

## DIVERSITY OF THE UTILITY AND BIOLOGICAL VALUE OF FRUITS OF SOME SWEET PEPPER CULTIVARS

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**Abstract.** Consumer attractiveness and the usefulness for food processing of sweet pepper are determined by fruits quality values. The large weight, thick pericarp and intensive color at physiological ripeness as well as the share of pericarp to the fruit weight are most important. Such sweet pepper cultivars are now available in Poland. These cultivars are adopted to growing in less favourable environmental conditions and they reveal high stability. The aim of this study was evaluate the open field yielding and comparing the utility and biological value of fruits of seven sweet pepper cultivars adapted to growing under less favorable environmental conditions in terms of the fresh vegetables market usefulness for consumption and processing. The highest average marketable yield of fruits was achieved from 'Caryca F<sub>1</sub>' cv., which was larger in comparison to the yield of 'Roberta F<sub>1</sub>' and 'Jova' cvs. The yield of remaining cultivars was not significantly different from 'Caryca F<sub>1</sub>' cv. Evaluated cultivars showed a great diversity in terms of their utility and biological value of fruits. The 'Mino' cv. was distinguished by the largest weight fruits while 'Jova' cv. by thick pericarp. The great weight of fruit, pericarp thickness and the great weight of edible parts of fruits was shown by 'Caryca F<sub>1</sub>' cv., while in a view of the assessed parameters of biological value the most L-ascorbic acid were contained 'Roberta F<sub>1</sub>', 'Robertina', 'Corrida F<sub>1</sub>' cv. fruits and the extract 'Roberta F<sub>1</sub>' cv. fruits.

**Key words:** *Capsicum annuum* L., fruit quality, marketable yield, vitamin C

### INTRODUCTION

The sweet pepper (*Capsicum annuum* subsp. *macrocarpum* L.) belongs to the economically important vegetables of the global reach. This vegetable is popular mainly due to its pro-health properties and taste [Perucka and Materska 2003, Pokluda 2004, Navarro et al. 2006, Topuz and Ozdemir 2007]. This plant comes from regions of warmer climate and it has the large environmental requirements. The yielding of sweet

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pepper in an open field cultivation in less favorable conditions is dependent on the air- and soil temperature in the vegetation period and assortment of the cultivar. Availability of cultivars adapted to growing in less favorable climate for pepper plants and increasing interest of the processing industry in Poland leads to the cultivation of the sweet pepper in the open field on the commercial scale [Kmieciak and Lisiewska 1994, Gajc-Wolska and Skąpski 2002, Buczkowska 2007, Rożek et al. 2012]. Manufacturers have many cultivars both of the native breeding and foreign origin [Buczkowska 2007, Gajc-Wolska et al. 2007]. Yielding in the field of these cultivars in the temperate climate zone is characterized by a relatively high stability, especially in the case of hybrids [Gajc-Wolska and Skąpski 2002, Gajc-Wolska et al. 2007, Korzeniewska and Niemirowicz-Szczytt 2007, Szafirowska and Elkner 2008, 2009]. Fruits of sweet pepper are a rich source of antioxidants, the most important of which is vitamin C present in significant quantities [Kmieciak and Lisiewska 1994, Lee and Kader 2000, Buczkowska and Najda 2002, Perucka and Materska 2003, Orłowski et al. 2004, Pokluda 2004, Frary et al. 2008, Szafirowska and Elkner 2008]. Sweet pepper also accumulates remarkable amounts of minerals, while ripe fruits are the source of carotenoids [Kmieciak and Lisiewska 1994, Perucka and Materska 2003, Pokluda 2004, Gajc-Wolska et al. 2007, Topuz and Ozdemir 2007, Jadczyk et al. 2010, Buczkowska and Michałojć 2012]. Dry matter, sugar, and extract contents are also important parameters of the biological value of sweet pepper [Kmieciak and Lisiewska 1994, Gajc-Wolska and Skąpski 2002, Dasgan and Abak 2003, Orłowski et al. 2004, Gajc-Wolska et al. 2007, Buczkowska and Sawicki 2008, Michalik 2010].

