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Macro- and micronutrient content in selected cultivars of *Capsicum annuum* L. depending on fruit coloration

Agnieszka Żurawik[1], Dorota Jadczak[1], Nikolay Panayotov[2], Piotr Żurawik[1]*

[1]*Department of Horticulture, West Pomeranian University of Technology Szczecin, Szczecin, Poland*
[2]*Department of Horticulture, Agricultural University, Plovdiv, Bulgaria*
**Corresponding author: azurawik@zut.edu.pl*

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Abstract: *Capsicum annuum* L. belongs to the Solanaceae family and is a species of huge economic importance and high nutritional value. A study conducted in the years 2014–2015 at the Department of Horticulture, West Pomeranian University of Technology in Szczecin, assessed the content of macro- and micronutrients in the fruit of selected Polish and Bulgarian cultivars of pepper collected at different stages of coloration development. The investigation included five Polish cultivars: Roberta, Marta Polka, Etiuda, Trapez and Cyklon and five Bulgarian cultivars: Bulgarski Ratung, Sivriya, Kurtovska Kapiya, Delikates and Dzuliunska Shipka. The study demonstrated a significant effect of cultivar and a degree of fruit coloration on the content of dry matter and macro- and micronutrients. The coloured fruits featured higher content of dry matter than the green ones and cv. Etiuda had the greatest dry matter. Green fruits contained more Mg, Mn and Zn, while the coloured ones more Ca and Fe. Cvs. Delikates and Dzuliunska Shipka were particularly rich in Mg and K, cv. Sivriya in Ca and cv. Etiuda in P, Cu, Zn and Mn were the most abundant in cv. Delikates, Fe in cv. Trapez, and Na in cv. Cyklon.

Keywords: mineral elements; vegetable; warm region; plant nutrition; accumulation

The genus *Capsicum* includes many species commonly cultivated in warm regions of the world, e.g. in Asia, Africa, North America, Southern and Central Europe (Thampi 2004, De Marino et al. 2006, García-Gaytán et al. 2017). One of them is *Capsicum annuum* L. that belongs to the Solanaceae family (Singh et al. 2009). It is a widespread crop (Hwang et al. 2013), and its cultivation is important not only from economic perspective but also, or mainly, due to its high nutritional value (Howard et al. 2000, Conforti et al. 2007, Azevedo-Meleiro and Rodriguez-Amaya 2009, Shetty et al. 2013). The species has numerous cultivars of sweet, hot and other flavours (Carvallo and Bianchetti 2008, Alvarez-Parrilla et al. 2012, Zayed et al. 2013, Baenas et al. 2019). Market demand for pepper is constantly increases. The fruits are consumed fresh or in a variety of purees, pastes, sauces, dry or powders (Topuz and Ozdemir 2007, Padilha et al. 2015). They are also used as a dye and aroma (Lutz and Freitas 2008). Pepper produces fruits of variable shape, colour, size, hotness and nutrient content (Nazzaro et al. 2009). Recent years have broadened consumer knowledge and awareness on health-promoting properties of vegetables and their role in human diet (Krochmal-Marczak et al. 2017). *Capsicum annum* is a valuable source of macro- and micronutrients essential to human body (Sun et al. 2007). Apart from genetic disposition and climatic conditions, its biological value depends also on cultivar and degree of ripeness (Golcz et al. 2009). As human life span is increasing, consumption of vegetables and absorption of valuable nutrients, including micronutrients, may prevent many civilization diseases (Eggersdorfer and Wyss 2018). Therefore, growers should pay attention not only to cultivar tolerance to environmental factors but also to nutritional quality, i.e. high content of health-promoting compounds (Neitzke 2012). The aim of the study was to assess the effects of coloration and cultivar on the content on macro- and micronutrients in the fruits of *Capsicum annuum*.

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MATERIAL AND METHODS

A field experiment aimed at harvesting fruit of selected pepper cultivars was conducted in the years 2014–2015 at the Vegetable Research Station in Dołuje (14°41'E, 53°43'N) belonging to the West Pomeranian University of Technology in Szczecin. The investigation included five Polish cultivars: Roberta, Marta Polka, Etiuda, Trapez and Cyklon and five Bulgarian cultivars: Bulgarski Ratung, Sivriya, Kurtovska Kapiya, Delikates and Dzuliunska Shipka.

