Belarus was higher and amounted from 1.5 to 4.5 kg from the shrub. KAPICZNIKOWA et al. (2005) reported that the yield obtained in Belarus and in Russia ranged from 3 to 10 kg and from 4 to 5 kg per shurb respectively. According to KOŁBASINA (2003), 5-year-old plants can yield

Table 1

Yield and morphology of fruits of the biotypes of cherry silverberry (means of 2012–2015) under the conditions of Olsztyn

Biotype	Yield [kg plant^{-1}]	The weight of 100 fruits [g]	Mean length of fruit [cm]	Mean width of fruit [cm]	Mean stalk length [cm]
01-1999	1.32^{d*}	112^{a}	1.28^{a}	0.96^{a}	3.77^{d}
9-34-1996	0.36^{a}	89^{a}	1.24^{a}	0.84^{a}	3.67^{c}
9-24-1996	0.71^{b}	105^{a}	1.26^{a}	0.99^{a}	3.40^{b}
9-19-1996	0.99^{c}	94^{a}	1.28^{a}	0.91^{a}	3.30^{a}

* The values denoted with the same letters are not significantly different at $p = 0.05$

3–4 kg fruit per shrub, 10-year-old plants – up to 15 kg and 20-year-old plants can yield up to 30 kg. SZAŁKIEWICZ and KAWECKI (2003) found that cultivation conditions, as well as climatic factors during the plant vegetation period, regardless of genetic factors, had a significant effect on yield and qualitative features of fruits. The cherry silverberry is a plant of low frost resistance and high regenerative properties (GORBUNOW and UDACZINA 1999). Since it is a photophilous plant, it must be provided with good light access (SĘKOWSKI 1993).

A statistical analysis of the morphological features of fruits and stones of the examined biotypes (Table 1 and Table 2) did not reveal any significant differences, except for the length of the fruit stalk, which significantly differentiated individual biotypes (Table 1). The longest stalks were observed in fruits of the 01-1999 biotype (3.77 cm), and the shortest one in the 9-19-196 biotype (3.30 cm).

Table 2

Morphological characteristics of stones from fruits of the biotypes of cherry silverberry (mean of 2012–2015)

Biotype	The weight of stone [g]	The length of stone [cm]	The width of stone [cm]	Fruit weight-to-stone weight ratio
01-1999	0.095^{a*}	1.08^{a}	0.35^{a}	11.79^{a}
9-34-1996	0.090^{a}	1.10^{a}	0.35^{a}	9.89^{a}
9-24-1996	0.105^{a}	1.10^{a}	0.38^{a}	10.00^{a}
9-19-1996	0.097^{a}	1.10^{a}	0.36^{a}	9.69^{a}

* For explanation see Table 1

The mean weight of 100 fruits of the examined biotypes was 100 g. The highest weight of 100 fruit, 112 g, was found for the 01-1999 biotype. In a study conducted by SZAŁKIEWICZ and KAWECKI (2003), the fruit weight of several cultivated forms under analysis obtained from the Institute for Fruit Growing in Samokhvalovitchy in Belarus ranged from 0.65 to 1.63 g, while according to KAWECKI et al. (2007), the weight of 100 fruits of the Russian cultivar 'Sachalinskij Pierwyj' was 140 g. What is of high importance in the evaluation of fruit quality, particularly in the context of their usability for processing, is the relation of the fruit weight to the stone weight. The current experiment did not demonstrate any significant differences between the biotypes as regards this parameter, which amounted from 9.69 for the 9-19-1996 biotype to 11.79 for the 01-99 biotype (Table 2).

Nevertheless, individual biotypes significantly differed in content of chemical components in fruits (Table 3).

Table 3

Biochemical composition of fruits of the cherry silverberry biotypes in fresh mass

Biotype	Dry matter [%]	Organic acids [%]	Total saccharides [%]	Monosa--ccharides [%]	Sugar/acid ratio	Vitamin C [mg 100 g^{-1}]
01-1999	12.64^{a*}	0.81^{a}	5.58^{b}	1.54^{a}	6.89^{b}	5.08^{b}
9-34-1996	13.44^{b}	1.20^{c}	6.30^{d}	1.92^{c}	5.25^{a}	4.22^{a}
9-24-1996	14.56^{c}	1.00^{b}	5.34^{a}	1.85^{b}	5.34^{a}	7.70^{c}
9-19-1996	15.55^{d}	0.78^{a}	5.77^{c}	1.96^{d}	7.40^{c}	4.96^{a}

* The values denoted with the same letters are not significantly different at $p = 0.01$

The dry matter content in fruit was quite varied and ranged from 12.64% in the 01-1999 biotype to 15.55% in the 9-19-1996 biotype. The biotypes of cherry silverberry evaluated by SZAŁKIEWICZ and KAWECKI (2003) contained 12.9–20.0% dry matter. Their maximum content was found in E 2 and E 3 forms, with the fruit weight amounting to 1 g. Similar results were obtained by WASIUK (2000).

