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EFFECT OF BIOLOGICAL PREPARATIONS ON THE HEALTH STATE OF PEPPER FRUITS AND CONTENT OF SACCHARIDES

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Abstract. Sweet pepper is an important vegetable plant, not only because of its economic importance, but also for the nutritional value of its fruits, mainly due to the fact that they are an excellent source of natural colours, especially carotenoids, antioxidant compounds and sugars. Saccharides content in the pepper fruits is the most important component of sweet taste of these fruits. In the available literature there are not many information about the influence of biological preparations on the content of the biological compounds and nutritional value of sweet pepper fruits. The aim of this study was to estimate the influence of some biological preparations such as Bioczos Płynny (garlic pulp), Biosept 33 SL (grapefruit extract), Bio-algeen S90 Plus (sea algae *Ascophyllum nodosum*), Boni Protect Forte (fungi *Aureobasidium pullulans*), on the health status of pepper fruits and quantitative and qualitative composition of saccharides in the fruits of Roberta F_1 cv. in 2010–2012. The effect of tested preparations on health state of fruits was presented as a proportion of the fruits number with diseases symptoms relative to the total number of fruits. In the present study fructose, glucose and sucrose content in sweet pepper fruits was evaluated. During the middle of the harvest period ripe, healthy and typical for cultivar fruits were collected for analysis. Sugars concentrations were determined in the water-soluble fraction, using high-performance liquid chromatography HPLC. The studies showed no significant effect of biological preparations on the average weight of the marketable fruits of sweet peppers. However tested preparations were a significant effect on the health state of pepper fruits. The smallest number of fruits with disease symptoms was obtained from plant protected with Bioczos Płynny. The protective use of biological preparations does not change significantly of saccharides content in sweet pepper fruits. However the results show that the treatment with biopreparation Boni Protect Forte resulted in a slight in-

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crease the content of glucose and fructose in pepper fruits, but the using of Bioczos Płynny decreased the content of glucose and sucrose.

Key words: *Capsicum annuum* L., biological control, health state of pepper fruits, sugars

INTRODUCTION

Pepper is an important vegetable as well as spice crop, cultivated worldwide. It is not only used in many cuisines but also found to have many medicinal properties Sweet pepper fruits contain large amounts of minerals (K, Ca, Mg, Na), sugars, pectin, vitamins, and antioxidants (phenolic compounds, carotenoids and vitamin C) [Lee and Kader 2000, Buczkowska and Najda 2002, Navarro et al. 2006, Gajc-Wolska et al. 2007, Perucka and Materska 2007, Jadczak et al. 2010, Buczkowska and Michałojć 2012, Russo 2012]. A wide spectrum of biological compounds has an important effect on human health preventing people against the diseases (mainly cancer and cardiovascular diseases) [Palevitch and Craker 1995, Perucka 1995, Howard et al. 2000, Perucka and Oleszek 2000, Marin et al. 2004, Jadczak et al. 2010]. Consumers pay attention to the quality, morphological characteristics and nutritional values of vegetables.

Presently, it is necessary to reduce the chemical agents in the production of vegetables, including the pepper, and the pressure is put on the use of integrated methods to achieve yield with a high quality [Regulation (EC) No 1107/2009]. Fungicides have been more frequently replaced with biotechnical and biological preparations used against fungal pathogens [Lipa and Pruszyński 2010, Jamiołkowska 2011a]. The natural substances, like grapefruit and garlic pulp extracts, sea algae or biological agents (*Aureobasidium pullulans*) are used in biocontrol as well in organic and conventional plant production. Many of them have antibacterial and antifungal properties and were use in the protection of vegetables against pathogens [Sultana et al. 2008, Arunkumar et al. 2010, Marjańska-Cichoń and Sapieha-Waszkiewicz 2010, Horoszkiewicz-Janka et al. 2012, Hadian 2012, Jamiołkowska 2013]. The biopreparations and biotechnical preparations involved of defense mechanisms in plants [Kozłowska and Konieczny 2003, Gayoso et al. 2004, Panina et al. 2007, Hassan and Mathesius 2012, Jamiołkowska 2013].

Chemical composition and nutritional value of pepper depends on the cultivar, weather conditions, cultivation methods, ripening stages [Markus et al. 1999, Lee and Kader 2000, Orłowski et al. 2004, Navarro et al. 2006, Perucka and Materska 2007, Szafirowska and Elkner 2009] and the health status of plants [Jamiołkowska 2011b, 2012, 2013]. Among the compounds that determine the nutritional value of pepper are vitamins, capsaicin, pigments, as well as various volatile oils. The sugars, proteins, minerals and certain organic acids are classed in the second group compounds [Bosland and Votava 2000]. Saccharides content in the pepper fruits is the most important component of sweet pepper taste. Its content is genetically determined (features variety), and modified by weather conditions during the growing season, as well as agricultural practices [Kmiecik and Lisiewska 1994, Dasgan and Abak 2003]. Sugars content is influenced also by maturity [Dobromilska 2000, Flores et al. 2004, Michałojć and Dzida 2012, Russo 2012].

In the available literature there are not many information about quantitative composition of saccharides in fruits peppers and the impact of plant protection treatments (including the use of biological preparations) on nutritional value of pepper fruits. The aim of this study was to estimate the influence of biological preparations on the health state of pepper fruits as well as the quantitative and qualitative composition of saccharides (glucose, fructose, sucrose) in the fresh weight of marketable fruits.