The experimental design involved randomised sub-blocks with four replications. The area of a single plot was 1.44 m^2 (1.2 × 1.2 m) and each plot harboured nine pepper plants.

Pepper seedlings were produced from seeds sown into seed trays in the third decade of March (2014 – 21 March; 2015 – 23 March) and cultivated in a heated greenhouse. After four weeks the seedlings were transferred into pots 10 cm in diameter filled with vegetable substrate of pH 5.4–6.0 and supplemented with macronutrient fertiliser NPK (14-16-18) + Mg (5) at 0.6 kg/m^3 and micronutrient fertiliser at 0.2 kg/m^3. During growth the seedlings were fed once with a liquid fertiliser Florovit (N – 3.0%; K – 2.0%; Cu – 70 mg/dm^3; Fe – 400 mg/dm^3, Mn – 170 mg/dm^3; Mo – 20 mg/dm^3; Zn – 150 mg/dm^3). Well-developed seedlings with non-woody stems and visible first flower buds, on average 25 cm tall, were transferred into the field to their final location in the first week of June (2014 – 6 June; 2015 – 5 June). They were planted into flat beds at 40 × 40 cm spacing and covered for two weeks with polypropylene non-woven fabric of the weight 17 g/m^2. Fertilisation scheme was based on a previous soil analysis – black specific soil (Table 1) and any deficiencies were supplemented up to the levels recommended for field cultivation of pepper, i.e. 300 kg NPK at 2:3:5 ratio. Phosphorus, potassium and half of nitrogen dose were applied in the spring during the field preparation. The other half of nitrogen dose was applied as top dressing three weeks after planting the seedlings. Weeding was carried out manually. In the first year of the study, pepper fruits were collected three times: on 20 August, 5 September and 19 September, and in 2015 two times: on 26 August and 9 September. Different number of harvests in individual years was due to less favourable temperatures in the first two months of the second year of the study. Similarly, light conditions were also disadvantageous in the same period of 2015. This shortened sunshine duration by 42 h in the analysed vegetative period. Plants were watered directly after replanting and later on as necessary. The second year of cultivation was also less favourable in terms of rainfall. After harvest, the fruits were sorted into green and coloured ones, and healthy and well-developed fruits were randomly selected from each cultivar and replication. The seeds were removed, the fruits were dried in a laboratory oven SLN 115 ECO (drying temperature was 40 °C) and ground in a laboratory mill WŻ-1.

Then after following dry matter mineralisation in a mixture of H_2SO_4 and H_2O the content of the following elements was determined: P (colorimetric method), K, Na and Ca (flame photometry), Mg (atomic absorption spectrometry, ASA). Following dry matter mineralisation in a mixture of HNO_3 and $HClO_4$ the content of Cu, Zn, Mn and Fe was assessed with ASA.

Results of chemical analyses were subjected to the Tukey's test and confidence intervals for $\alpha = 0.05$ confidence level were calculated.

RESULTS AND DISCUSSION

The study demonstrated a correspondence between pepper fruit coloration and cultivar and dry matter content. The results are presented in Table 2. Colored fruits featured greater dry matter content than the green ones. The greatest dry matter content was determined for cv. Etiuda, and the smallest for cvs. Dzuliunska Shipka and Delikates. The differences were considerable and amounted to 7.53% and 6.54%, respectively. The same correlation was confirmed between dry matter content and fruit

Table 1. Chemical properties and mineral composition of the soil collected from the experimental field in consecutive years of the study before starting the experiment

Year	pH_{H_2O}	Salinity (g NaCl/dm^3)	Mineral content (mg/dm^3 of soil)					
			$N\text{-}NO_3$	P	K	Ca	Mg	Cl
2014	7.4	0.28	27	106	58	3 200	100	7
2015	7.4	0.25	32	142	145	2 036	93	12

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Table 2. Dry matter content (%) in the fruit of *Capsicum annuum* depending on the cultivar and coloration degree

