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NUTRITIONAL VALUE AND CONTENT OF BIOACTIVE COMPOUNDS IN RASPBERRY FRUIT FROM ORGANIC, BIODYNAMIC AND CONVENTIONAL FARMS

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Abstract: Organic farming is very popular in the world. Biodynamic farming is less recognized both by practice and science. There is very sparse data about the nutritional value of biodynamic plant crops. The aim of the study was to investigate if there are significant differences in the nutritional value and content of bioactive compounds in raspberry fruit produced in biodynamic (BIOD), organic (ORG) and conventional (CONV) systems. The results were divergent - in 2016 ORG raspberries contained more bioactive compounds than CONV. In 2017 the results were opposite - CONV fruits had significantly higher level of bio compounds than ORG ones. Composition differences between BIOD and ORG raspberries were also not consistent and showing various trends in the subsequent study years. There is a need for long lasting studies looking for the main factors deciding about the composition of fruits in dependence on the cultivation system.

Introduction: Nowadays, the massive development of intensive agriculture became a major threat for natural environment. This shows a strong need for a more sustainable alternatives. Organic and biodynamic farming apeared to be one of such alternatives. Moreover, demand for organic and biodynamic foods is also strongly driven by perception of consumers that they are more nutritious and can help them to maintain good health [1]. However, scientific opinion is divided on whether there are significant nutritional differences between organic and conventional foods. In addition, available studies results on the health effects of the organic foods are limited and there is a lack of research undertaking the topic of the health-related quality of biodynamic compared to the organic and conventional products [2].

Raspberries are among the most commonly consumed berry fruit worldwide. As there is an increasing market demand for organically produced raspberries, organic acreage is also increasing. Poland became the largest producer of raspberries in both organic and conventional system in the world [3].

Material and methods: Raspberry fruit samples ‘Polka’ cultivar were collected from biodynamic, organic and conventional farms matched for location in 2016 and 2017. Number of farms/plots (samples collected) in 2016 were 10 (3 CONV, 4 ORG, 3 BIOD) and 8 (2 CONV,3 ORG, 3 BIOD) in 2017. Fruit samples (each sample = 1.5 kg) were collected in the full maturity phase. The collected fruit samples were immediately refrigerated and transported to the laboratory of the WULS. Part of each sample (0.5 kg) was immediately used for sensory analyses (fresh fruit). The remaining 1.0 kg was freeze-

dried, ground in a laboratory mill and stored in -80ºC before further analyses, to prevent loss of biologically active compounds. The fruit samples were analyzed in terms of selected important parameters of their nutritional value.

Results: Table 1 shows the content of raspberries cultivated in 2016 and 2017. Comparing CONV and ORG fruits (ORG as a whole so ORG + BIOD together) from 2016 we can see that organically grown raspberries contained more total sugars, total polyphenols, total phenolic acids, total flavonoids and total anthocyanins than conventionally grown fruits. However, anti-oxidant activity was higher for the CONV fruits. Comparing the quality of BIOD and ORG fruits we can see that for parameters as total phenolic acids and anti-oxidant activity the results were more profitable in the case of BIOD fruits. However, for other parameters as total sugars and total flavonols the results were opposite. Therefore it is difficult to judge which production system is causing better nutritive quality of fruits.

In 2017 the results are completely different than in 2016 and indicate that CONV fruits had significantly higher level of most analyzed compounds than ORG ones (taken as a whole so ORG and BIOD together). On the other hand, comparison of the quality of ORG and BIOD fruits points that nutritive value of BIOD fruits was better, because most analyzed compounds were significantly more abundant in BIOD raspberries than ORG ones.

