

THE COMMON SEA BUCKTHORN – A VALUABLE FRUIT

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A B S T R A C T

From 2001 to 2003, five varieties of sea buckthorn were evaluated in terms of yield and chemical composition at the Educational and Experimental Station of the University of Warmia and Mazuria in Olsztyn, Poland. The varieties evaluated were 'Podarok Sadu', 'Botanicheskaya', 'Otrodnaya', 'Trofimovskaya', and an un-named wild variety. The first four varieties were obtained from the Belarusian Institute of Pomology at Samokhvalovitchi, Belarus. The wild variety was collected from near Olsztyn, Poland. The highest yields of 'Podarok Sadu', 'Otrodnaya', and 'Trofimovskaya' were in 2003. The highest yields of 'Botanicheskaya' and the wild variety were in 2002. The varieties with the highest average yields were 'Otrodnaya' (10.3 kg) and 'Podarok Sadu' (8.3 kg). The variety with the lowest average yield was the wild variety (3.5 kg).

The varieties were also evaluated in terms of dry matter content, total sugar content, monosaccharide content, organic acids content, and vitamin C content. There were significant differences in chemical composition from variety to variety and from year to year. The variety with the highest total sugar content, monosaccharide content, and organic acids content was 'Trofimovskaya'. The wild variety had the highest dry matter content, but the lowest vitamin C content.

Key words: chemical composition of fruits, morphology of fruits, sea buckthorn, yield

INTRODUCTION

The sea buckthorn (*Hippophae rhamnoides* L.) belongs to the *Elaeagnaceae* family. Its natural range includes a large area of eastern, central and western Asia, the Pyrenees, the Alps, the Carpathians, and northern

Europe up to England, Norway and central Sweden (Załęcki, 1991; Sękowski, 1993; Łukasiewicz, 1997; Ważbińska, 2000).

The berries usually ripen in September and can be collected until December. They are orange or golden, elongated or almost round, and are densely set on short stalks along the shoots. Upon ripening, the berries have a bitterish taste. After freezing, they have an aromatic, sour taste.

The berries are widely used in the food processing and phytotherapeutical industries. They are used to make homemade jelly, juice, marmalade, fruit liqueurs, vodka and wine (Kawecki et al., 1999; Ważbińska, 2000). They contain from 200 to 600 mg·100 g⁻¹ of vitamin C, and are used in the food processing industry to increase the vitamin C content of products such as juices and beverages (Kawecki et al., 2001).

The seeds are also useful. They contain about 30 mg·100 g⁻¹ of vitamin E and up to 12.5% of fat. They are good sources of tannin and volatile oils (Kawecki et al., 2001; 1999; Kawecki and Pilarek, 1998; Sękowski, 1993). The seeds and berries contain over a hundred different chemical compounds which are essential for human health, including high concentrations of vitamins E, P, B₁ and B₂, organic acids, nitrogen compounds, carotene and flavones. The high concentration of carotene and flavones makes the sea buckthorn a valuable source of vegetable dyes for the food processing industry.

The aim of this trial was to evaluate four Belarusian varieties and one wild Polish variety of sea buckthorn in terms of yield and chemical composition.

MATERIAL AND METHODS

From 2001 to 2003, five varieties of sea buckthorn were evaluated in terms of yield and chemical composition at the Educational and Experimental Station of the University of Warmia and Mazuria in Olsztyn, Poland. The varieties evaluated were 'Podarok Sadu', 'Botanitcheskaya', 'Otrodnaya', 'Trofimovskaya', and an un-named wild variety. The first four varieties were obtained from the Belarusian Institute of Pomology at Samokhvalovitchi, Belarus, and were planted in the Experimental Garden in 1998. The wild variety was collected from near Olsztyn, Poland.

Four female bushes and one male bush of each variety were planted 3 x 4 meters apart in a rusty-brown, light loamy sand. The varieties were evaluated in terms yield, berry weight, length and width, dry matter content, total sugar content, monosaccharide content, organic acids content, and vitamin C content.