Cultivar (C)	Fruit coloration (FC)								
	green			coloured			mean for cultivar		
	2014	2015	2014–2015	2014	2015	2014–2015	2014	2015	2014–2015
Bulgarski Ratung	14.9	15.0	14.9	18.5	20.5	19.5	16.7	17.7	17.2
Sivriya	14.8	14.9	14.8	18.4	19.5	19.0	16.6	17.2	16.9
Kurtovska Kapiya	14.5	13.0	13.8	15.5	18.0	16.7	15.0	15.5	15.2
Delikates	11.8	11.2	11.5	12.4	14.4	13.4	12.1	12.8	12.4
Dzuliunska Shipka	9.85	11.6	10.7	11.2	13.2	12.2	10.5	12.4	11.4
Marta Polka	13.9	14.8	14.3	19.4	19.8	19.6	16.7	17.3	17.0
Trapez	15.9	15.1	15.5	18.4	19.6	19.0	17.2	17.3	17.2
Cyklon	13.7	11.5	12.6	12.5	15.4	13.9	13.1	13.4	13.2
Etiuda	16.6	15.9	16.2	18.0	25.4	21.7	17.3	20.6	19.0
Roberta	14.0	14.8	14.4	18.4	19.6	19.0	16.2	17.2	16.7
Mean	14.0	13.8	13.9	16.3	18.5	17.7			
$LSD_{0.05}$ FC	0.514	0.424	0.323						
$LSD_{0.05}$ C	1.952	1.610	1.195						
$LSD_{0.05}$ C/FC	2.761	2.276	1.690						
$LSD_{0.05}$ FC/C	1.626	1.341	0.321						

LSD – least significant difference

coloration degree, while in green fruits dry matter of cv. Etiuda was greater only as compared with cv. Dzuliunska Shipka. Mean content of dry matter in pepper fruits in our study reached 15.6%. This is not consistent with the findings of Buczkowska and Michałojć (2012), who determined dry matter content in pepper fruits to be 10.5%.

Pepper fruits are an important source of minerals (Buczkowska et al. 2015), with P, K, Ca and Mg being the most valuable macronutrients (Cole et al. 2016). Rubio et al. (2002), Pérez-López et al. (2007) and Tomlekova et al. (2017) claimed that the content of minerals changed during ripening. This claim was supported in our study that showed significant differences in the content of macronutrients depending on the coloration degree (Table 3). Valverde et al. (2013) and Pérez-López et al. (2007) demonstrated a decreasing content of Mg in ripening pepper fruits. This finding was also confirmed in our study, as green fruits were richer in Mg, while the coloured ones contained more Ca. Contrasting results were published by Francke (2010). The content of other investigated macronutrients did not differ significantly depending on pepper fruit coloration. These results are concurrent with those published by Rubio et al. (2002), who found red pepper fruits to be more abundant in K, Mg and P than green ones.

Our study confirmed a significant effect of cultivar on fruit macronutrient content, which is in line with a report by Tomlekova et al. (2017). The results are presented in Table 3. Fruits of cv. Etiuda contained significantly more P but only in comparison with cvs. Sivriya and Kurtovska Kapiya, and the differences reached 1.08 and 1.04 g/kg DM, respectively. The cultivars richest in Mg were Delikates and Dzuliunska Shipka. Low content of Mg was also found in cvs. Bulgarski Ratung and Sivriya. An inverse correspondence was demonstrated for Ca, which was the most abundant in cv. Sivriya and the least in cv. Delikates. Pepper cvs. Delikates and Dzuliunska Shipka were also much richer in potassium as compared with cvs. Etiuda and Bulgarski Ratung. Cv. Cyklon accumulated significantly more Na. Among coloured fruits, cv. Dzuliunska Shipka accumulated more phosphorus, while cvs. Delikates and Dzuliunska Shipka accumulated high levels of magnesium. Calcium was the most abundant in cv. Sivriya and the least in cvs. Cyklon, Delikates and Dzuliunska Shipka. Cv. Cyklon was rich in sodium but only when compared with cv. Dzuliunska Shipka. The analysis of macronutrient content in green fruits revealed higher levels of phosphorus in cvs. Trapez and Etiuda, of magnesium in cvs. Delikates and Dzuliunska Shipka and of calcium in cv. Sivriya.