Table 1. Chemical composition of raspberries from biodynamic, organic and conventional agriculture in 2016 and 2017

	2016				2017				p-value	
	Biodynamic	Organic	Conventional	Biodynamic +Organic	Biodynamic	Organic	Conventional	Biodynamic +Organic	2016	2017
dry matter (g/100 g FW)	13.77±0.79[1]a[2]	13.00±1.03a	13.42±0.74a	13.33±1.01a	15.33±1.05a	12.70±0.43c	14.77±0.52ab	14.02±1.54b	0.2085	<0.001
vitamin C (mg/100 g FW)	38.90±8.26a	36.21±8.67a	31.38±2.73a	37.37±8.60a	31.57±1.85b	30.59±5.24b	36.01±1.25a	31.08±3.96b	0.1374	0.030
dehydroascorbic acid	16.93±8.60a	13.80±6.67a	10.45±4.09a	15.14±7.71a	18.36±1.02a	15.25±1.98c	16.12±1.85c	16.80±2.22bc	0.2092	0.0024
l-ascorbic acid	21.98±3.44a	22.42±3.29a	20.93±2.61a	22.23±3.36a	13.21±1.37b	15.35±3.59b	19.89±1.10a	14.28±2.92b	0.6198	0.0002
total sugars (g/100 g FW)	5.16±0.52b	7.38±1.53a	6.24±1.18ab	6.43±1.63a	4.77±0.29b	3.32±0.55d	5.60±0.95a	4.05±0.85c	0.0009	<0.001
glucose	2.02±0.21b	2.52±0.46a	2.38±0.42ab	2.31±0.45ab	1.31±0.16a	0.84±0.13c	1.25±0.14a	1.08±0.28b	0.2580	<0.000

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saccharose	0.39±0.12c	1.54±0.50a	0.45±0.23c	1.05±0.69b	1.152±0.18a	0.659±0.11b	1.151±0.27a	0.91±0.29c	<0.0001	<0.0001
fructose	2.75±0.25a	3.31±0.59a	3.40±0.87a	3.07±0.55a	2.31±0.16bc	1.83±0.35c	3.20±0.60a	2.07±0.36bc	0.0912	<0.0001
total organic acids (g/100 g FW)	1.57±0.10a	1.50±0.13a	1.48±0.08a	1.53±0.13a	1.77±0.14a	1.53±0.04c	1.67±0.07ab	1.65±0.16b	0.3146	0.003
citric acid	1.54±0.10a	1.46±0.13a	1.45±0.08a	1.50±0.13a	1.73±0.14a	1.49±0.04c	1.64±0.07ab	1.61±0.16b	0.2967	0.002
malic acid	0.03±0.00a	0.03±0.00a	0.03±0.00a	0.03±0.00a	0.040±0.00a	0.035±0.00b	0.035±0.00b	0.04±0.00ab	0.7697	0.00099
total polyphenols (mg/100 g FW)	95.56±8.59a	97.23±10.47a	79.21±9.72b	96.51±9.74a	129.30±15.77a	120.65±12.82a	133.83±7.23a	124.97±15.01a	0.00003	0.216
total phenolic acids (mg/100 g FW)	25.26±2.77a	13.14±5.25c	6.12±0.71d	18.33±7.42b	7.80±0.74b	4.91±0.62c	11.20±3.32a	6.35±1.60bc	<0.0001	<0.0001
ellagic acid	0.46±0.03a	0.47±0.07a	0.49±0.07a	0.46±0.06a	1.033±0.12a	0.869±0.14b	1.028±0.14a	0.95±0.15ab	0.6986	0.041
gallic acid	0.75±0.07a	0.75±0.27a	0.66±0.03a	0.75±0.21a	0.84±0.07a	0.55±0.07c	0.74±0.14ab	0.69±0.16b	0.4634	<0.0001
chlorogenic acid	1.54±0.16a	1.08±0.23b	1.06±0.43c	1.28±0.30ab	1.21±0.09b	0.79±0.12b	6.12±2.62a	1.00±0.23b	0.0018	<0.0001
caffeic acid	0.44±0.07c	1.50±1.15b	2.43±0.25a	1.04±1.02bc	0.40±0.04a	0.32±0.01c	0.37±0.01b	0.36±0.05b	<0.0001	<0.0001