Morphological measurements were performed on 100 berries from each bush. Chemical analyses were performed on a sample of 1 kg of each variety. The data presented are the average of three parallel measurements.

Dry matter content was measured after drying at 105°C. Total sugar content was measured using the Luff-Schoorl method (Ładoński and Gospodarek, 1986). Organic acids were measured using the Petersburski method (Pijanowski et al., 1973). Vitamin C content was measured using the Pijanowski modification of the Tillman method (Pijanowski et al., 1973).

The significance of differences among means was determined using Duncan's multiple range t-test at $P = 0.05$ and $P = 0.01$.

RESULTS

Yields varied widely from variety to variety and from year to year (Tab. 1). The variety with the highest three-year average yield was 'Otrodnaya' (10.3 kg/bush), followed by 'Podarok Sadu' (8.3 kg/bush), 'Trofimovskaya' (7.6 kg/bush), 'Botanitcheskaya' (7.5 kg/bush), and the wild variety (3.5 kg/bush).

Yields for 'Podarok Sadu', 'Otrodnaya' and 'Trofimovskaya' were significantly higher in 2003 than in the other two years of the study. This was especially the case for 'Podarok Sadu' and 'Otrodnaya', which had yields in 2003 that were three times higher than their yields in 2002, their next best year.

Yields for 'Botanitcheskaya' and the wild variety were significantly higher in 2002 than in the other two years of the study.

Table 1. Yield in common sea buckthorn from 2001 to 2003

Variety	Yield [kg per bush]			Three-year mean for variety
	2001	2002	2003	
'Podarok Sadu'	3.1 efg*	4.8 efgh	17.0 b	8.3 a
'Botanitcheskaya'	5.8 efgh	9.7 cd	6.9 def	7.5 b
'Otrodnaya'	3.8 fgh	7.0 def	20.1 a	10.3 a
'Trofimovskaya'	5.1 efgh	7.3 de	10.4 c	7.6 b
Wild variety	3.1 gh	5.3 efgh	2.2 h	3.5 c
Mean for year	4.2 c	6.8 b	11.3 a	
Three-year mean	7.4			
LSD _{0.05}				
Factor I (variety)	1.653			
Factor II (experimental years)	1.280			
F.I x F.II	2.863			

*Values followed by the same letter do not significantly differ according to Duncan's multiple-range t-test at $P = 0.05$

Results for fruit weight, length and width are presented in Table 2. The variety with the highest three-year average fruit weight was 'Botanitcheskaya' (0.65 g), followed by 'Trofimovskaya' (0.62 g), 'Podarok Sadu' (0.60 g), 'Otrodnaya' (0.56 g), and the wild variety (0.43 g).

Berry weight varied from year to year, and was significantly lower in 2002 for all varieties except the wild variety, which bore its smallest berries in 2003.

Berry weight, length and width in 'Podarok Sadu', 'Botanitcheskaya', 'Otrodnaya', 'Trofimovskaya' were not significantly different. Berry weight, length and width in the wild variety were all significantly lower than in the Belarusan varieties (Tab. 2).

Results for dry matter content, total sugar content, and monosaccharides content are presented in Table 3.

The variety with the highest three-year average dry matter content was the wild variety (17.0%), followed by 'Podarok Sadu' (15.5%), 'Trofimovskaya' (15.2%), 'Otrodnaya' (14.8%), and 'Botanitcheskaya' (14.6%). The wild variety had the highest dry matter content in all three years of the study. All varieties had by far their highest dry matter contents in 2002, and their lowest dry matter contents in 2001.

The variety with the highest three-year average total sugar content was 'Trofimovskaya' (2.78%), followed by 'Otrodnaya' (2.20%), 'Botanitcheskaya' (2.19%), the wild variety (2.05%), and 'Podarok Sadu' (1.99%).

All varieties except 'Botanitcheskaya' had their highest total sugar contents in 2003, especially 'Trofimovskaya', which had a total sugar content more than twice as high in 2003 than in the other two years of the study. 'Botanitcheskaya' had its highest total sugar content in 2001, the year in which most of the other varieties had their lowest total sugar contents.