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Table 3. Macronutrient content in the fruit of *Capsicum annuum* depending on the cultivar and coloration degree (g/kg dry matter)

FC	Cultivar (C)	2014					2015					2014–2015				
		K	Ca	P	Mg	Na	K	Ca	P	Mg	Na	K	Ca	P	Mg	Na
Green	Bulgarski Ratung	25.5	0.23	6.26	1.05	0.055	44.9	0.12	5.40	0.66	0.108	35.2	0.17	5.83	0.85	0.082
	Sivriya	37.6	0.32	5.50	1.01	0.056	44.1	0.19	3.97	0.66	0.091	40.8	0.25	4.73	0.83	0.074
	Kurtovska Kapiya	40.4	0,19	4.93	0.89	0.050	40.1	0.10	3.96	0.66	0.103	40.2	0.15	4.44	0.78	0.077
	Delikates	45.4	0.18	5.59	1.44	0.053	46.2	0.08	4.24	1.00	0.070	45.8	0.13	4.92	1.22	0.062
	Dzuliunska Shipka	50.9	0.19	6.94	1.60	0.059	42.5	0.08	4.47	0.82	0.083	46.7	0.14	5.70	1.21	0.071
	Marta Polka	40.5	0.23	6.21	1.01	0.058	40.4	0.11	4.69	0.75	0.094	40.4	0.17	5.45	0.88	0.076
	Trapez	37.3	0.21	6.78	1.22	0.057	48.1	0.15	5.87	0.90	0.090	42.7	0.18	6.33	1.06	0.074
	Cyklon	44.4	0.19	5.74	1.10	0.065	43.1	0.15	3.88	0.63	0.109	43.7	0.17	4.81	0.86	0.087
	Etiuda	34.3	0.24	6.82	1.10	0.061	40.9	0.15	5.76	0.77	0.085	37.6	0.20	6.29	0.94	0.073
	Roberta	46.7	0.23	6.35	1.36	0.054	41.1	0.14	3.97	0.72	0.081	43.9	0.19	5.16	1.04	0.068
Mean		40.3	0.22	6.11	1.18	0.057	43.1	0.13	4.62	0.76	0.091	41.7	0.18	5.37	0.97	0.074
Coloured	Bulgarski Ratung	39.3	0.38	4.69	0.62	0.063	49.1	0.24	5.54	0.79	0.112	44.2	0.31	5.12	0.70	0.088
	Sivriya	43.3	0.54	4.48	0.78	0.054	44.7	0.29	5.55	0.81	0.093	44.0	0.42	5.01	0.79	0.074
	Kurtovska Kapiya	40.9	0.29	5.24	0.68	0.063	46.3	0.21	5.52	0.77	0.136	43.6	0.25	5.38	0.73	0.100
	Delikates	45.8	0.28	5.38	1.27	0.062	48.1	0.13	5.85	1.39	0.058	47.0	0.21	5.61	1.33	0.060
	Dzuliunska Shipka	44.6	0.29	6.02	1.28	0.062	45.0	0.13	6,16	1.14	0.116	44.8	0.21	6.09	1.21	0.037