MATERIAL AND METHODS

Agricultural experiment. The experiment was carried out during the period 2010–2012 in the horticultural farm near Lublin (N51°20', E22°49'). Plants of sweet pepper (cultivar Roberta F_1) were the objects of research. The experiment was set up in the soil with a pH of 6.5. Wheat was the forecrop for pepper in three years. In the year preceding pepper cropping, organic fertilization was applied at the rate of 40 t ha^{-1}. Spring mineral nutrition was done according to the soil analysis ($kg \cdot ha^{1}$): N-100 (nitrogen nitrate), P-60 (superphosphate), K-140 (potassium sulphate). Foliar nutrition was applied as post-crop: once with Florovit (0.5%), twice with calcium nitrate (1.0%).

The seedlings were produced in the greenhouse and planted in the field in the third decade of May at spacing of 0.67 × 0.35 m. This agricultural study was set up as an one-factor experiment in 4 replications. The area of one experimental plot was 4.69 m^2 and 20 plants were grown in each plot. The biological preparations such as Bioczos Płynny, Biosept 33SL, Bio-algeen S90 Plus and Boni Protect Forte were used six times in the vegetable season as protective treatments of pepper plants. The application of preparations started 1 month after planting of seedlings and applied every 7–10 days depending on the weather conditions. The plants without treatments and plants protected with Amistar 250 SC (azoxystrobine) were the control combinations. Fungicide was applied two times in vegetation according to the Recommendations of Plant Protection for years 2010–2012 (tab. 1). Preparations were applied by spraying and watering of plant with 100–200 ml liquid for each plant. Plants were weeded manually during the growing period.

Table 1. Field experimental combination in 2010–2012

Experimental combination	Concentration of preparation (%)	Number of treatments
C – control, plant without treatments	lack	lack
A – control, plants protected with azoxystrobine (fungicide Amistar 250 SC)	0.1	2
BCZ – plants protected with garlic pulp extract (biotechnical preparation Bioczos Płynny)	2.0	6
BS – plants protected with grapefruit extract (biotechnical preparation Biosept 33SL)	0.2	6
BA – plants protected with sea algae *Ascophyllum nodosum* (biotechnical preparation Bio-algeen S90 Plus)	0.3	6
BP – plants protected with blastospores fungi *Aureobasidium pullulans* strains (biopreparation Boni Protect Forte)	0.1	6

Fruits were harvested from mid-August to October as they mature. The total and marketable fruits yield as well as the total fruits number was determined. The total fruits number consisted of marketable fruits, diseased fruits and undergrown fruits. The average weight of the fruit, in each harvest. was calculated by dividing the weight of marketable yield of fruits by their number. The effect of tested preparations on health state was presented as a proportion of the fruits number with diseases symptoms in 2010–2012, relative to the total number of fruits, as well as the mean values of these parameters in 2010–2012.

Determination of saccharides content. During the middle of the harvest period, five healthy and uniform fruits in the red states were selected from each combinations. Fruits were washed with deionized water, rinsed free of seeds, cut into small pieces and homogenized. Determination of sugars: glucose, fructose and sucrose in pepper fruits was made according to the method worked out on a basis of norm PN-EN 12630:2002. Sugars concentrations were determined in the water-soluble fraction, using high-performance liquid chromatography HPLC (LC-20 AD UFLC Shimadzu). In the mobile phase we used a solution of edetate calcium disodium (Ca-EDTA). Compounds were detected using the refractometer detector (RID-10A Shimadzu) – detector temperature 40°C. A quantitative analysis was done by the internal standard method. All determination were performed in three replicates. Before the quantitative and qualitative determination of sugars in the sample, we prepared standard solutions of different sugars: sucrose, glucose and fructose. With those standard solutions of different sugars we made calibration lines for each one of the sugars, which were later used for assessing the concentrations corresponding to the different peaks in the chromatograms.

Standard uncertainty for the determination of sucrose and glucose content was 2.7%, while the fructose standard uncertainty was 2.2%. These uncertainties were estimated taking into account the coverage factor k = 2, which provides a level of confidence of approximately 95%.

Statistical analysis. The obtained results were analyzed by analysis of variance (Tukey test) at 5% significance level using the SAS statistical system (SAS Version 9.1, SAS Inst., Cary, N.C., U.S.A.).

RESULTS AND DISCUSSION

Biological and biotechnical preparations have an effect on the health state and the yield of many vegetables [Gajc-Wolska et. al. 2007, Dobromilska et al. 2008, Dobromilska and Gubarewicz 2008, Jamiołkowska 2009, Hadian 2012, Jamiołkowska 2013]. According to Jamiołkowska [2013] the use of garlic extract (Bioczos Płynny) and grapefruit extract (Biosept 33 SL) in protection of pepper plants decrease the number of pathogenic fungi colonizing the plants. Antifungal and antibacterial properties of garlic described Abdulrahman and Alkhail [2005] as well as Jamiołkowska and Wagner [2011]. Effectiveness of sea algae against plant pathogens show many researchers [Koziara et al. 2006, Sultana et al. 2008, Arunkumar et al. 2010, Jimenez et al. 2011].