For consumers, the sweet pepper fruits characterized by large weight, thick pericarp, and intensive color at full ripeness, are the most attractive [Gajc-Wolska and Skąpski 2002, Nowaczyk et al. 2005, Korzeniewska and Niemirowicz-Szczytt 2007, Nowaczyk and Nowaczyk 2007, 2008, Szafirowska and Elkner 2009, Jadczyk et al. 2010]. The value of raw fruits of a given sweet pepper cultivar is determined by the pericarp weight, sometimes referred to as biological fruit weight, as well as the technological fruit weight, which is the biological weight of fruit minus the weight of pericarp at the calyx [Nowaczyk and Nowaczyk 2007, Szafirowska and Elkner 2008, Nowaczyk et al. 2008]. In commercial cultivation of sweet pepper for the industry, the important properties, which determine the suitability of a cultivar are accepted the biological and technological efficiency of the fruit, which are, respectively: percentage of the biological weight of fruit and technological weight of fruit in relation to the fruit weight (%) [Nowaczyk and Nowaczyk 2007, Nowaczyk et al. 2005, 2008].

The aim of this study was to evaluate the yielding and characteristics of fruits of seven sweet pepper cultivars growing in open field in terms of selected parameters of utility and biological value.

## MATERIAL AND METHODS

The study was conducted in 2006–2008 in a private farm in Zezulín (51.35°N, 22.85°E) near the city of Lublin, in the lessive soil developed from the loess formations on lime marls containing 1.8% of organic matter in the plow layer. Winter wheat was

the forecrop for sweet pepper. Every year in autumn, the organic fertilization using manure was applied at the rate of 30 t·ha<sup>-1</sup>. Depending on a year, mineral nutrients contents in the soil were as follows: N-NO<sub>3</sub> 15–45, P 90–125, K 100–140, Ca 700–1150, Mg 70–115 mg·dm<sup>-3</sup>. Mineral fertilization was used two weeks before seedlings planting in quantities: 90–100 kg N (ammonium nitrate), 50–60 kg P (triple superphosphate), 110–130 kg K (potassium sulfate) per 1 hectare. Sweet pepper was foliar-treated: twice with calcium nitrate (1%) and twice with Florovit (0.5%). Sweet pepper was grown from the seedlings in pots prepared in the greenhouse of The University of Life Science in Lublin, The Experimental Station, Lublin-Felin. The tempered seedlings were planted in the field in the third decade of May at spacing 0.67 m × 0.35 m, thus 4.26 plants grew per 1 m<sup>2</sup>. Material consisted of fruits of seven sweet pepper cultivars: ‘Roberta F<sub>1</sub>’, ‘Robertina’, ‘Corrida F<sub>1</sub>’ (Department of Plant Genetics, Breeding, and Biotechnology, SGGW Warsaw), ‘Mino’ (Capsi-Nova L. and P. Nowaczyk), ‘Caryca F<sub>1</sub>’ (PlantiCo Gołębiew), as well as ‘Marysia’ and ‘Jova’ (Czech cultivars, seed distributor – Oseva Polska LTD), which are of a great productive importance in Poland now.

Table 1. Air temperature and total precipitation in 2006–2008 years against a background of many-year averages

	Years	Months				
		May	June	July	August	September
Air temperature (°C)	2006	13.6	16.9	21.9	17.3	15.7
	2007	14.9	18.1	19.1	18.4	12.9
	2008	12.7	17.7	18.3	19.3	12.6
	1951–2005	13.0	16.4	17.8	17.1	12.6
Total precipitation (mm)	2006	59.5	37.9	6.8	198.3	11.0
	2007	80.5	87.8	87.0	37.6	129.8
	2008	101.6	85.9	77.1	45.0	102.2
	1951–2005	57.7	65.7	83.5	68.6	51.6

The experiment was set up as univariate by means of randomized blocks in 4 replicates with 40 plants per plot. The area of each plot was 9.4 m<sup>2</sup>. Fruits were harvested at physiological ripeness stage, separately from each replicate, and then total and marketable yield of fruits were assessed. The harvest was carried out from the 2<sup>nd</sup> decade (cultivars: ‘Roberta F<sub>1</sub>’, ‘Robertina’, ‘Mino’, ‘Marysia’, ‘Jova’) or from the 3<sup>rd</sup> decade of August (‘Caryca F<sub>1</sub>’, ‘Corrida F<sub>1</sub>’) to the 3<sup>rd</sup> decade of September (a final harvest). Fruits randomly selected from each harvest (5 fruits per replicate) were subject to determination of the following utility features: fruit weight (g), then after excision of inedible parts, the pericarp weight, i.e. the biological weight of fruit, and after cutting out the pericarp at the calyx, so-called technological weight of fruit, as well as the pericarp thickness using digital caliper (mm) [Nowaczyk and Nowaczyk 2007, Nowaczyk et al. 2005, 2008]. Each year after the harvest complete, yielding of studied cultivars was