The variety with the highest three-year average monosaccharides content was 'Trofimovskaya' (2.16%), followed by 'Otrodnaya' (1.88%), the wild variety (1.73%), 'Podarok Sadu' (1.61%), and 'Botanitcheskaya' (1.55%).

All varieties except 'Botanitcheskaya' had their highest monosaccharides contents in 2003, especially 'Trofimovskaya', which had a monosaccharides content more than twice as high in 2003 than in the other two years of the study. 'Botanitcheskaya' had its highest monosaccharides content in 2001, the year in which most of the other varieties had their lowest monosaccharides contents.

Results for organic acids content and vitamin C content are presented in Table 4.

The variety with the highest three-year average organic acids content was 'Otrodnaya' (1.67%), followed by 'Botanitcheskaya' (1.17%), 'Podarok Sadu' (1.07%), 'Trofimovskaya' (0.98%), and the wild variety (0.96%).

Table 2. Fruit weight, length and width common sea buckthorn from 2001 to 2003

Variety	Weight [g]				Length [cm]				Width [cm]			
	2001	2002	2003	Three-year mean for variety	2001	2002	2003	Three-year mean for variety	2001	2002	2003	Three-year mean for variety
‘Podarok Sadu’	0.66	0.49	0.66	0.60 ab	1.15	1.18	1.06	1.13 a	0.85	0.85	0.80	0.83 a
‘Botanicheskaya’	0.67	0.48	0.80	0.65 a	1.15	1.13	1.02	1.10 a	0.85	0.84	0.85	0.85 a
‘Otrodnaya’	0.54	0.49	0.65	0.56 b	1.04	1.18	0.99	1.07 a	0.81	0.80	0.79	0.80 a
‘Trofimovskaya’	0.62	0.51	0.74	0.62 ab	1.10	1.18	1.07	1.12 a	0.85	0.83	0.82	0.83 a
Wild variety	0.53	0.45	0.30	0.43 c	1.08	1.14	0.74	0.99 b	0.81	0.79	0.62	0.74 b
Mean for year	0.60 a*	0.48 b	0.63 a	-	1.10 b	1.16 a	0.98 c	-	0.83 a	0.82 ab	0.78 b	-
Three-year mean	0.57			-	1.08			-	0.81			-
LSD _{0,01}												
Factor I (variety)	0.077				0.719				0.491			
Factor II (experimental years)	0.059				0.557				0.380			
F.I x F.II	0.133				1.245				0.850			

*For explanation, see Table 1

Table 3. Dry matter content, total sugar content and monosaccharides content in common sea buckthorn fruits from 2001 from 2003

Variety	Dry matter content [%]				Total sugar content [%]				Monosaccharides content [%]			
	2001	2002	2003	Three-year mean for variety	2001	2002	2003	Three-year mean for variety	2001	2002	2003	Three-year mean for variety
‘Podarok Sadu’	14.5	17.9	14.0	15.5 b*	1.28	1.94	2.75	1.99 d	1.09	1.40	2.33	1.61 d
‘Botanitcheskaya’	13.4	16.3	14.1	14.6 b	2.40	1.97	2.21	2.19 b	1.72	1.46	1.46	1.55 e
‘Otrodnaya’	13.8	17.0	13.8	14.8 b	1.42	2.04	3.14	2.20 b	1.18	1.52	2.94	1.88 c
‘Trofimovskaya’	13.2	17.1	15.4	15.2 b	2.09	1.97	4.28	2.78 a	1.60	1.46	3.41	2.16 a
Wild variety	14.9	18.5	17.5	17.0 a	1.59	1.97	2.60	2.05 c	1.30	1.49	2.41	1.73 b
Mean for year	14.0	17.4	15.0	15.4	1.76	1.98	3.00	2.24	1.38	1.47	2.51	1.78
Three-year mean	15.4				2.25				1.79			
LSD _{0,01}												
Factor I (variety)	1.414				0.044				0.049			
Factor II (experimental years)	2.450				0.077				0.081			
F.I x F.II	1.096				0.034				0.036			

