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THE ESTIMATION OF BIOACTIVE COMPOUNDS CONTENT IN ORGANIC AND CONVENTIONAL SWEET CHERRY (*Prunus avium* L.)

Summary

The rules of organic fruit production are a very strict. Only natural fertilizers and plant protection products are allowed. Fruit produced by organically way are characterized by a higher content of biologically active compounds in comparison with conventional one. The consumer prefer sweet cherry fruits due to their pleasant taste and the pro-healthy properties. Sweet cherry fruits are a very good source of phenolic compounds in our diet. In cherries, especially those with dark colour you can find also the anthocyanins valuable for the health. In the experiment four varieties of cherries were used: Regina cv, Kordia cv, Hedelfińska cv, Bütnera Red cv. from organic and conventional production. In the fruit dry matter content and phenolic compounds were measured. The obtained results showed that organic sweet cherry fruits contained significantly more total sugars including glucose and fructose, total anthocyanins, especially cyanidin-3.5-di-O-rutinozide, as well as two identified flavonoids: luteolin and quercetin. Conventional sweet cherry fruits were characterized by significantly higher amount of dry matter, organic acids including citric and malic acids, and quercetin-3-O-glucoside, kaempferol content. Sweet cherry fruits are a very good diversification of our diet, it's a good idea to consume, especially those from organic farming.
***Key words**: organic sweet cherry, conventional sweet cherry, polyphenols, dry matter, nutritive value, vitamin C*

OZNACZENIE ZAWARTOŚCI ZWIĄZKÓW BIOLOGICZNIE CZYNNYCH W OWOCACH CZEREŚNI EKOLOGICZNYCH I KONWENCJONALNYCH (*Prunus avium* L.)

Streszczenie

W ekologicznym sadownictwie wymagane są bardzo restrykcyjne metody. Tylko naturalne nawozy i środki ochrony roślin są dozwolone. Owoce wyprodukowane metodami ekologicznymi charakteryzują się wyższą zawartością związków biologicznie czynnych w porównaniu z owocami konwencjonalnymi. Owoce czereśni są cenione przez konsumentów ze względu na przyjemny smak oraz wartości pro-zdrowotne. Są bardzo dobrym źródłem związków polifenolowych w naszej diecie. W owocach czereśni, szczególnie tych o ciemnym zabarwieniu można znaleźć tez cenne dla zdrowia antocyjany. W doświadczeniu użyto cztery odmiany czereśni: Regina cv, Kordia cv, Hedelfińska cv, Bütnera Red cv. z produkcji ekologicznej i konwencjonalnej. W owocach zmierzono zawartość suchej masy oraz związków polifenolowych. Otrzymane wyniki wskazują, że czereśnie ekologiczne charakteryzowały się istotnie większą zawartością cukrów ogółem w tym glukozy i fruktozy, antocyjanów ogółem, szczególnie rutynozydu-3,5-di-O-cyjanidyny, jak tez zidentyfikowanych flawonoidów: luteoliny i kwercetyny. Owoce czereśni konwencjonalnych charakteryzowały się istotnie wyższa zawartością suchej masy, kwasów organicznych, szczególnie kwasu cytrynowego i jabłkowego, ale też glikozydu-3-O-kwercetyny i kempferolu. Owoce czereśnie są bardzo dobrym urozmaiceniem naszej diety, dlatego warto spożywać, szczególne te z upraw ekologicznych.
***Słowa kluczowe:** ekologiczne czereśnie, konwencjonalne czereśnie, polifenole, sucha masa, wartość odżywcza, witamina C*

1. Introduction

Organic fruit production is based only on the use of natural agricultural methods. In organic orchards only green manure, plant composts and natural fertilizers as animal (manure) are allowed. For the plant protection only natural methods as: pheromone traps, yellow and stick tabs as well as predators are mainly used [7]. Maintenance of high biodiversity is a priority in environmental management (Simonides, 2010). One of the most important issues is to pay attention to proper selection of cultivars for organic production [7]. The modern consumer of fruits is the person more and more informed. He looks for the fruits of high biological value. Organic fruits contains a higher level of bioactive compounds [3], and give more guarantee for high food safety for example in absence of pesticides residues [9]. Fruits cherries are a source of valuable bioactive compounds from a group of polyphenols (flavonoids and anthocyanins. The aim of the presented experiment was to compare bioactive compounds content in selected sweet cherry fruits from organic and conventional production.