evaluated and the percentage of biological and technological weight of fruit in relation to the whole fruit was calculated, thus determining the average value of the biological productivity of fruits and technological efficiency of fruits (%) of assessed sweet pepper cultivars. Fruits of all cultivars harvested the same period (2<sup>nd</sup> decade of September) were subject to laboratory analyses. All determinations were performed in 3 replicates: dry matter by means of dryer method (+105°C), L-ascorbic acid by means of Roe method with modifications by Ewelina, total sugars (%) applying Luff-Schoorl method, extract (%) refractometrically.

The yielding results as well as selected parameters of the utility and biological values of fruits were statistically processed by means of variance analysis. The significance of differences was calculated by T-Tukey's multiple confidence at the confidence level of 5%. Characterization of the weather conditions during the sweet pepper cultivation in the field in 2006–2008 on a background of respective parameters in many-year period is presented in Table 1.

## RESULTS

Evaluated cultivars of sweet pepper have shown wide variation in the size of the average fruit marketable yield. In 2006–2008, higher mean yield of marketable fruits was harvest from the 'Caryca F<sub>1</sub>' (4.45 kg·m<sup>-2</sup>), than 'Roberta F<sub>1</sub>' (3.37 kg·m<sup>-2</sup>) and 'Jova' (3.46 kg·m<sup>-2</sup>). The yield of the remaining cultivars was not significantly different from 'Caryca F<sub>1</sub>'cv. (tab. 2). Statistically significant differences in the average marketable yield of sweet peppers between years of research were recorded. Considerably lower yield was harvested in 2006 (3.42 kg·m<sup>-2</sup>) as compared to 2007 (3.98 kg·m<sup>-2</sup>) and 2008 (4.25 kg·m<sup>-2</sup>). The share of marketable yield in the total yield was highly significant, as

Table 2. Yielding characterization of seven sweet pepper cultivars

Cultivar	Marketable yield (kg m <sup>-2</sup> )				Share of marketable yield in total yield (%)			
	2006	2007	2008	mean	2006	2007	2008	mean
Roberta F <sub>1</sub>	3.21	3.26	3.64	3.37	86.3	89.1	96.1	90.5
Robertina	3.25	3.20	4.95	3.80	85.5	74.6	95.7	85.3
Corrida F <sub>1</sub>	3.07	4.09	4.74	3.97	84.5	94.2	96.9	91.9
Caryca F <sub>1</sub>	3.95	5.27	4.13	4.45	88.0	96.2	95.7	93.3
Mino	3.62	4.60	4.10	4.11	88.5	84.9	94.7	89.4
Marysia	3.75	4.30	4.05	4.03	88.2	94.8	92.4	91.8
Jova	3.06	3.20	4.12	3.46	85.7	74.3	93.1	84.4
Mean	3.42	3.98	4.25	3.88	86.7	86.9	94.9	89.5
LSD <sub>0.05</sub>								
Cultivar (a)	0.648	0.769	0.805	0.767				
Years (b)					0.382			
Interaction (a × b)					1.150			

it was from 86.7% to 94.9%, on average. In 2006, the marketable yield higher than  $3.5 \text{ kg}\cdot\text{m}^{-2}$  was achieved only from the following cultivars: 'Mino', 'Marysia' and 'Caryca F<sub>1</sub>', whereas for the remaining ones it ranged from 3.06 ('Jova') to  $3.25 \text{ kg}\cdot\text{m}^{-2}$  ('Robertina'). A large variation in marketable yield between assessed cultivars was observed in 2007. The lowest marketable yield was obtained from 'Robertina', 'Jova', and 'Roberta F<sub>1</sub>' cultivars ( $3.20\text{--}3.26 \text{ kg}\cdot\text{m}^{-2}$ ), while the largest from 'Caryca F<sub>1</sub>' ( $5.27 \text{ kg}\cdot\text{m}^{-2}$ ). Good yield of marketable fruits was also harvested from 'Corrida F<sub>1</sub>', 'Marysia', and 'Mino' ( $4.09\text{--}4.60 \text{ kg}\cdot\text{m}^{-2}$ ). In 2008, the marketable yield of fruits from six cultivars ranged from  $4.05 \text{ kg}\cdot\text{m}^{-2}$  ('Marysia') to  $4.13 \text{ kg}\cdot\text{m}^{-2}$  ('Caryca F<sub>1</sub>'), and significantly lower from 'Roberta F<sub>1</sub>' ( $3.64 \text{ kg}\cdot\text{m}^{-2}$ ).