p-coumaric acid	22.07±3.03a	9.34±5.98c	1.48±0.18d	14.80±8.00b	4.31±0.75a	2.38±0.41c	2.93±0.69bc	3.35±1.14b	<0.001	<0.001
total flavonoids (mg/100 g FW)	95.10±8.57a	96.76±10.41a	78.72±9.69b	96.05±9.70a	121.50±16.19a	115.74±12.41a	122.63±4.94a	118.62±14.71a	0.0003	0.675
total flavonols (mg/100 g FW)	0.82±0.06b	1.23±0.36a	1.25±0.38a	1.05±0.34ab	1.51±0.29a	1.00±0.18c	1.24±0.33abc	1.26±0.35b	0.0065	0.0026
luteolin	0.40±0.03b	0.42±0.16b	0.59±0.14a	0.41±0.12b	0.14±0.01c	0.18±0.02a	0.17±0.03ab	0.16±0.03b	0.0089	0.0018
quercetin	0.14±0.02b	0.20±0.09b	0.45±0.23a	0.17±0.07b	0.25±0.12a	0.28±0.07a	0.10±0.04b	0.26±0.10a	<0.001	0.0016
kaempferol-3-O-glucoside	0.23±0.02b	0.46±0.27a	0.16±0.03b	0.36±0.23ab	1.04±0.13a	0.51±0.13b	0.94±0.34a	0.78±0.30ab	0.0012	<0.001
kaempferol	0.04±0.02a	0.16±0.16a	0.05±0.07a	0.11±0.13a	0.08±0.05a	0.03±0.02b	0.02±0.01b	0.05±0.04ab	0.0913	0.0066
total anthocyanins (mg/100 g FW)	94.28±8.54a	95.53±10.36a	77.47±9.61b	95.00±9.64a	119.99±16.26a	114.74±12.51a	121.39±4.80a	117.36±14.75a	0.0002	0.716
cyanidin-3,5-O-di-glucoside	46.57±3.94ab	56.63±13.99a	45.00±4.81b	52.32±11.97ab	82.96±16.21a	77.24±8.69a	85.90±4.32a	80.10±13.32a	0.0344	0.493
pelargonidin-3,5-di-O-glucoside	26.67±8.05a	18.88±4.04b	18.55±4.71b	22.22±7.21ab	12.73±1.13a	11.28±1.86a	11.70±0.37a	12.00±1.70a	0.0111	0.196
delphinidin-3,5-di-O-glucoside	21.04±2.50a	20.03±7.45a	13.91±0.76b	20.46±5.88a	24.30±1.95a	26.22±3.70a	23.79±1.32a	25.26±3.11a	0.0064	0.263
procyanidins (g/kg FW)	2.78±0.23a	2.45±0.10a	2.35±0.25a	2.59±0.24a	1.35±0.67a	1.06±0.28b	1.16±0.08a	1.20±0.54ab	0.1620	0.0075
ABTS µMol	2850.44	2787.63	2821.53	2724.99	2958.35	2572.91	3017.43	2765.63	0.	0.

Trolox/100 g FW	±170.34 a	±199.52 b	±122.07 a	±207.03 b	±387.44 a	±115.34 a	±205.53 a	±344.74 a	00 01	92 4

[1]Data are presented as the mean ± SD with ANOVA p-value

[2] Means in rows followed by the same letter are not significantly different at the 5% level of probability ($p<0.05$)

Discussion: Kazimierczak et al. [4] compared the contents of antioxidant compounds in two varieties of raspberry fruits came from certified organic and conventional production. Organic raspberries contained more total phenolic acids (18.34 vs. 15.89 mg/100 g), total flavonoids (19.11 vs. 14.57 mg/100 g) and total anthocyanins (174.69 vs. 109.59 mg/100 g) in comparison to conventional ones. This is confirmed by research of Skupień et al. [5] in which total anthocyanins content amounted 28.1-48.1 mg/100 g in organic-group and 26.7-43.6 for conventional raspberies fruits. The aim of the study conducted by Ponder and Hallmann [6] was to compare the content of bioactive compounds in organic vs. conventional raspberries. The organic raspberries samples contained significantly more total phenolic acids (62.9 vs. 44.3 mg/100 g), total flavonoids (93.53 vs. 82.65 mg/100 g) and total anthocyanins (82,53 vs. 73.83 mg/100 g) than conventional fruits.

Conclusion: In 2016 ORG raspberries contained more bioactive compounds than CONV. In 2017 the results were opposite - CONV fruits had significantly higher level of bio compounds than ORG ones. Composition differences between BIOD and ORG raspberries were also not consistent and showing various trends in the subsequent study years. There is a need for long lasting studies looking for the main factors deciding about the composition of fruits in dependence on the cultivation system.

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Disclosure of Interest: None Declared

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