*For explanation, see Table 1

Table 4. Organic acids content and vitamin C content in common sea buckthorn fruits from 2001 to 2003

Variety	Organic acids content [%]				Vitamin C content [mg·100 g ⁻¹]			
	2001	2002	2003	Three-year mean for variety	2001	2002	2003	Three-year mean for variety
‘Podarok Sadu’	1.35	1.16	0.69	1.07 c*	169	176	138	161 d
‘Botanitcheskaya’	1.74	1.35	0.43	1.17 b	201	196	138	178 c
‘Otrodnaya’	2.89	1.54	0.57	1.67 a	198	178	196	191 b
‘Trofimovskaya’	1.30	1.19	0.44	0.98 d	195	186	211	197 a
Wild variety	1.49	1.14	0.26	0.96 d	130	114	125	123 e
Mean for year	1.75	1.28	0.48	1.17	167	170	162	170
Three-year mean	1.17				166			
LSD _{0.01}								
Factor I (variety)	0.078				4.445			
Factor II (experimental years)	0.134				6.945			
F.I x F.II	0.060				3.106			

*For explanation, see Table 1

All varieties had their highest organic acids contents in 2001, and by far their lowest organic acids contents in 2003.

The variety with the highest three-year average vitamin C content was 'Trofimovskaya' (197 mg·100 g⁻¹), followed by 'Otrodnaya' (191 mg·100 g⁻¹), 'Botanitcheskaya' (178 mg·100 g⁻¹), 'Podarok Sadu' (161 mg·100 g⁻¹), and the wild variety (123 mg·100 g⁻¹).

Vitamin C content did not significantly differ from year to year, except for 'Botanitcheskaya', which had a significantly lower vitamin C content in 2003, and the wild variety, which had a significantly lower vitamin C content in 2002.

DISCUSSION

Sea buckthorn bushes begin to bear when they are three or four years old and reach peak productivity when they are six to eight years old. They continue to bear until they are twenty years old (Grochowski, 1992).

The marketable yield of sea buckthorn has been reported to be as high as 15 kg/bush (Załęcki, 1991). In our study, yields ranged widely from 2.2 to 20.1 kg/bush, with an average of 7.4 kg/bush. The highest yields recorded were for 'Otrodnaya' (20.1 kg/bush) and 'Podarok Sadu' (17.0 kg/bush), both in 2003. In 2001 and 2002, none of the varieties had yields over 10 kg/bush.

Fruit weight in sea buckthorn has been reported to range from 0.5 to 1.0 g (Pluta, 1999). In our study, fruit weight ranged from 0.30 to 0.80 g, with an average of 0.57 g. The highest fruit weight recorded was for 'Botanitcheskaya' (0.80 g) in 2003. Fruit weights were higher in 2001 and 2003 than in 2002.

Fruit length in sea buckthorn has been reported to be about 1.0 cm (Grochowski, 1992). In our study, fruit length ranged from 0.74 cm to 1.18 cm, with an average of 1.08 cm. The highest average fruit lengths were recorded in 2002, and the lowest average fruit lengths were recorded in 2003.

Dry matter content in sea buckthorn has been reported to be about 14.8% (Nesterowicz et al., 1999). In our study, dry matter content ranged from 13.2 to 18.5%, with an average of 15.4%. Dry matter contents were highest in 2002 and lowest in 2001.

Total sugar content in sea buckthorn has been reported to be up to 3.6% (Kawecki et al., 1999). In our study, total sugar content ranged from 1.28 to 4.28%, with an average of 2.25%. By far the highest total sugar content recorded was for 'Trofimovskaya' (4.28%) in 2003. Total sugar contents were generally higher in 2003 than in the other two years of the study.

Organic acids content in sea buckthorn has been reported to be up to 2.6% (Kawecki et al., 1999). In our study, organic acids content ranged from

0.26 to 2.89%, with an average of 1.17%. By far the highest organic acids content recorded was for 'Otrodnaya' (2.89%) in 2001. Organic acids contents were highest in 2001, and by far the lowest in 2003.