Many authors show the influence of growing conditions (including biopesticides) on the yield of pepper and contents of nutrients in fruits [Cwalina-Ambroziak and Amarowicz 2012, Buczkowska and Michałojć 2012, Jamiołkowska 2013]. Present study

showed no significant effect of tested biological preparations on the average weight of the marketable fruit of pepper Roberta F_1 cv. Exception was marketable fruits obtained in 2012 from the plants protected with Boni Protect Forte. They were characterized by significantly lower weight of the fruits related to the fruits obtained from other experimental combinations (tab. 2). In the available literature, there are little information on the impact of biological preparations on quality fruits of Solanaceous vegetables. Dobromilska and Gubarewicz [2008] showed that the use of the preparation Bioalgeen have a positive impact on the yield of marketable fruits of tomato. Stępowska [2008] also found a beneficial effect of the preparation Goëmar Göteo (marine algae) on the yield of sweet pepper grown in plastic tunnel. Mariańska-Cichoń and Sapiecha-Waszkiewicz [2011] showed no significant effect of garlic preparations (Bioczos Standard Bioczos Owadobójczy, Bioczos Grzybobójczy) on the average weight of strawberry fruits. Similar results were presented by Gospodarek et al. [2012], who describe no significant effect of Bioczos BR on the bean seed yield. Sadowski et al. [2007] showed that Biosept 33 SL had no significant effect on the quantity and quality of roots and seeds of red beet grown in the ecological system.

Table 2. Average marketable fruit weight (g) of sweet pepper plants in 2010–2012

Experimental combination	Average marketable fruit weight (g)			
	2010	2011	2012	mean 2010–2012
Control	119.6 [a]	130.3 [a]	167.1 [a]	139.0 [a]
Amistar 250 SC	115.5 [a]	133.9 [a]	146.5 [ab]	132.0 [ab]
Bioczos Płynny	117.5 [a]	129.9 [a]	127.5 [b]	125.0 [ab]
Biosept 33 SL	114.5 [a]	127.6 [a]	125.1 [b]	122.4 [ab]
Bio-algeen S90 Plus	108.9 [a]	121.7 [a]	149.0 [ab]	126.5 [ab]
Boni Protect Forte	124.4 [a]	123.1 [a]	92.8 [c]	113.4 [b]
Statistical significance	ns	ns	*	*

* – significant different, ns: nonsignificant at $P < 0.05$

Table 3. Share of pepper fruits number with diseases symptoms in the total fruits number (%) in 2010–2012

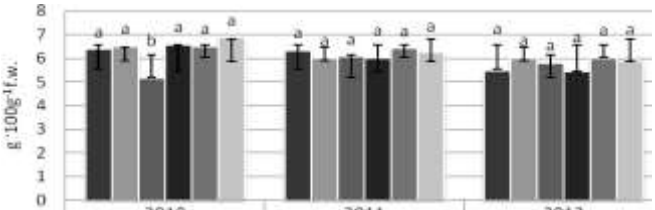
Experimental combination	2010	2011	2012	Mean 2010–2012
Control	8.0	5.84	28.23	9.38
Amistar 250 SC	4.66	4.63	22.58	6.94
Bioczos Płynny	2.09	5.85	15.27	4.78
Biosept 33 SL	9.59	3.94	15.18	7.46
Bio-algeen S90 Plus	10.04	6.22	20.08	8.38
Boni Protect Forte	9.47	5.68	19.17	8.51
Average	7.42	5.34	20.66	–

Visible effect of the biological preparations on the health state of pepper fruits was demonstrated as the number of fruits with diseases symptoms in the total number of fruits. The smallest number of fruits with disease symptoms were obtained from plants protected with Bioczos Płynny (4.78%, with average from 2010–2012), to compare with control without fungicide (9.58%, with average from 2010–2012) (tab. 3). In other experimental combinations the number of fruits with diseases symptoms ranged on average from 6.94% (Amistar 250 SC) to 8.54% (Boni Protect Forte) (tab. 3). Independently of the used preparations the most fruits with diseases symptoms were collected in 2012 (20.66%), and less in 2010 (7.42%) and 2011 (5.34%). It was related to the weather conditions during period of

growth and ripening of pepper in the field. The obtained results indicate that the tested biological preparations are effective in protection of pepper fruits against pathogens. Mariańska-Cichosz and Sapiecha-Waszkiewicz [2010] show a lower efficacy Bioczos Standard to protection of strawberries in the vegetation rich in rainfall.

Studies on the nutritional value of peppers depend mainly on genetic characteristics of cultivar, weather and growing conditions [Kmiecik and Lisiewska 1994, Gajc-Wolska and Skąpski 2002, Pokluda 2004, Navarro et al. 2006, Szafirowska and Elkner 2009]. The impact of biological preparations on the contents of chemical components in the pepper fruits is poorly understood [Gajc-Wolska et al. 2007, Jamiołkowska 2013].

Sugars are significant substances that determine the taste of pepper fruits [Bosland and Votava 2000, Michalik 2010]. These biological components are stabilizers of vitamin C [Brich and Pepper 1983]. In general, vegetables and fruits containing a lot of vitamin C usually characterized by high carbohydrate content. Pepper fruits have a high vitamin C content and a high sugars concentration [Dobromilska 2000, Lee and Kader 2000, Buczkowska and Najda 2002, Flores et al. 2004, Pokluda 2004, Russo 2012].