2. Material and methods

For experiment purpose four sweet cherry cultivars have been used: Regina cv, Kordia cv, Hedelfińska cv, Bütnera Red cv. Sweet cherry fruit were collected in June of 2015 in the full maturity in the bulk quantity of 2 kg of each variety and combinations in the organic orchard of Horticulture Institute in Skierniewice located in Nowy Dwór and the conventional orchard located in Dąbrowice. In the fruit the content of dry matter (by scale method), sugars, organic acids, polyphenol with separation of individual flavonoids, anthocyanins and phenolic acids and vitamin C (by HPLC method) have been measured. The results were statistically elaborated using post-hoc Tukey's test (p=0.05). Experimental factors were: production system (organic vs. conventional) and cultivar: Regina cv, Kordia cv, Hedelfińska cv, Bütnera Red cv.

3. Results

The content of dry matter, sugars, organic acids, vitamin C, and individual groups of polyphenols' compounds are presented in Table 1. Organic sweet cherries contained a significantly more total sugars and anthocyanins in fruits compared to conventional ones. At the same time in conventional fruits we found significantly higher level of dry matter and organic acids. There were no statistically significant differences in the content of vitamin C, total polyphenols, total phenolic acids and total flavonoids, among conventional and organic cherries (Table 1).

The examined sweet cherry cultivars were different in case of dry matter content in fruits. Kordia cv. and Hedelfińska cv. contained significantly less dry matter in comparison to other fruits (Table 1). The total sugars content was higher in the fruits of Regina cv. and Bütnera Red cv. whose fruits also contained the highest amount of organic acids. There was no significant effect of the cultivar on the vitamin C content in the sweet cherry fruits (Table 1). Bütnera Red cv. fruits were characterized by the lowest total polyphenol content including anthocyanins, while the Kordia fruits contained significantly less total phenolic acids compared to the other examined cultivars. Only in the fruits of the Regina cv. we found significantly more total flavonoids. The other cultivars showed no differences between the content of the compounds from this group. Organic sweet cherries were characterized by a significantly higher content of sugars (glucose and fructose) compared to conventional ones, where we found significantly more sucrose (Fig. 1).

Bütnera Red cv. contained significantly more glucose, and Hedelfińska cv. significantly more sucrose when compared with the rest of the examined cultivars of sweet cherries. Conventional sweet cherries were more rich in organic acids. In their fruits we found significantly more citric and malic acids compared with organic cherries. Significantly more organic acids we found in fruit Bütnera Red cv. (Fig. 2). In the case of vitamin C organic fruit contained significantly more dehydroksyascorbic acid (DHA), and conventional fruits - L-ascorbic acid (L-ASC) and the differences were significant statistically. In the fruit of Bütnera Red cv. we found significantly more DHA acid, and in the fruit of the Regina cv. significantly more L-ASC acid. At the same time, the fruits of this cultivar were characterized by significantly lower content of DHA (Fig. 3).

Organic sweet cherries were characterized by a higher content of chlorogenic acid and flavonoids quercetin and luteolin compared with conventional one. But in conventional sweet cherry fruits we found more p-coumaric acid and quercetin-3-O-glucoside, myrycetin and kempferolu (Fig. 4). The examined sweet cherry cultivars showed significant differences in terms of the content of the individual phenolic compounds. Significantly more chlorogenic acid we found in Regina and Bütnera Red fruits. At the same time, it has been observed that the fruits of this cultivars contained significantly more p-coumaric acid (Fig. 5).