Basic quality parameters of fruits determining their acceptance by consumers include the content of acids and sugars and their respective proportions. Those parameters also determine the level of evaluation of the sweet and sour taste of fruits. The value of the sugar/acid ratio was similar for fruits of the 9-34-1996 biotope and the 9-24-1996 biotope, which were one of the sourest. The fruits with a sugar/acid ratio higher than the values for the 01-1999 biotype were produced by the 9-19-1996 biotype, which was characterized by the lowest content of organic acids (Table 3). Fruits of this biotype, as well as of the 9-34-1996 biotype, contained the lowest amounts of vitamin C. The highest content of this vitamin, 7.7 mg 100 g^{-1}, was found for fruit of the 9-24-1996 biotype, while they were the least abundant in total sugar (5.34%). The highest amounts of this component, 6.30%, were found in fruits of the 9-34-1996 biotype. In the research by WASIUK (2000), the content of organic acid in fruits of several forms of the cherry silverberry cultivated in Ukraine ranged from 1.4% to 2.3%, while SZAŁKIEWICZ and KAWECKI (2003) obtained a higher content in fruits of other forms of this species cultivated in Belarus, i.e. between 2.14% and 2.52%. However, the highest differences were recorded as regards the content of ascorbic acid.

Slightly lower contents of ascorbic acid were found by SZAŁKIEWICZ and KAWECKI (2003): 2.35-4.34 mg 100 g^{-1} as compared to the present study, while the content of vitamin C in the fruits examined in Ukraine by WASIUK (2000) was significantly higher and amounted from 15.8 to 33.1 mg 100 g^{-1}. ISACZKIN et al. (2003) reported that the fruit contains 22 mg 100 g^{-1} vitamin C. The cherry silverberry also contains low amounts of fat. As reported by PIŁAT et al.

(2013), the total amount of lipids in cherry silverberry fruits amounted to about 1.4 g in 100 g of pulp. This fat contains from 48.7% to 54.5% unsaturated fatty acids, in which α-linolenic acid, known as omega-3 fatty acid, accounts for 17.5% to 20.8% and linolinic acid (omega-6) – from 21.8% to 25.9%.

The highest content of α-linolenic acid (20.8%) and linolinic acid (25.9%) in the pulp of the fruit was found for the 9-24-1996 biotype (Figure 1.). Lipids accumulated in stones of silverberry fruits contained an amount of oleic acid that was three times higher than the value found for lipids in the fruit pulp (Figure 2). The amount of oleic acid ranged from 19.3% (for the 9-24-1996 biotype) to 22.7% (for the 9-34-1996 biotype). According to dieticians,

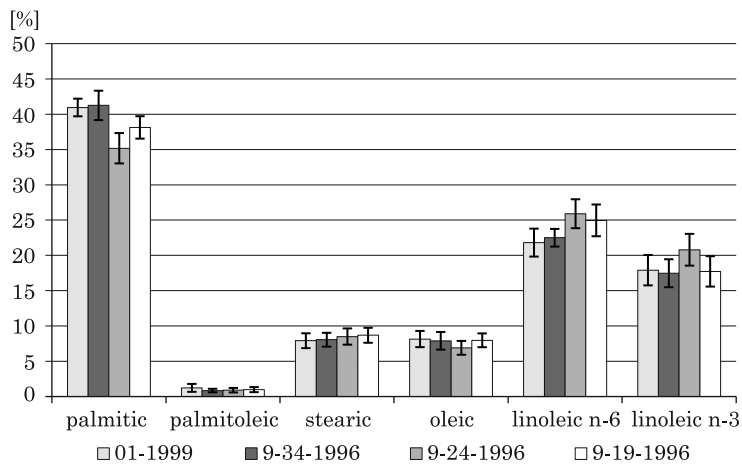

Fig 1. The fatty acids composition (% of total lipids) in the silverberry fruit pulp

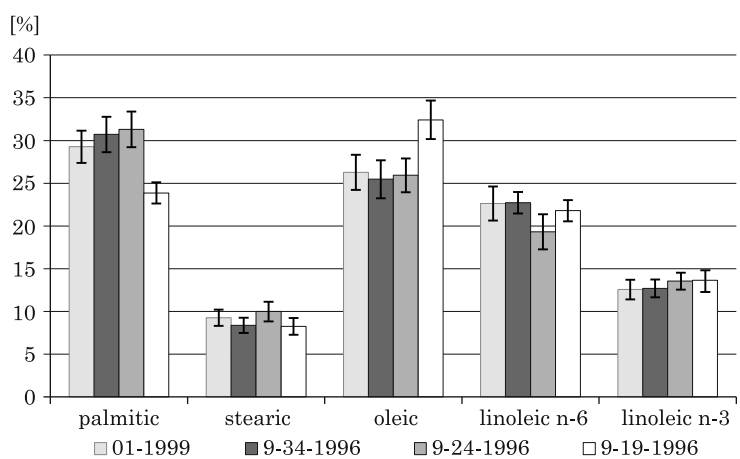

Fig 2. The fatty acids composition (% of total lipids) in the silverberry fruit stone

the omega-6 to omega-3 fatty acid ratio should range between 1:1 and 5:1, while in the silverberry fruit this ratio amounts to about 1.2:1 to 1.4:1 in the pulp, and from 1.4:1 to 1.8:1 in the stone of the silverberry fruits.

Conclusions

1. Although the natural conditions of Olsztyn make it possible to cultivate the examined biotypes of cherry silverberry, the yield was not high. The 01-1999 biotype of the Polish selection was characterized by a higher yield and weight of fruit, as well as by a higher relation of the fruit weight to the stone weight in comparison to biotypes selected in Belarus.
2. The fruits of the examined biotypes also significantly differed in terms of their chemical composition. Fruits of the 9-19-196 biotype were characterized by high dry matter content, low acidity and a high sugar/acid ratio. The 9-24-1996 biotype fruits were characterized by the highest content of vitamin C.
3. Both fruits and stones of cherry silverberry contained fat rich in n-3 and n-6 fatty acids. In cherry silverberry fruits, this ratio amounted from 1.2:1 to 1.4:1 in the pulp and from 1.4:1 to 1.8:1 in the stone.

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