Table 3. Fruit weight and thickness of pericarp in the fruits of seven sweet pepper cultivars

Cultivar	Fruit weight (g)				Thickness of pericarp (mm)			
	2006	2007	2008	mean	2006	2007	2008	mean
Roberta F <sub>1</sub>	108.0	90.6	104.3	101.0	4.3	5.2	4.6	4.7
Robertina	101.2	107.4	122.2	110.3	4.3	4.7	4.9	4.6
Corrida F <sub>1</sub>	99.1	76.8	88.8	88.2	6.0	6.0	4.6	5.5
Caryca F <sub>1</sub>	136.0	120.6	112.7	123.1	7.2	7.4	6.5	7.0
Mino	133.4	129.4	109.7	124.2	4.1	5.7	4.8	4.9
Marysia	98.0	97.0	101.3	98.8	4.8	6.6	5.9	5.8
Jova	92.2	101.2	114.4	102.6	6.9	8.4	8.8	8.0
Mean	109.7	103.3	107.6	106.9	5.4	6.3	5.7	5.8
LSD <sub>0.05</sub>								
Cultivar (a)				10.42				1.25
Years (b)				n.s.				n.s.
Interaction (a × b)				42.45				2.49

n.s.: not significant

There were significant differences between cultivars and related to the parameters determining the utility value of fruits. Cultivars 'Mino' (124.2 g) and 'Caryca F<sub>1</sub>' (123.1 g) were characterized by the fruit of the highest mean weight, while 'Corrida F<sub>1</sub>' (88.2 g) and 'Marysia' (98.8 g) by the lowest (tab. 3). In 2006 and 2007, fruits of the following cultivars were distinguished by the highest weight: 'Mino' and 'Caryca F<sub>1</sub>', while in 2008, 'Robertina' cv. The largest difference in the utility value parameters of fruits of assessed sweet pepper cultivars was recorded in relation to the pericarp thickness (tab. 3). 'Jova' cv. was distinguished by the thickest pericarp wall (mean 8.0 mm) as compared to fruits of 'Robertina', 'Roberta F<sub>1</sub>', and 'Mino' (4.6–4.9 mm, on average). Based on the variance analysis, no significant differences in the pericarp thickness and other parameters of the utility value of assessed cultivars between years of research, were found. Fruits of evaluated cultivars showed a large variation in the weight of edible parts. This was evidenced by values of their biological and technological weights

(tab. 4). Fruits of ‘Caryca F<sub>1</sub>’ (106.8 g) and ‘Mino’ (105.1 g) were characterized by significantly the highest average pericarp weight as compared to other cultivars (72.8–94.0 g). Fruits of these cultivars were distinguished by the greatest biological and technological weights in 2006 and 2007, whereas in 2008 ‘Robertina’ cv. fruits were outstanding. In all the years of research, significantly the lowest biological (65.4–78.6 g) and technological weight (58.0–59.8 g) was recorded for fruits of ‘Jova’ cv. On the basis of the share of biological and technological weight of the fruit in the total mass of the fruit (%), biological and technological efficiency of sweet pepper fruits was determined (fig. 1). It has been shown that the biological efficiency of fruit of assessed cultivars in 2006–2008 was in the range from 82.9 to 85.5%, while technological efficiency of fruits from 68.8 to 70.3%, respectively. ‘Jova’ cv. was characterized by the lowest biological and technological fruit efficiency. Depending on the year of study, the biological efficiency of that cultivar fruits ranged from 64.6 to 80.6%, and the technological efficiency was only from 58.0 to 59.8% of the whole fruit weight.