Organic sweet cherries were characterized by significantly higher content of cyanidin-3,5-di-O-rutinoside (Fig. 6). Hedelfińska cv. contained significantly more cyanidin compared with all examined cultivars. In the case of cyanidin-3,5-di-O-glucoside, it was found that this Kordia cv. was characterized by significantly lower level of that anthocyanin in comparison to the rest of tested cultivars.

Table 1. The content of dry matter, total sugars, total organic acids in (g/100 g FW), vitamin C and polyphenols' compounds in (mg/100 g FW) in selected sweet cherry cultivars from organic and conventional cultivation (mean value ± standard deviation); n=3

Tab. 1. Zawartość suchej masy, cukrów ogółem, kwasów organicznych (w g/100 g ś.m.), witaminy C i związków polifenolowych (w mg/100 g ś.m.) w owocach wybranych odmian czereśni z uprawy ekologicznej i konwencjonalnej (wartość średnia ± odchylenie standardowe), n=3

	Dry matter	Total sugars	Total organic acids	Vitamin C	Total polyphenols	Total phenolic acids	Total flavonoides	Total anthocyanins
organic sweet cherry	16.49±1.17 a[1]	15.25±1,47 b	0.20±0,02 a	9.32±0,51 a	168.85±45,8 a	117.43±43,0 a	4.36±0,65 a	47.07±9,02 b
conventional sweet cherry	18.68±1.50 b	12.59±1,33 a	0.24±0,02 b	9.41±0,74 a	163.09±43,8 a	113.29±34,5 a	6.43±3,29 b	43.38±10,5 a
Regina cv.	18.23±2.04 b	14.10±0,47 b	0.22±0,03 b	9.05±0,99 a	194.37±11,2 c	136.14±9,0 b	8.58±0,83 b	49.65±4,75 b
Kordia cv.	16.11±0.22 a	12.82±0,24 a	0.19±0,01 a	9.36±0,14 a	139.53±14,2 b	87.95±14,9 a	4.16±0,17 a	47.43±0,70 b
Hedelfińska cv.	17.88±1.25 ab	13.59±1.09 a	0.22±0.01 b	9.29±0.61 a	201.81±22.3 c	143.19±20.9 c	4.38±0.63 a	54.24±2.30 c
Bütnera Czerwona cv.	18.12±0.42 b	15.16±0.65 b	0.24± 0.01 c	9.77±0.19 a	128.18±4.4 a	94.16±5.4 a	4.45±0.54 a	29.57±1.49 a
p-value								
cultivation method	0.0003	<0.0001	<0.0001	n.s.[2]	n.s.	n.s.	<0.0001	0.0097
cultivar	0.0183	0.014	0.001	n.s.	<0.0001	0.0001	<0.0001	<0.0001

[1] The same letter means no statistical differences between groups
[2] n.s. (not significant p>0.05)

Source: own work / Źródło: opracowanie własne

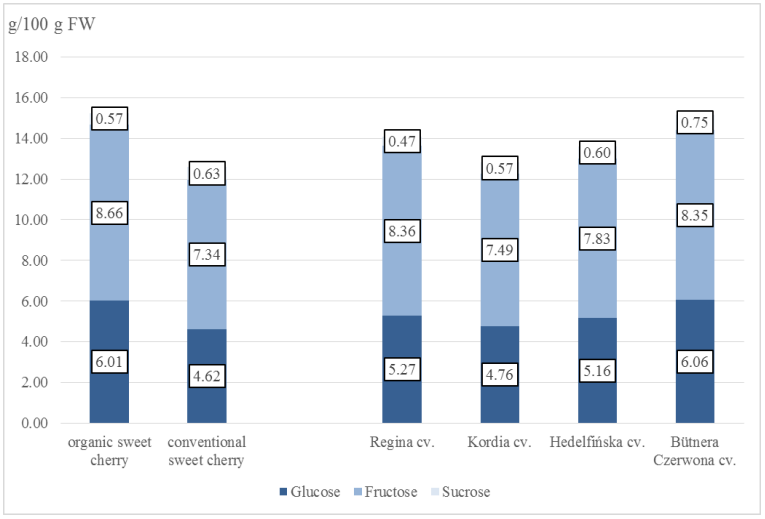

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Fig. 1. The content of sugars in examined cultivars of sweet cherry fruits from organic and conventional production: p-value (cultivation method): glucose <0.0001, fructose 0.0001, sucrose 0.023; p-value (cultivars): glucose 0.001, fructose n.s., sucrose <0.0001
Rys. 1. Zawartość cukrów w owocach badanych odmian czereśni ekologicznych: p-value (metoda uprawy): glukoza <0.0001, fruktoza 0.0001, sacharoza 0.023; p-value (odmiany): glukoza 0.001, fruktoza n.s., sacharoza <0.0001