Vitamin C content in sea buckthorn has been reported to range from 200 to 600 mg·100 g⁻¹ (Kawecki et al., 1999). In our study, vitamin C content ranged from 114 to 211 mg·100 g⁻¹, with an average of 166 mg·100 g⁻¹. The highest vitamin C content recorded was for 'Trofimovskaya' (211 mg·100 g⁻¹) in 2003. 'Trofimovskaya' had the highest three-year average vitamin C content, and the wild variety had the lowest.

Total sugar content and organic acids content depend on the weather during the vegetative period. In 2003, the summer was mostly warm and sunny, which meant that the total sugar contents recorded that year were high, and the organic acids contents were low.

CONCLUSIONS

1. The variety with the highest three-year average yield was 'Otrodnaya' (10.3 kg/bush), and the variety with the lowest three-year average yield was the wild variety (3.5 kg/bush).
2. The variety with the highest three-year average fruit weight was 'Botanitcheskaya' (0.65 g), and the variety with the lowest three-year average fruit weight was the wild variety (0.43 g).
3. The variety with the highest three-year average dry matter content was the wild variety (17.0%), and the variety with the lowest three-year average dry matter content was 'Botanitcheskaya' (14.6%).
4. The variety with the highest three-year average total sugar content was 'Trofimovskaya' (2.78%), and the variety with the lowest three-year average total sugar content 'Podarok Sadu' (1.99%).
5. The variety with the highest three-year average monosaccharides content was 'Trofimovskaya' (2.16%), and the variety with the lowest three-year average monosaccharides content was 'Botanitcheskaya' (1.55%).
6. The variety with the highest three-year average organic acids content was 'Otrodnaya' (1.67%), and the variety with the lowest three-year average organic acids content was the wild variety (0.96%).
7. The variety with the highest three-year average vitamin C content was 'Trofimovskaya' (197 mg·100 g⁻¹), and the variety with the lowest three-year average vitamin C content was the wild variety (123 mg·100 g⁻¹).
8. Under the climatic conditions prevailing in Olsztyn, all four of the Belarusian sea buckthorn varieties bore fruit of satisfactory quality.

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ROKITNIK ZWYCZAJNY – WARTOŚCIOWA ROŚLINA OWOCODAJNA

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S T R E S Z C Z E N I E

W latach 2001-2003 w Zakładzie Dydaktyczno-Doświadczalnym UWM w Olsztynie zbadano skład chemiczny owoców 5 odmian rokitnika zwyczajnego: 'Podarok Sadu', 'Botaniczeskaja', 'Otrodnaja', 'Trofimowskaja' i Forma bezodmianowa. Sadzonki Formy bezodmianowej pozyskano z krzewów nasadzeń miejscowych, natomiast jednoroczne sadzonki 4 pozostałych odmian przywieziono w 1998 roku z Instytutu Sadownictwa w Samochwałowiczach na Białorusi. Najwyższy średni plon otrzymano w 2003 roku. Jedynie krzewy Formy bezodmianowej i odmiany 'Botaniczeskaja' w omawianym roku plonowały na niższym poziomie niż w 2002 roku. Największe średnie plony owoców uzyskano z odmiany 'Otrodnaja' – 10,3 kg z rośliny oraz z odmiany 'Podarok Sadu' – 8,3 kg z rośliny. Forma bezodmianowa plonowała najslabiej – 3,54 kg z krzewu.

W badaniach laboratoryjnych określono zawartość suchej masy, cukrów ogółem, cukrów prostych, kwasów organicznych oraz witaminy C. Analiza statystyczna wykazała istotne różnice w zawartości badanych związków zarówno pomiędzy odmianami, jak i w latach badań. Największe średnie zawartości cukrów prostych, kwasów organicznych, cukrów prostych i ogółem zanotowano u odmiany 'Trofimowskaja'. Owoce Formy bezodmianowej charakteryzowały się najmniejszą zawartością witaminy C, ale zawierały najwięcej suchej masy.

Słowa kluczowe: morfologia owoców, plon, rokitnik zwyczajny, skład chemiczny owoców