Table 4. Biological weight and technological weight of fruits of seven sweet pepper cultivars

Cultivar	Biological weight (g)				Technological weight (g)			
	2006	2007	2008	mean	2006	2007	2008	mean
Roberta F <sub>1</sub>	85.1	78.8	88.1	84.0	67.6	62.3	69.0	66.3
Robertina	86.6	87.6	107.8	94.0	73.8	73.5	88.2	78.5
Corrida F <sub>1</sub>	89.3	67.6	75.9	77.6	73.7	63.6	63.4	66.9
Caryca F <sub>1</sub>	117.2	110.5	92.8	106.8	97.6	91.1	76.1	88.3
Mino	117.1	104.3	93.9	105.1	88.0	84.2	76.8	83.0
Marysia	87.1	84.8	88.8	86.9	69.2	71.6	72.6	71.1
Jova	74.3	65.4	78.6	72.8	58.0	58.5	59.8	58.8
Mean	93.8	85.6	89.4	89.6	75.5	72.1	72.3	73.3
LSD <sub>0.05</sub>								
Cultivar (a)				6.92				6.25
Years (b)				n.s.				n.s.
Interaction (a × b)				28.00				25.48

n.s.: not significant

Sweet pepper fruits contained mean dry matter content at the level of 7.69% (tab. 5). Evaluated cultivars were statistically different in relation to the dry matter weight of fruits. Significantly the highest mean dry matter was determined in the fruits of ‘Roberta F<sub>1</sub>’ (8.21%) as compared to other cultivars, in which the dry matter weight of fruits was from 7.27% (‘Caryca F<sub>1</sub>’) to 7.79% (‘Robertina’). There was no statistical difference between the years of research in the dry matter of fruits of evaluated sweet pepper cultivars. Dry matter in sweet pepper ranged from 7.33 (2006) to 7.88% (2007). In 2006 and 2007, the largest amounts of dry matter were determined in fruits of ‘Roberta F<sub>1</sub>’, the smallest in fruits of ‘Caryca F<sub>1</sub>’ cv., while in 2008, the highest dry matter was contained in ‘Corrida F<sub>1</sub>’ cv., and the lowest – ‘Marysia’ cv.