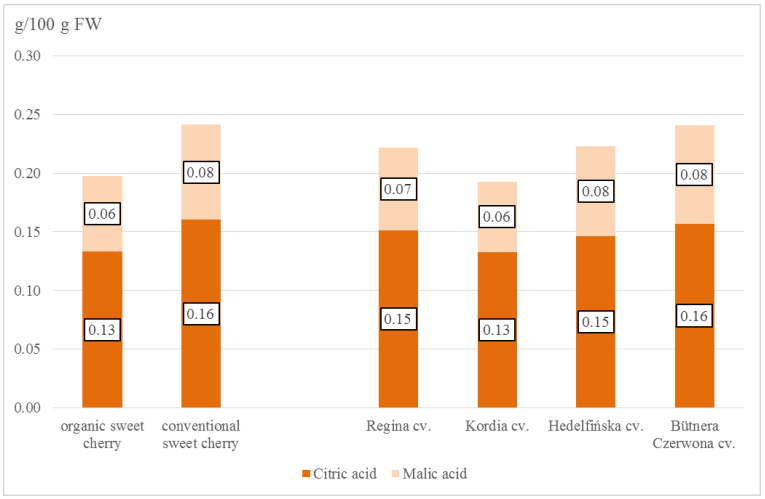

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Fig. 2. The content of organic acids in examined cultivars of sweet cherry fruits from organic and conventional production: p-value (cultivation method): citric acid <0.0001, malic acid <0.000; p-value (cultivars): citric acid 0.082, malic acid <0.0001
Rys. 2. Zawartość kwasów organicznych w owocach badanych odmian czereśni z uprawy ekologicznej i konwencjonalnej :p-value (metoda uprawy): kwas cytrynowy <0.0001, kwas jabłkowy <0.0001; p-value (odmiany): kwas cytrynowy 0.082, kwas jabłkowy <0.0001

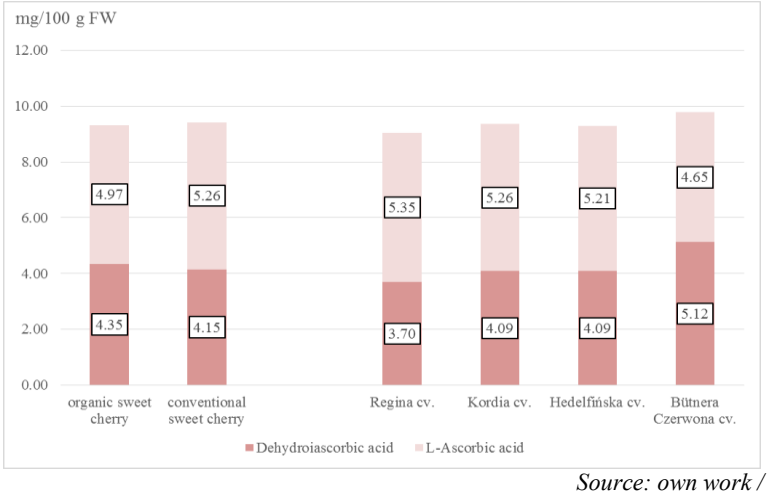

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Fig. 3. The content of vitamin C in examined cultivars of sweet cherry fruits from organic and conventional production. p-value (cultivation method): DHA acid n.s., L-ASC acid n.s.; p-value (cultivars): DHA acid <0.0001, L-ASC acid 0.030.
Rys. 3. Zawartość witaminy C w owocach wybranych odmian czereśni z produkcji ekologicznej i konwencjonalnej. p-value (metoda uprawy): kwas DHA n.s., kwas L-ASC n.s.; p-value (odmiany): kwas DHA <0.0001, kwas L-ASC 0.030