	2010	2011	2012
C	6,367	6,309	5,463
A	6,486	6,006	6,001
BCZ	5,147	6,051	5,8
BS	6,566	5,995	5,443
BA	6,491	6,405	5,995
BP	6,863	6,233	5,901

Data are expressed as means ±standard deviations on sugars content basis; values having the same letters are not significantly different ($P < 0.05$). Abbreviations – see table 1

Fig. 1. The total content of saccharides (g·100 g^{-1} f. w.) in pepper fruits in 2010–2012

In this experiment the total sugars concentration in the fruits varied from 5.141g·100 g^{-1} to 6.863·100 g^{-1} and varied from year to year (fig. 1). In this study was determined glucose, fructose and sucrose content. Significant differences were also observed in saccharides content within the combinations in the studied years (tab. 4–6, fig. 1). Saccharides content depends on the effect of several factors [Bosland and Votava 2000]. It could be considerably influenced by weather condition and cultivar [Buczkowska and Najda 2002, Gajc-Wolska and Skąpski 2002, Dobromilska et al. 2008, Szafirowska and Elkner 2009, Buczkowska and Michałojć 2012, Russo 2012]. The total saccharides content significantly increase with maturation, red pepper fruits having the highest levels [Navarro et al. 2006]. The highest glucose content were observed in fruits harvested in 2010 (from 2.149 to 2.812 g·100 g^{-1} f. w., with average 2.573 g·100 g^{-1} f. w.), and the

lowest in 2011 (from 2.313 to 2.497 g·100 g^{-1} f. w., with average 2.377 g·100 g^{-1} f. w.) (tab. 4). The average percentage content of glucose in a total amount of sugars in pepper fruits varied between 40 and 43% (fig. 3). Similarly, the content of fructose was changing, and it was highest in fruits harvested in 2011 (from 2.646 to 3.056 g·100 g^{-1} f. w., with average 2.908 g·100 g^{-1} f. w.), and lowest in 2010 (from 2.659 to 3.082 g·100 g^{-1} f. w., with average 2.861 g·100 g^{-1} f. w.) (tab. 5). The average percentage content of fructose in a total amount of saccharides in pepper fruits varied between 45 and 50% (fig. 3). Among the analyzed saccharides the lowest content was that of sucrose (9–13% a total amount of sugars) and its lowest value was recorded in the fruits harvested in 2012 (from 0.356 to 0.414 g·100 g^{-1} f. w., with average 0.372 g·100 g^{-1} f. w.) (tab. 6, fig. 3).

Table 4. The content of glucose (g·100 g^{-1} f. w.) in the pepper fruits in 2010–2012

Experimental combination	Glucose (g·100 g^{-1} f. w.) (±U)		
	2010	2011	2012
Control	2.610 ^{bc}* ±0.0704	2.373 ^{a}* ±0.064	2.267 ^{b}* ±0.0612
Amistar 250 SC	2.627 ^{abc} ±0.0709	2.313 ^{a} ±0.0624	2.577 ^{a} ±0.0695
Bioczos Płynny	2.149 ^{d} ±0.058	2.332 ^{a} ±0.0629	2.499 ^{a} ±0.0674
Biosept 33 SL	2.748 ^{ab} ±0.0741	2.497 ^{a} ±0.0604	2.441 ^{ab} ±0.0659
Bio-algeen S90 Plus	2.497 ^{c} ±0.0674	2.367 ^{a} ±0.0639	2.590 ^{a} ±0.0699
Boni Protect Forte	2.812 ^{a} ±0.0759	2.384 ^{a} ±0.0643	2.596 ^{a} ±0.07
Mean	2.573	2.377	2.495
Statistical significance	**	ns	*

The values are mean ±coverage factor (U),* – significant different, ns: nonsignificant at $P < 0.05$

Table 5. The content of fructose (g·100 g^{-1} f. w.) in the pepper fruits in 2010–2012

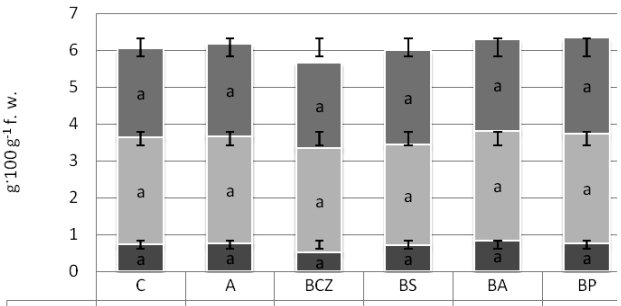
Experimental combination	Fructose (g·100 g^{-1} f. w.) (±U)		
	2010	2011	2012
Control	2.823 ^{ab}* ±0.061	3.056 ^{a}* ±0.0672	2.838 ^{b}* ±0.0624
Amistar 250 SC	2.828 ^{ab} ±0.0622	2.877 ^{a} ±0.0632	3.010 ^{ab} ±0.0662
Bioczos Płynny	2.659 ^{b} ±0.0584	2.885 ^{a} ±0.0634	2.951 ^{ab} ±0.0649
Biosept 33 SL	2.946 ^{ab} ±0.0648	2.646 ^{b} ±0.0662	2.625 ^{c} ±0.0577
Bio-algeen S90 Plus	2.833 ^{ab} ±0.0623	3.056 ^{a} ±0.0672	3.037 ^{a} ±0.0668
Boni Protect Forte	3.082 ^{a} ±0.0678	2.930 ^{a} ±0.0644	2.935 ^{ab} ±0.0645
Mean	2.861	2.908	2.899
Statistical significance	*	*	**

Note – see table 4

Table 6. The content of sucrose (g·100 g^{-1} f. w.) in the pepper fruits in 2010–2012