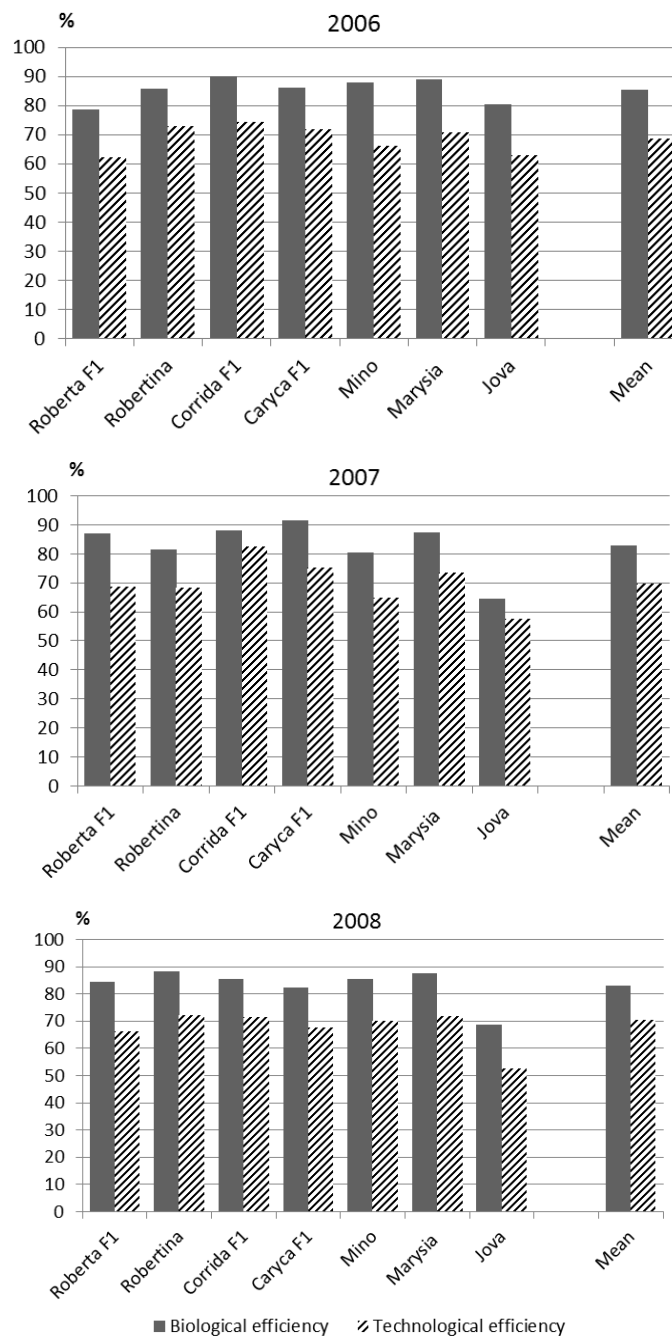


Fig. 1. Biological and technological efficiency of sweet pepper fruits

Fruits of evaluated cultivars showed a considerable variation in the content of extract (tab. 5). Its highest mean level was determined in fruits of 'Roberta F<sub>1</sub>' cv. (7.0%) as compared to fruits of 'Caryca F<sub>1</sub>' cv. (5.8%). Remarkable differences in the extract amounts were observed in the years of study. In 2006, the average extract content in sweet pepper was 6.6%. Based on the variance analysis, no significant differences in the amount of extract in fruits between the assessed cultivars were recorded, while in 2007, significantly more extract was determined in fruits of 'Marysia', 'Robertina', and 'Roberta F<sub>1</sub>' cv. (7.0–7.5%) as compared to 'Mino' and 'Caryca F<sub>1</sub>' cv. (5.5–5.6%). In 2008, the content of extract also varied depending on the cultivar. Significantly more extract was recorded rather in fruits of 'Corrida F<sub>1</sub>' cv. (6.7%) than 'Caryca F<sub>1</sub>' cv. (5.9%).

Table 5. Content of dry matter and extract in the fruits of seven sweet pepper cultivars

Cultivar	Dry matter (%)				Extract (%)			
	2006	2007	2008	mean	2006	2007	2008	mean
Roberta F <sub>1</sub>	8.04	8.65	7.94	8.21	7.0	7.5	6.4	7.0
Robertina	7.61	8.02	7.74	7.79	7.0	7.3	6.2	6.8
Corrida F <sub>1</sub>	7.04	7.52	8.23	7.60	6.5	5.6	6.7	6.3
Caryca F <sub>1</sub>	6.83	7.42	7.55	7.27	6.0	5.5	5.9	5.8
Mino	7.31	7.91	7.73	7.65	6.8	6.9	6.4	6.7
Marysia	7.44	8.03	7.03	7.50	6.6	7.0	6.5	6.7
Jova	7.05	7.63	7.54	7.41	6.5	6.8	6.5	6.7
Mean	7.33	7.88	7.68	7.63	6.6	6.7	6.4	6.6
LSD <sub>0.05</sub>								
Cultivar (a)				0.346				0.13
Years (b)				n.s.				0.25
Interaction (a × b)				1.420				0.52

n.s.: not significant

Fruits of assessed cultivars contained high concentration of L-ascorbic acid – an average of 251.5 mg·100 g<sup>-1</sup> f.m. (tab. 6). Statistically significant differences between evaluated cultivars in terms of this component content, were recorded. Definitely the largest mean level of L-ascorbic acid was determined in fruits of 'Corrida F<sub>1</sub>' (308.4 mg·100 g<sup>-1</sup> f.m.), while the smallest fruits of 'Marysia' and 'Caryca F<sub>1</sub>' (211.1–211.8 mg·100 g<sup>-1</sup> f.m.), as well as 'Mino' (228.2 mg·100 g<sup>-1</sup>). Statistical diversity of L-ascorbic acid content between years of study was proved for fruits of all assessed sweet pepper cultivars. Significantly the largest mean amounts of the component was accumulated by sweet pepper in 2006 (289.5 mg·100 g<sup>-1</sup>) as compared to 2007 (270.5 mg·100 g<sup>-1</sup>) and 2008 (194.5 mg·100 g<sup>-1</sup>). In 2006 and 2007, fruits of 'Corrida F<sub>1</sub>' cultivar were distinguished by the highest abundance in L-ascorbic acid, as well as 'Roberta F<sub>1</sub>' and 'Robertina' in 2008.