	Marta Polka	40.3	0.40	5.64	0.84	0.054	45.0	0.26	5,02	0.92	0.116	42.6	0.33	5.33	0.88	0.085
	Trapez	42.8	0.31	5.38	0.81	0.051	42.5	0.19	5.67	0.82	0.081	42.6	0.25	5.47	0.82	0.066
	Cyklon	39.7	0.28	6.02	0.94	0.068	42.8	0.13	5.33	0.93	0.156	41.3	0.21	5.67	0.93	0.112
	Etiuda	38.4	0.32	5.54	0.81	0.066	39.2	0.19	5.69	0.94	0.096	38.8	0.26	5.61	0.87	0.081
	Roberta	41.5	0.40	5.26	0.91	0.057	41.1	0.23	5.52	0.93	0.087	41.3	0.31	5.39	0.92	0.072
Mean		41.7	0.35	5.36	0.89	0.060	44.4	0.20	5.57	0.94	0.105	43.0	0.28	5.47	0.92	0.078
Mean for cultivar	Bulgarski Ratung	32.4	0.31	5.47	0.83	0.059	47.0	0.18	5.47	0.72	0.110	39.7	0.24	5.47	0.78	0.085
	Sivriya	40.5	0.43	4.99	0.89	0.055	44.4	0.24	4.76	0.73	0.092	42.4	0,34	4.87	0.81	0.074
	Kurtovska Kapiya	40.6	0.24	5.08	0.79	0.056	43.2	0.16	4.74	0.72	0.120	41.9	0.20	4.91	0.75	0.088
	Delikates	45.6	0.23	5.48	1.36	0.057	47.2	0.11	5.04	1.19	0.064	46.4	0.17	5.26	1.28	0.061
	Dzuliunska Shipka	47.7	0.24	6.48	1.44	0.060	43.7	0.11	5.32	0.98	0.100	45.7	0.18	5.90	1.21	0.054
	Marta Polka	40.4	0.31	5.93	0.92	0.056	42.7	0.18	4.85	0.83	0.105	41.5	0.25	5.39	0.88	0.081
	Trapez	40.1	0.26	6.08	1.02	0.054	45.3	0.17	5.72	0.86	0.085	42.7	0.22	5.90	0.94	0.070
	Cyklon	42.1	0.24	5.88	1.02	0.066	42.9	0.14	4.61	0.78	0.132	42.5	0.19	5.24	0.90	0.100
	Etiuda	36.3	0.28	6.18	0.96	0.064	40.0	0.17	5.72	0.85	0.091	38.2	0.23	5.95	0.90	0.077
	Roberta	44.1	0.32	5.81	1.14	0.055	41.1	0.18	4.74	0.82	0.084	42.6	0.25	5.27	0.98	0.070
$LSD_{0.05}$ FC		1.241	0.020	0.178	0.063	0.003	ns	0.014	0.200	0.016	0.010	ns	0.012	ns	0.032	ns
$LSD_{0.05}$ C		4.713	0.075	0.675	0.239	0.011	ns	0.054	0.759	0.061	0.039	5.838	0.043	0.479	0.117	0.019
$LSD_{0.05}$ C/FC		6.665	ns	0.954	ns	ns	ns	ns	1.073	0.087	ns	ns	0.061	0.678	0.165	0.026
$LSD_{0.05}$ FC/C		3.926	ns	0.562	ns	ns	ns	ns	0.632	0.051	ns	ns	0.012	0.130	0.032	0.005