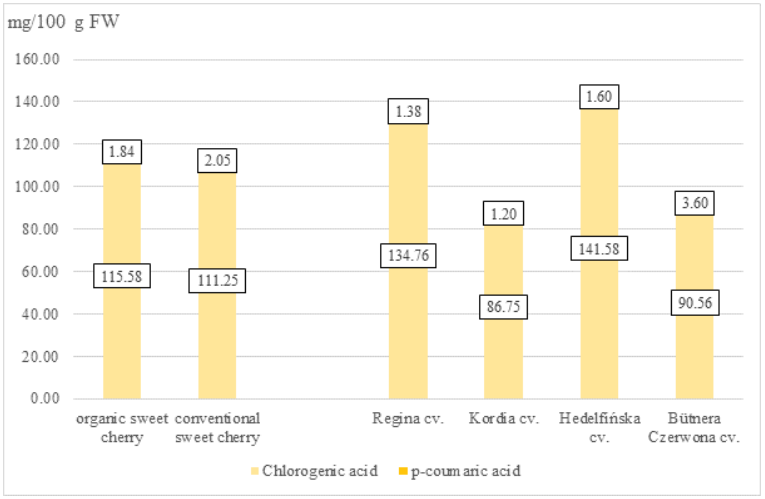

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Fig. 4. The content of phenolic acids in examined cultivars of sweet cherry fruits from organic and conventional production. p-value (cultivation method): chlorogenic acid n.s., p-coumaric acid n.s.; p-value (cultivars): chlorogenic acid 0.0001, p-coumaric acid <0.0001

Rys. 4. Zawartość kwasów polifenolowych w owocach badanych odmian czereśni z uprawy ekologicznej i konwencjonalnej. p-value (metoda uprawy): kwas chlorogenowy n.s., kwas p-kumarynowy n.s.; p-value (odmiana): kwas chlorogenowy 0.0001, kwas p-kumarynowy <0.0001

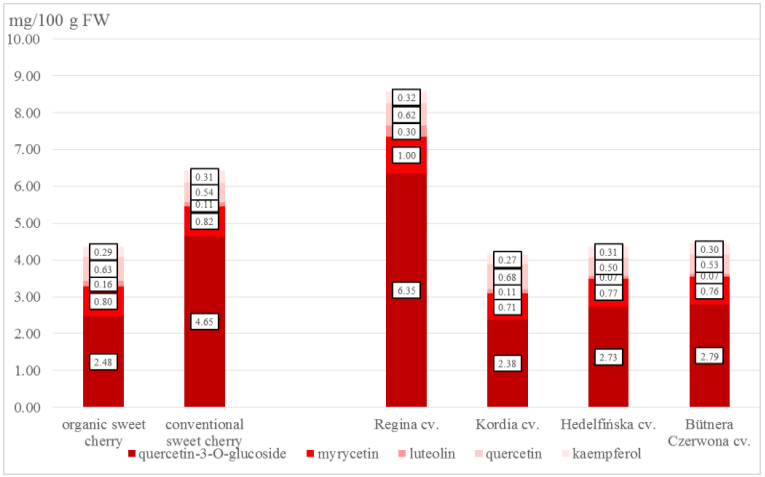

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Fig. 5. The content of flavonoids in examined cultivars of sweet cherry fruits from organic and conventional production. p-value (cultivation method): quercetin-3-O-glucoside<0.0001, myrycetin n.s. luteolin 0.0069, quercetin 0.028, kaempferol 0.0064; p-value (cultivars): quercetin-3-O-glucoside<0.0001, myrycetin <0.0001, luteolin<0.0001, quercetin0.0126, kaempferol 0.014