Experimental combination	Sucrose (g·100 g^{-1} f. w.) (±U)		
	2010	2011	2012
Control	0.934 ^{cd}* ±0.0252	0.880 ^{bc}* ±0.0237	0.358 ^{a}* ±0.0096
Amistar 250 SC	1.031 ^{b} ±0.0278	0.816 ^{cd} ±0.022	0.414 ^{a} ±0.011
Bioczos Płynny	0.339 ^{e} ±0.0091	0.834 ^{c} ±0.0225	0.350 ^{a} ±0.0094
Biosept 33 SL	0.872 ^{d} ±0.0235	0.852 ^{bc} ±0.0223	0.377 ^{a} ±0.01
Bio-algeen S90 Plus	1.161 ^{a} ±0.0313	0.982 ^{a} ±0.0265	0.368 ^{a} ±0.009
Boni Protect Forte	0.969 ^{bc} ±0.0261	0.919 ^{ab} ±0.0248	0.370 ^{a} ±0.009
Mean	0.884	0.880	0.372
Statistical significance	**	**	ns

Note – see table 4



	C	A	BCZ	BS	BA	BP
glucose	2,416	2,506	2,327	2,562	2,485	2,597
fructose	2,906	2,905	2,832	2,739	2,975	2,982
sucrose	0,724	0,754	0,508	0,7	0,837	0,753

Note – see fig. 1

Fig. 2. The content of glucose, fructose, sucrose (g·100 g^{-1} f. w.) in the pepper fruits (average of 2010–2012)

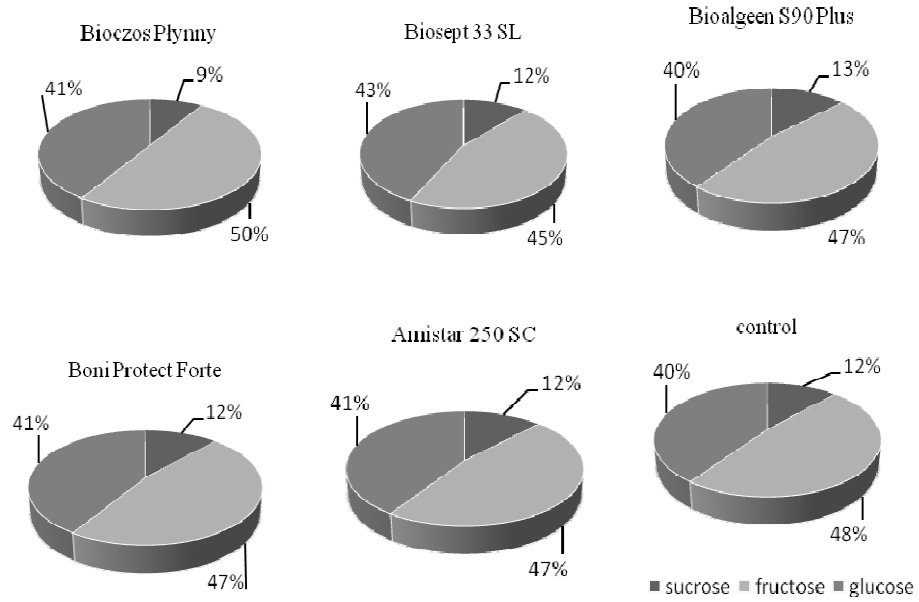


Fig. 3. Share of glucose, fructose, sucrose content in the total content of saccharides (%), in fresh weight of pepper fruits (average of 2010–2012)

Many authors confirm influence of agricultural practices, among them the use of agrochemicals, on nutritional value of vegetable fruits [Bosland and Votava 2000, Cwalina-Ambroziak and Amarowicz 2012, Russo 2012]. The spraying tomato plants with Bio-algeen S 90 Plus stimulate not only vegetative growth of plants, but also increase the content of dry matter, vitamin C and some minerals compounds in tomato

fruits [Dobromilska and Gubarewicz 2008, Dobromilska et al. 2008]. In the experiment conducted by Gajc-Wolska and co-authors [2007] the use of preparations from marine algae (Goëmar Göteo and BM 86) increased content of vitamin C, dry matter and potassium in pepper fruits. Jamiołkowska [2013] presents other results, which show that use of Bioczos Płynny, Biosept 33SL, Bio-algeen S 90 Plus and Boni Protect Forte do not change content of vitamin C in pepper fruits to compare to control and fungicide combinations. In our experiment mean content of saccharides in fruits was dependent on the type of biological preparation. Fruits collected from plants treated with Boni Protect Forte and Biosept in 2010–2012 had the highest average glucose content (respectively with averages 2.597 g·100 g^{-1} f. w., and 2.562 g·100 g^{-1} f. w.), but the lowest only in fruits from plants treated with Bioczos Płynny (with average 2.327 g·100 g^{-1} f. w.) (fig. 2). The highest fructose amount characterized the fruits from plants protected with Boni Protect Forte and Bio-algeen, and their average values were respectively 2.982 g ·100 g^{-1} f. w., and 2.975 g·100 g^{-1} f. w. (fig. 2). Mean content of reducing sugars from experimental combination did not differ significantly from the control and fungicide combinations (fig. 2). In an experiment carried out by Cwalina-Ambroziak and Amarowicz [2012] the concentration of reducing sugars was highest in fruits of pepper plants sprayed with Biochicol 020 PC (chitosan) than in the control. Also the results presented by Cwalina-Ambroziak and Amarowicz [2012] showed that the use of fungicide Bravo 500 SC (50% clorothalonil) did not change content of sugars comparing to the biopreparations (Asashi SL, Polyversum) and control combinations. In the present study the content of sucrose was as low as presented by Navarro et al. [2006]. The lowest content of sucrose was in fruits from plants protected with Bioczos Płynny (0.508 g·100 g^{-1} f. w., on average) and the highest from plants sprayed with Bio-algeen (0.837 g·100 g^{-1} f. w., on average) (fig. 2). Mean content of sucrose from experimental combinations did not differ significantly from the control and fungicidal combinations. Based on the data presented in this study, it can be concluded that the amount of sugars in sweet pepper fruits was slightly modified by using biological preparations. This results showed that the use of biological preparations does not have a significantly effect on saccharides content in ripe fruits. These preparations also modified slightly dry matter content and vitamin C in fruits of sweet pepper, as demonstrated Jamiołkowska [2013] and Jamiołkowska and Wagner [2015]. C