ns – non-significant differences; FC – fruit coloration; *LSD* – least significant difference

Mean content of phosphorus was 5.42 g/kg DM and depended neither on cultivar nor coloration degree. This finding did not confirm a report by Jadczak et al. (2010), who claimed that mean content of P in pepper fruit was 3.28 g/kg DM. The content of K, Ca and Mg in our study reached 42.4, 0.23 and 0.95 g/kg DM, respectively. However, Jadczak et al. (2010), found K content to be on average by 21.6 g/kg

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Table 4. Micronutrient content in the fruit of *Capsicum annuum* depending on the cultivar and coloration degree (mg/kg dry matter)

FC	Cultivar (C)	2014				2015				2014–2015			
		Fe	Cu	Zn	Mn	Fe	Cu	Zn	Mn	Fe	Cu	Zn	Mn
Green	Bulgarski Ratung	60.0	4.90	11.8	9.52	35.9	4.02	18.1	5.25	48.0	4.46	14.9	7.39
	Sivriya	61.5	5.44	13.0	8.39	38.1	4.23	16.2	5.98	49.8	4.84	14.6	7.18
	Kurtovska Kapiya	61.7	4.20	9.48	9.50	40.7	7.30	17.8	6.36	51.2	5.75	13.6	7.93
	Delikates	74.3	5.57	14.9	14.9	36.1	5.51	23.5	9.23	55.2	5.54	19.2	12.1
	Dzuliunska Shipka	70.0	5.91	14.2	10.0	31.3	4.67	16.4	8.52	50.6	5.29	15.3	9.26
	Marta Polka	68.7	3.39	11.5	7.90	47.8	4.29	14.8	5.71	58.2	3.84	13.2	6.80
	Trapez	107.3	6.57	15.9	10.0	68.1	4.83	22.5	5.66	87.7	5.70	19.2	7.85
	Cyklon	57.0	4.22	13.1	7.92	52.6	4.42	23.7	5.89	54.8	4.32	18.4	6.91
	Etiuda	67.0	5.29	12.8	8.84	55.2	3.53	16.6	6.67	61.1	4.41	14.7	7.75
	Roberta	78.6	4.73	12.9	11.6	52.2	4.08	15.7	7.32	65.4	4.41	14.3	9.46
Mean		70.6	5.02	13.0	9.86	45.8	4.69	18.5	6.66	58.2	4.83	15.7	8.26
Coloured	Bulgarski Ratung	55.1	3.77	10.3	5.34	51.3	4,62	12.5	5.22	53.2	4.20	11.4	5.28
	Sivriya	79.7	3.94	11.1	6.51	47.6	4,62	14.6	5.15	63.6	4.28	12.8	5.83
	Kurtovska Kapiya	63.4	3.54	11.2	5.90	50.5	5,46	17.4	5.15	56.9	4.50	14.3	5.53
	Delikates	76.9	7.81	17.5	10.7	58.4	7.56	21.7	9.17	67.6	7.78	19.6	9.91
	Dzuliunska Shipka	63.2	5.73	14.5	8.12	51.4	6.91	16.4	7.08	57.3	6.32	15.5	7.60
	Marta Polka	72.4	6.58	11.1	7.36	49.2	4.29	23.6	5.46	60.8	5.43	17.3	6.41
	Trapez	86.5	3.92	11.1	6.95	58.0	5.23	19.3	6.91	72.2	4.57	15.2	6.93
	Cyklon	56.9	4.92	13.6	6.74	48.6	5.39	18.0	5.71	52.7	5.16	15.8	6.22
	Etiuda	65.3	3.36	14.0	5.54	51.3	3.69	16.6	5.63	58.3	3.53	15.3	5.58
	Roberta	72.2	3.61	15.2	5.96	49.2	4.38	15.8	6.10	60.7	4.00	15.5	6.03
Mean		69.1	4.72	13.0	6.91	51.6	5.23	17.6	6.16	60.3	4.98	15.3	6.53
Mean for cultivar	Bulgarski Ratung	57.6	4.34	11.0	7.43	43.6	4.32	15.3	5.24	50.6	4.33	13.2	6.33
	Sivriya	70.6	4.69	12.1	7.45	42.9	4.42	15.4	5.56	56.7	4.56	13.7	6.51
	Kurtovska Kapiya	62.5	3.87	10.3	7.70	45.6	6.38	17.6	5.76	54.1	5.12	14.0	6.73
	Delikates	75.6	6.69	16.2	12.8	47.2	6.63	22.6	9.20	61.4	6.66	19.4	1.0
	Dzuliunska Shipka	66.6	5.82	14.3	9.06	41.3	5.79	16.4	7.80	54.0	5.81	15.4	8.43
	Marta Polka	70.5	4.99	11.3	7.63	48.5	4.29	19.2	5.58	59.5	4.64	15.2	6.61
	Trapez	96.9	5.24	13.5	8.49	63.1	5.03	20.9	6.29	80.0	5.14	17.2	7.39
	Cyklon	56.9	4.57	13.4	7.33	50.6	4.91	20.9	5.80	53.8	4.74	17.1	6.57
	Etiuda	66.2	4.33	13.4	7.19	53.3	3.61	16.6	6.15	59.7	3.97	15.0	6.67
	Roberta	75.4	4.17	14.1	8.78	50.7	4.23	15.8	6.71	63.1	4.20	14.9	7.75
$LSD_{0.05}$ FC		ns	0.244	ns	0.254	2.982	0.231	0.771	0.195	1.820	ns	0.461	0.155
$LSD_{0.05}$ C		8.658	0.928	2.116	0.964	11.321	0.875	2.926	0.741	6.730	0.602	1.705	0.574
$LSD_{0.05}$ C/FC		12.244	1.312	2.992	1.363	16.010	1.238	4.139	1.047	9.518	0.852	2.412	0.812
$LSD_{0.05}$ FC/C		7.212	0.773	1.762	0.803	9.431	0.729	2.438	0.617	1.823	0.163	0.461	0.155

ns – non-significant differences; FC – fruit coloration; *LSD* – least significant difference