Rys. 5. Zawartość związków flawonoidowych w owocach badanych odmian czereśni z uprawy ekologicznej i konwencjonalnej p-value (metoda uprawy): glikozyd-3-O-kwercetyny<0.0001, myrycetyna n.s.; luteolina 0.0069, kwercetyna 0.028, kempferol 0.0064; p-value (odmiana): glikozyd-3-O-kwercetyny<0.0001, myrycetyna <0.0001, luteolina <0.0001, kwercetyna 0.0126, kempferol 0.014

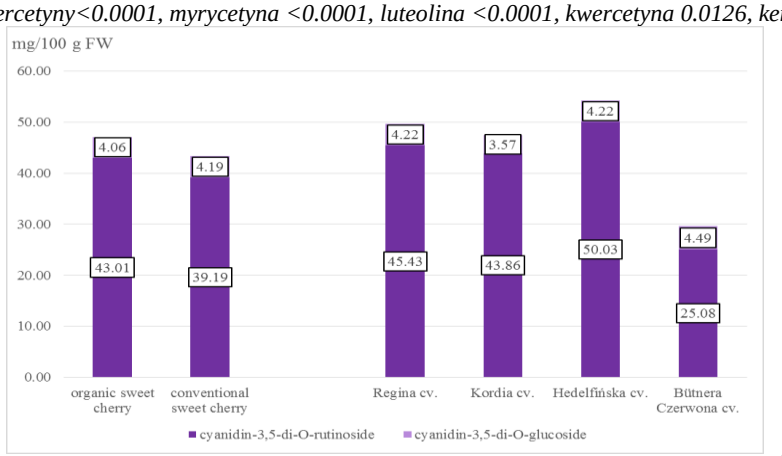

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Fig. 6. The content of anthocyanins in examined cultivars of sweet cherry fruits from organic and conventional production. p-value (cultivation method): cyanidin-3,5-di-O-rutinoside 0.0046, cyanidin-3,5-di-O-glucoside n.s.; p-value (cultivars): cyanidin-3,5-di-O-rutinoside, 0.0001, cyanidin-3,5-di-O-glucoside <0.0001 0.0001

Rys. 6. Zawartość antocyjanów w owocach badanych odmian czereśni z uprawy ekologicznej i konwencjonalnej. p-value (metoda uprawy): rutynozyd-3,5-di-O-cyjanidyny 0.0046, glikozyd-3,5-di-O-cyjanidyny n.s.; p-value (odmiana): rutynozyd-3,5-di-O-cyjanidyny ,0.0001, glikozyd-3,5-di-O-cyjanidyny <0.0001

4. Disscusion

Fruits of sweet cherry are appreciated by consumers for the good taste and their many nutritional pro-healthy properties. In presented paper we have shown that examined sweet cherry cultivars contained different amount of dry matter. Kordia cv. contains 16.11 g/100 g FW and Regina cv 18.23 g/100 g FW. It was consistent with results presented by Młynarczyk [6], who found 14.59 g/100 g FW, of dry matter in fruits Kordia cv. as well as 17.88 g/100 g FW Regina cv. The sweet cherry fruits contain only a small amounts of vitamin C. In presented studies the highest level of vitamin C have been found in Bütnera Red cv. fruits (9.77 mg/100 g FW). Contrary in a study conducted by Młynarczyk [6], it was shown that the fruits of this cultivar were characterized by significantly higher content of vitamin C, as it was until 25.09 mg/100 g FW. In his work Ferretti [2], showed that the content of vitamin C in the sweet cherries was in the range of 7-10 mg/100 g FW.