Table 6. Content of L-ascorbic acid and total sugars in the fruits of seven sweet pepper cultivars

Cultivar	L-ascorbic acid (mg 100 g <sup>-1</sup> f.m.)				Total sugars (%)			
	2006	2007	2008	mean	2006	2007	2008	mean
Roberta F <sub>1</sub>	337.3	264.2	239.4	280.3	1.88	1.65	2.74	2.09
Robertina	302.3	238.4	276.6	272.4	1.94	1.79	2.95	2.23
Corrida F <sub>1</sub>	352.6	376.1	196.5	308.4	2.87	1.94	3.08	2.63
Caryca F <sub>1</sub>	227.2	264.9	143.3	211.8	1.94	1.82	2.34	2.37
Mino	236.5	294.5	153.7	228.2	1.93	1.89	2.48	2.10
Marysia	282.3	211.9	139.1	211.1	2.59	2.30	3.27	2.72
Jova	288.1	243.2	213.1	248.2	2.13	1.89	2.59	2.20
Mean	289.5	270.5	194.5	251.5	2.18	1.90	2.92	2.33
LSD <sub>0.05</sub>								
Cultivar (a)				4.24				0.165
Years (b)				8.26				0.323
Interaction (a × b)				17.46				0.682

The content of total sugars in sweet pepper was 2.33%, on average (tab. 6). The largest mean of total sugars were determined in fruits of 'Marysia' cv. (2.72%), 'Corrida F<sub>1</sub>' cv. (2.63%), and 'Caryca F<sub>1</sub>' cv. (2.37%). Statistically significant differences of sugars content in sweet pepper were found in each year of study. More sugars were accumulated in fruits of assessed cultivars in 2008 as compared to the content of these nutrients in fruits harvested in 2006 and 2007.

## DISCUSSION

The marketable yield of sweet pepper achieved in 2006–2008 near Lublin was comparable to that obtained in the region in other studies [Buczowska and Bednarek 2005, Buczowska 2007, Rożek et al. 2012], as well as results of other authors carried out in other Polish regions [Gajc-Wolska and Skąpski 2002, Gajc-Wolska et al. 2007, Korzeniewska and Niemirowicz-Szczyt 2007, Szafirowska and Elkner 2008, Michalik 2010]. The significant diversity in yielding of this vegetable was noticed the years of the experiment. In 2006 a considerably lower marketable yield was obtained. It was due to changing weather conditions during cultivation. In 2006 the meteorological conditions were less favourable for fruits ripening. In August the mean daily temperature was lower in comparison with the years 2007–2008. moreover, very high rainfalls whose sun exceeded almost 3 times the perennial values for this month were observed. The success of the filed cultivation of sweet pepper is greatly determined by a proper cultivar selection. This study took into account the cultivars that were also distinguished in other research by a high stability of yielding in the field under less favorable environmental conditions and are important for large-scale production [Gajc-Wolska and Skąp-