CONCLUSIONS

The studies showed no significant effect of biological preparations on the average weight of the marketable fruits of sweet pepper Robert F_1 cv. However tested preparations were a significant effect on the health state of pepper fruits. The smallest number of diseased fruits, in the total fruits number, was obtained from plants protected with Bioczos Płynny.

The protective use of tested biological preparations does not change significantly of saccharides content in sweet pepper fruits. However the results show that the treatment with biopreparation Boni Protect Forte resulted in a slight increase the content of glucose and fructose in pepper fruits, but the using of Bioczos Płynny decreased the content of glucose and sucrose.

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REFERENCES

Abdulrahman, A., Alkhail, A. (2005). Antifungal activity of some extract against some plant pathogenic fungi. Pak. J. Biol. Sci., 8(3), 413–417.

Arunkumar, K., Sivakumar, S.R., Rengasamy, R. (2010). Review on bioactive potential in seaweeds (Marine Macroalgae): a special emphasis on bioactivity of seaweeds against plant pathogens. Asian J. Plant Sci., 9(5), 227–240.

Bosland, P.W., Votava, E.J. (2000). Peppers: Vegetable and Spice Capsicums. CABI Publishing. London, UK.

Brich, G.G., Pepper, T. (1983). Protection of vitamin C by sugars and their hydrogenated derivatives. J. Agr. Food Chem., 31, 980–985.

Buczkowska, H., Najda, A. (2002). A comparison of some chemical compounds in the fruit of sweet and hot pepper (*Capsicum annuum* L.). Folia Hort., 14(2), 59–67.

Buczkowska, H., Michałojć, Z. (2012). Comparison of qualitative traits, biological value, chemical compounds of sweet pepper fruit. J. Elementol., 17(3), 367–377.

Cwalina-Ambroziak, B., Amarowicz, R. (2012). Effects of biological and fungicidal environment protection on chemical composition of tomato and red pepper fruits. Pol. J. Environ. Stud., 21(4), 831–836.

Dasgan, H.Y., Abak, K. (2003). Effects of plant density and number of shoots on yield and fruit characteristics of pepper grown in glasshouses. Turk. J. Agric. For., 27, 29–35.

Dobromilska, R. (2000). The effect of the planting method and planting spacing on the growth, yielding and biological value of sweet pepper cv. Mayata F_1. Annakes UMCS, , Horticultura, 8, 333–339.

Dobromilska, R., Gubarewicz, K. (2008). Influence of Bio-Algeen S-90 on the yield and quality of small-size tomato. In: Biostumulators in modern agriculture, Solanaceous crops, Dąbrowski, Z.T (ed.). Plantpress, Warszawa, 7–12.

Dobromilska, R., Mikiciuk, M., Gubarewicz, K. (2008). Evaluation of cherry tomato yielding and fruit mineral composition after using of Bio-algeen S-90 preparation. J. Elementol., 13(4), 491–499.

Flores, P., Navarro, J.M., Garrido, C., Rubio, J.S., Martinez, V. (2004). Influence of Ca^{2+}, K^+ and NO_3^- fertilisation on nutritional quality of pepper. J. Sci. Food Agric., 84, 569–574.

Gajc-Wolska, J., Skąpski, H. (2002). Yield of field grown sweet pepper depending on cultivars and growing conditions. Folia Hort., 14(1), 95–103.

Gajc-Wolska, J., Zielony, T., Łyszkowska, M. (2007). The effect of Göteo, BM 86 on yield, fruit quality of sweet pepper (*Capsicum annuum* L.) in the field production. Progress in Research on Capsicum & Eggplant. Niemirowicz-Szczytt K. (ed.). Warsaw Univ. Life Sci. Press., 267–274.

Gayoso, C., Pomar, F., Merino, F., Bernal, M.A. (2004). Oxidative metabolism and phenolic compounds in *Capsicum annuum* L. var. *annuum* infected by *Phytophthora capsici* Leon. Sci. Hortic., 102, 1–13.

Gospodarek, J., Gleń, K., Boligłowa, E. (2012). Effect of non-chemical preparations application in broad bean protection against harmfulness of broad bean seed beetle (*Brunchus fufimanus* Boh.) and seed yield. J. Res. Appl. Agric. Eng., 57(3), 124–128.

Hadian, S. (2012). Antifungal activity of some plant extracts against some plant pathogenic fungi in Iran. Asian J. Exp. Biol. Sci., 3(4), 714–718.

Hassan, S., Mathesius, U. (2012). The role of flavonoids in root-rhizosphere signaling: opportunities and challenges for improving plant-microbe interaction. J. Exp. Bot., 10, 1–16.

Horoszkiewicz-Janka, J., Jajor, E., Korbas, M. (2012). Usage of biopreparations as seed dressing in legume cultivation. J. Res. Appl. Agric. Eng., 57(3), 162–166.