DM lower, and of Ca and Mg by 2.30 and 0.07 g/kg DM higher.

Our study also demonstrated a significant effect of fruit coloration on their micronutrient content (Table 4), which is in line with the reports by Rubio et al. (2002), Pérez-López et al. (2007), Francke (2010), and Tomlekova et al. (2017). According to Rubio et al. (2002), red pepper fruits are richer in Fe. This was

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confirmed in our experiment that revealed significantly higher levels of Fe in coloured fruits *vs*. the green ones. An inverse relationship was reported by Pérez-López et al. (2007). The results of our study were not on par with those published by Rubio et al. (2002), who claimed that red fruits were richer in Mn and Zn than the green ones, and with a report by Valverde et al. (2013), who described an increasing content of Zn in ripening pepper fruits. Our research confirmed the findings of Pérez-López et al. (2007), who claimed that green pepper fruits are richer in Zn than the coloured ones. No correlation was found between the degree of coloration and copper accumulation, which corroborated the results of Valverde et al. (2013).

According to Tomlekova et al. (2017), pepper fruits differ in their mineral composition depending on the cultivar. Our study showed a considerable influence of the cultivar on fruit content of micronutrients (Table 4). Irrespective of the coloration degree cv. Delikates accumulated the highest amounts of manganese, while cultivars with the lowest Mn levels included Bulgarski Ratung, Sivriya, Cyklon, Marta Polka, Etiuda and Kurtovska Kapiya. Fruits of cv. Delikates were also the richest in Cu and Zn, while the lowest levels of Cu were determined for cv. Etiuda and of Zn for cv. Bulgarski Ratung. According to Tomlekova et al. (2017), fruits of different pepper cultivar differ in their Fe content. Our study corroborated this claim, and the highest and lowest Fe content was detected in cv. Trapez and Bulgarski Ratung, respectively. The difference was 29.4 mg/kg DM Ripe fruits of cv. Delikates accumulated the greatest amounts of Mn and Cu. Coloured fruits of this cultivar contained also more Zn but only in comparison with cv. Bulgarski Ratung. Moreover, coloured fruits of cv. Trapez contained more Fe than cvs. Cyklon and Bulgarski Ratung. Coloured fruits of cv. Bulgarski Ratung accumulated considerably lower amounts of Mn, Fe and Zn, and fruits of cv. Etiuda had low levels of Cu. Our analysis of micronutrient content in green fruits showed high levels of Mn and Zn in cv. Delikates. The other cultivars rich in Zn were Trapez and Cyklon. Green fruits of cv. Trapez featured also high levels of Fe and Cu. The study also demonstrated the lowest accumulation of Mn, Cu and Zn in green fruits of cv. Marta Polka and of Fe in cv. Bulgarski Ratung. Mao et al. (2009) pointed out to the importance of Zn to Cu ratio. Zinc predominance may indicate anticancer properties. In our study, Zn content was by 10.6 mg/kg DM higher than that of Cu, which may suggest antioxidant properties of pepper.

Considering the content of macro- and micronutrients in pepper fruit, the species is of crucial importance to human diet. Element content in pepper fruit depends on their maturity – green peppers contain more Mg, Mn and Zn, while mature and pigmented fruit are richer in Ca and Fe. Nutrient composition is also determined by pepper cultivar. Cv. Sivriya was distinctive in its content of Ca, cv. Etiuda of P, cv. Cyklon of Na and cv. Trapez of Fe. The cultivar Delikates seems the most recommendable, as highly abundant in Cu, Zn and Mn, and similarly cv. Dzuliunska Shipka in Mg and K.

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