Sweet cherry fruits are one of the best source of easily digested sugars (glucose and fructose) and small amounts of sucrose. In the presented studies we demonstrated that examined fruits of sweet cherry cultivars contained different level of sugars, but only to the extent content of glucose. These results are consistent with those presented by Ursnik et al. [8], who presented that the glucose content in sweet cherries fruits was from 6.1 g/100 g FW till 12.3 g/100 g FW. In the presented study sweet cherry fruits contained from 7.5 g/100 g FW till 8.36 g/100 g FW of fructose. These results are consistent with those presented by Usenik et al. [8]. The sucrose content in fruits of cherries was on relatively low level 0.57-0.75 g/100 g FW depending on the cultivars. We were able to identify two organic acids (citric and malic) in fruits of sweet cherries. Organic sweet cherry fruits were characterized by significantly lower level of organic acids, and their content was variable and depended mainly on the cultivar. The obtained results were similar to those presented by Usenik et al. [8]. Sweet cherry fruits are a very good source of phenolic compounds in our diet. In presented experiment it was found that the content of polyphenols in fruits mainly depend on the examined cultivars (Table 1). The contents of total polyphenols (including phenolic acids, flavonoids and anthocyanins) were comprised in the range 128-201 mg/100 g FW. The studies presented by Młynarczyk [6] showed that total polyphenol content, in the old sweet cherry cultivars was 53,75 mg/100 g FW, and in the new sweet cherry cultivars it was much more: 115.61 mg/100 g FW. According to Kim et al. [5] Regina cv. contained 104.3 mg/100 g FW of total polyphenols including 40.7 mg/100 g FW of anthocyanins. In studies presented by Młynarczyk [6] Regina cv. contained 78.59 mg/100 g FW of total polyphenols where it was 62.28 mg/100 g FW of anthocyanins. Ferretti et al. [2] showed that Regina cv. contained 104 mg/100 g FW of total polyphenols, including 41 mg/100 g FW of anthocyanins. In the presented studies we showed that sweet cherry fruit Hedelfińska cv. contained much more total polyphenols (202 mg/100 g FW) including 54 mg/100 g FW of anthocyanins. In Ferretti et al. [2] studies the fruits of this cultivar contained 96 mg/100 g FW of total polyphenols including 40 mg/100 g FW of anthocyanins. In presented experiment sweet cherry cultivars differred between themselves in terms of the content of chlorogenic acid and p-coumaric acids in fruits (Fig. 4). Similarly it was presented by Jakobek et al. [4]. In the study presented by Chaoranalikit et al. [1] an average level of quercetin derivatives in sweet cherry fruits was in the range 1.15-11.2 mg/100 g. FW. The presented results are consistent with this report. In fruits of organic cherries we found 3.11 mg/100 g FW quercetin derivatives, but in conventional fruits it was more (5.19 mg/100 g FW) of quercetin derivatives (Fig. 5). Similar effect was presented by Jakobek et al. [4], who showed that the sweet cherry fruits contain from 0.78 mg/100 g FW to 3.96 mg/100 g FW quercetin derivatives. Sweet cherry cultivars with dark fruits are a very rich in anthocyanins. In presented experiment we were able make quality and quantity analysis of two anthocyanins in cherry fruits: cyanidin-3.5-di-O-rutinozide and cyanidin-3.5-di-O-glucoside (Fig 6). In his work Kim et al. [5] report that the content of cyanidin in sweet cherry fruits was dependent on the cultivar and fruits color and it was in range from 29.08 mg/100 g FW till 86.08 mg/100 g FW, while in the work presented by Usenik [8] the content of cyanidin was from 96.9 mg/100 g FW to 98.9 mg/100 g FW of cyanidin.

5. Conclusions

1. Organic sweet cherry fruits contained significantly more total sugars including glucose and fructose, total anthocyanins, especially cyanidin-3.5-di-O-rutinozide, as well as two identified flavonoids: luteolin and quercetin.
2. Conventional sweet cherry fruits were characterized by significantly higher amount of dry matter, organic acids including citric and malic acids, and quercetin-3-O-glucoside, kaempferol content.
3. Among the analyzed sweet cherry cultivars a special attention should be paid to the Hedelfińska cv. and Bütnera Red cv. The fruits of those cultivars were characterized by high nutritional value and the highest level of bioactive compounds contents.
4. At the base of the obtained results and significant differences between sweet cherry cultivars it have to be shown tha cherries are a very good source of biologically active compounds. Organic sweet cherry fruits contain significantly more of bioactive polyphenol group of selected components and therefore they are recommended as pro-healthy and seasonal fruits.

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