Howard, L.R., Talcott, S.T., Brenes, C.H., Villalon, B. (2000). Changes in phytochemical and antioxidant activity of selected pepper cultivars (*Capsicum* species) as influenced by maturity. J. Agric. Food Chem., 48(5), 1713–1720.

Jadczak, D., Grzeszczuk, M., Kosecka, M. (2010). Quality characteristics and content of mineral compounds in fruit of some cultivars of sweet pepper (*Capsicum annuum* L.). J. Elementol., 15(3), 509–515.

Jamiołkowska, A. (2009). The influence of bio-preparation Biosept 33 SL on fungi colonizing of sweet pepper plants (*Capsicum annuum* L.) cultivated in the field. EJPAU, 12, 3. (http.//www.ejpau.media.pl/volume12/issue3/art-13.html).

Jamiołkowska, A. (2011a). Laboratory effect of azoxystrobin (Amistar 250 SC) and grapefruit extract (Biosept 33 SL) on growth of fungi colonizing zucchini plants. Acta Sci. Pol. Hortorum Cultus, 10(2), 245–257.

Jamiołkowska, A. (2011b). Zdrowotność i plonowanie papryki ostrej (*Capsicum annuum* L.) uprawianej w polu w warunkach klimatycznych Lublina. Prog. Plant Prot., 51(3), 1041–1046.

Jamiołkowska, A. (2012). Fungi occurring the pericarp and yield of sweet pepper (*Capsicum annuum* L.) cultivated in the field. Phytopathologia, 62, 5–14.

Jamiołkowska, A. (2013). Preparaty biotechniczne i biologiczne w ochronie papryki słodkiej (*Capsicum annuum* L.) przed grzybami chorobotwórczymi i indukowaniu reakcji obronnych roślin. Ser. Rozpr. Nauk., 376, Wyd. UP w Lublinie, pp.117.

Jamiołkowska, A., Wagner, A. (2011). Effect of garlic pulp (Bioczos Plynny) on some fungi pathogenic to vegetables. In: AFPP – Fourth International Conference on Non Chemical Crop Protection Methods, Lille – 8, 9 and 11 march, 213–220.

Jamiołkowska, A., Wagner, A. (2015). Effect of some natural preparations on contents of protein and dry matter in sweet pepper (C*apsicum annuum* L.). EJPAU, 18, 2. http://www.ejpau.media.pl/volume18/issue2/abs-05.html

Jimenez, E., Dorta, F., Medina, C., Ramirez, A., Ramirez, I., Pena-Cortes, H. (2011). Antipathogenic activities of macro-algae extracts. Mar. Drugs, 9, 739–756.

Kmiecik, W., Lisiewska, Z. (1994). Evaluation of eight sweet pepper cultivars for field growing in the Kraków region from the aspect of requirements of the canning industry. Folia Hort., 6(2), 35–43.

Koziara, W., Sulewska, H., Panasiewicz, K. (2006). Effect of resistance stimulator application to some agricultural crops. J. Res. Appl. Agric. Eng., 51(2), 82–87.

Kozłowska, M., Konieczny, G. (2003). Biologia odporności roślin na patogeny i szkodniki. Wyd. AR w Poznaniu.

Lee, S.K., Kader, A.A. (2000). Preharvest and postharvest factors influencing vitamin C content of horticultural crops. Postharv. Biol. Tech., 20, 207–220.

Lipa, J.J, Pruszyński, S. (2010). Stan wykorzystania metod biologicznych w ochronie roślin w Polsce i na świecie. Prog. Plant Prot., 50(3), 1033–1043.

Marjańska-Cichoń B., Sapiecha-Waszkiewicz, A. (2010). Skuteczność preparatów biotechnicznych opartych na ekstrakcie z czosnku w zwalczaniu szarej pleśni na truskawce. Prog. Plant Prot., 50(1), 378–382.

Marin, A., Ferreres, F., Tomas-Barberan, F.A., Gil, M.I. (2004). Characterization and quantitation of antioxidant constituents of sweet pepper (*Capsicum annuum* L.). J. Agric. Foot Chem., 52(12), 3861–3869.

Markus, F., Daood, H.G., Kapitany, J., Biacs, P.A. (1999). Change in the carotenoid and antioxidant content of spice red pepper (Paprika) as a function of ripening and some technological factors. J. Agric. Food Chem., 47, 100−107.

Michalik, Ł. (2010). The effect of non-woven PP fabric covers on the yielding and the fruit quality of field-grown sweet peppers. Acta Sci. Pol. Hortorum Cultus, 9(4), 25–32.

Michałojć, Z., Dzida, K. (2012). Yielding and biological value of sweet pepper fruits depending on foliar feeding using calcium. Acta Sci. Pol. Hortorum Cultus, 11(3), 255–264.

Navarro, J.M., Flores, P., Garrido, C., Martinez, V. (2006). Changes in the content of antioxidant compounds in pepper fruits at different ripening stages, as affected by salinity. Food Chem., 96, 66–73.

Orłowski, M., Grzeszczuk, M., Jadczak, D. (2004). The estimation of the yield and content of some chemical compounds in the fruits of chosen hot pepper (*Capsicum annuum* L.) cultivars. Folia Hort., 16(2), 11–16.

Palevitch, D., Craker, L.E. (1995). Nutritional and medicinal importance of red pepper (*Capsicum* spp.). J. Herbs Spices Med. Plants, 3, 55–83.

Panina, Y., Fravel, D.R., Baker, C.J., Shcherbakova, A. (2007). Biocontrol and plant pathogenic *Fusarium oxysporum* – induced changes in phenolic compounds in tomato leaves and roots. J. Phytopathol., 155, 475–481.

Perucka, I. (1995). Efekt działania etefonu na wzrost roślin oraz akumulację karotenoidów i kapsaicynoidów w owocach papryki ostrej *Capsicum annuum* L. Rozpr. Nauk., 181, Wyd. AR w Lublinie, pp. 48.

Perucka, I., Materska, M. (2007). Antioxidant vitamin content of *Capsicum annuum* fruits extracts as affected by processing and varietal factors. Acta. Sci. Pol. Technol. Aliment., 6(4), 64–74.

Perucka, I., Oleszek, W. (2000). Extraction and determination of capsaicinoids in fruit of hot pepper *Capsicum annuum* L. by spectrophotometry and high-performance liquid chromatography. Food Chem., 71, 287–291.

Pokluda, R. (2004). Content of selected nutritional element in fruits of several pepper cultivars. Annales UMCS, Horticultura, 14, 37–43.

Recommendations of Plant Protection for years 2010–2012. Institute of Plant Protection – Polish Research Institute, Poznań.

Regulation (EC) No 1107/2009 of the European Parliament and of the Council of 21 October 2009 concerning the placing of plant protection products on the market. Official Journal of the Europe 09/1 from 24.11. 2009.

PN-EN 12630:2002. Soki owocowe i warzywne. Oznaczanie zawartości glukozy, fruktozy, sorbitolu i sacharozy. Metoda wysokosprawnej chromatografii cieczowej.

Russo, V.M. (2012). Pepper, Botany, Production and Uses. CABI, London, UK.

Sadowski, Cz., Lenc, L., Korpal, W. (2007). Investigations on the possibility of protection of organically grown red beet against fungal diseases. J. Res. Appl. Agric. Eng., 52(4), 38–44.

Stępowska, A. (2008). Effects of GA 142 (Goëmar Goteo) and GA 14 (Goëmar BM86) extracts on sweet pepper yield in non-heated tunnels. In: Biostimulators in modern agriculture, Solanaceous crops. Dąbrowski, Z.T. (ed.). Plantpress, Warszawa, 45–51.

Sultana, V., Ara, J., Esteshamul-Haque, S. (2008). Suppression of root rotting fungi and root knot nemathode of chili by seaweed and *Pseudomonas aeruginosa*. J. Phytopath., 156, 390–395.

Szafirowska, A., Elkner, K. (2009). The comparison of yielding and nutritive value of organic and conventional pepper fruits. Veget. Crops Reser. Bull., 71, 111–121.

WPŁYW PREPARATÓW BIOLOGICZNYCH NA ZDROWOTNOŚĆ OWOCÓW PAPRYKI SŁODKIEJ I ZAWARTOŚĆ SACHARYDÓW

Streszczenie. Ze względu na wysoką wartość biologiczną owoców papryka słodka jest warzywem o dużym znaczeniu gospodarczym. Owoce papryki są bogatym źródłem naturalnych barwników, zwłaszcza karotenoidów, wielu związków o właściwościach przeciwutleniających, a także sacharydów. Wielkość i jakość plonu papryki słodkiej zależy od technologii uprawy, w tym od profilaktycznych zabiegów ochrony roślin. W dostępnej literaturze jest niewiele informacji na temat wpływu preparatów biologicznych stosowanych do ochrony roślin papryki na wartość biologiczną owoców. Celem pracy wykonanej w latach 2010–2012 była ocena wpływu pięciu preparatów biologicznych: Bioczos Płynny (miazga czosnkowa), Biosept 33 SL (ekstrakt z grejpfruta), Bio-algeen S90 Plus (algi morskie *Ascophyllum nodosum*), Boni Protect Forte (grzyb *Aureobasidium pullulans*), na zdrowotność owoców oraz masę owocu handlowego i skład jakościowy sacharydów w papryce słodkiej odmiany Roberta F_1. Wpływ badanych preparatów na zdrowotność owoców przedstawiono jako udział liczby owoców z objawami chorobowymi w stosunku do liczby owoców ogółem. Do oznaczenia sacharydów wykorzystano owoce zdrowe, typowe dla odmiany i w pełni dojrzałe. Zawartość cukrów określano we frakcji rozpuszczalnej w wodzie za pomocą wysokosprawnej chromatografii cieczowej HPLC. W badaniach nie wykazano istotnego wpływu ochrony roślin preparatami biologicznymi na średnią masę owocu handlowego papryki słodkiej. Wykazano natomiast znaczący wpływ preparatów biologicznych na zdrowotność owoców. Najmniejszym udziałem liczby owoców z objawami chorobowymi w liczbie owoców ogółem odznaczało się plonowanie roślin chronionych preparatem Bioczos Płynny. Profilaktyczne stosowanie preparatów biologicznych nie powodowało istotnych zmian w zawartości sacharydów w owocach papryki słodkiej. Wykazano, jednak, iż zabiegi ochronne biopreparatem Boni Protect Forte wpływały nieznacznie na wzrost zawartości glukozy i fruktozy w owocach papryki, a stosowanie Bioczosu Płynnego na zmniejszenie zawartości glukozy i sacharozy.

Słowa kluczowe: *Capsicum annuum* L., ochrona biologiczna, zdrowotność owoców papryki, cukry

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