ski 2002, Buczkowska 2007, Gajc-Wolska et al. 2007, Korzeniewska and Niemirowicz-Szczytt 2007]. The overall objective of this study was to characterize and evaluate the selected utility and biological traits of fruits of seven sweet pepper cultivars. Assessed cultivars showed a wide diversity of studied parameters. In terms of the fruit weight and the weight of edible parts (biological and technological weight), fruits of 'Mino' and 'Caryca F<sub>1</sub>' cv. appeared to be the most impressive. The attractiveness of latter one, as well as that of 'Roberta F<sub>1</sub>', referring to these characteristics has been shown in other works [Szafirowska and Elkner 2008, 2009, Rożek et al. 2012]. The pericarp thickness is very important utility and technological feature [Gajc-Wolska and Skąpski 2002, Buczkowska 2007, Korzeniewska and Niemirowicz-Szczytt 2007, Nowaczyk and Nowaczyk 2007, Nowaczyk et al. 2008, Rożek et al. 2012]. Fruits of 'Jova' and 'Caryca F<sub>1</sub>' cv. were characterized by the thickest pericarp. Results of previous works indicate that fruits of 'Caryca F<sub>1</sub>' cv. and other cultivars and hybrid lines had thicker pericarp than those of stabilized cultivars [Buczkowska 2007, Korzeniewska and Niemirowicz-Szczytt 2007, Jadczyk et al. 2010]. Szafirowska and Elkner [2008, 2009] considering remarkable biological and technological efficiency of 'Caryca F<sub>1</sub>' cv. fruits, recommend it as the leading for conventional and organic cultivation. Rożek et al. [2012] also showed that fruits of 'Caryca F<sub>1</sub>' and 'Roberta F<sub>1</sub>' cv. from a single harvest represent a large utility value and can provide a good raw material for the processing. Fruits of 'Jova' cv. have a high weight of the edible parts in the entire mass (about 50%), and therefore, this cultivar is not suitable for commercial production, especially for industry. There were no statistically significant differences between the years of research relating to the studied traits of sweet pepper. This shows that the fruit weight, pericarp thickness, and the weight of edible parts of fruits, are relatively stable genetic characteristics, especially in heterosis cultivars and can slightly vary due to environmental factors, especially weather and agronomy [Gajc-Wolska and Skąpski 2002, Jadczyk et al. 2010]. Variation of the dry matter was recorded in fruits of evaluated cultivars. The dry matter content in fruits of all assessed cultivars did not significantly differ between the years of research. This is due to the fact that dry weight and the extract content in sweet pepper fruits are determined by the varietal characteristics, fruit ripeness phase, and to a lesser extent by other factors [Kmieciak and Lisiewska 1994, Gajc-Wolska and Skąpski 2002, Dasgan and Abak 2003, Orłowski et al. 2004, Pokluda 2004, Ayuso et al. 2008, Buczkowska and Sawicki 2008, Jadczyk et al. 2010, Michalik 2010]. Hot pepper fruits contain much more dry matter [Buczkowska and Najda 2002, Topuz and Ozdemir 2007]. Sweet pepper fruits are an abundant source of vitamin C, the accumulation of which depends on varietal traits [Frery et al. 2008], although it is also modified by environmental, agrotechnical, and post-harvest conditions [Lee and Kader 2000, Gajc-Wolska and Skąpski 2002, Szafirowska and Elkner 2008]. Ripe fruits of assessed sweet pepper cultivars were characterized by large amounts of L-ascorbic acid – its mean content reached over 250 mg·100g<sup>-1</sup>, which are values similar to those found by other authors [Gajc-Wolska and Skąpski 2002, Golcz and Kozik 2004, Orłowski et al. 2004, Pokluda 2004], and higher than those quoted in previous works [Kmieciak and Lisiewska 1994, Lee and Kader 2000, Buczkowska and Najda 2002, Gajc-Wolska et al. 2007, Topuz and Ozdemir 2007, Buczkowska and Sawicki 2008, Szafirowska and Elkner 2008, Michalik 2010, Milenković et al. 2012]. The largest quantities of L-ascorbic acid

were accumulated by fruits of 'Corrida F<sub>1</sub>' cv., while the smallest – 'Caryca F<sub>1</sub>' and 'Marysia' cv. Considerable differences of this vitamin content between years of the research were observed for all assessed cultivars. The lowest concentration of L-ascorbic acid was accumulated by sweet pepper in 2008. It may result from the fact that prior to the fruit harvest (2<sup>nd</sup> decade of September 2008), less favorable weather conditions occurred, which also affected the L-ascorbic acid accumulation in sweet pepper [Buczowska and Najda 2002]. Total sugars contents (determined by means of Luff-Schoorl method) were lower as compared to those found by other author who used the same method [Buczowska and Najda 2002, Orłowski et al. 2004, Gajc-Wolska et al. 2007, Michalik 2010]. The extract content in sweet pepper fruits amounted to 6.6 %, on average, which are comparable results to those published by other researchers [Kmieciak and Lisiewska 1994, Gajc-Wolska and Skąpski 2002, Buczowska and Sawicki 2008] or much higher than those reported by Shukla et al. [2011] in 'California Wonder' cv. fruits.

Based on the results presented in this study, it can be concluded that the amount of extract in sweet pepper fruits is a varietal feature, which can be modified only within certain limits by environmental or agronomic factors. A cultivar, in fruit of which the extract content was the smallest, was 'Caryca F<sub>1</sub>', which has been previously shown [Buczowska and Sawicki 2008]. This cultivar should be regarded as distinctive referring to yielding as well as fruit utility value, however, selected parameters of biological value indicate that fruits of other cultivars evaluated in present study were characterized by a greater biological value.

## CONCLUSIONS

The sweet pepper cultivars assessed in this work were distinguished by relatively high stability of yielding in the field under a temperate climate. The highest marketable yield of fruits was achieved from 'Caryca F<sub>1</sub>' cv., than 'Roberta F<sub>1</sub>' and Jova. The yield of remaining cultivars was not significantly different from 'Caryca F<sub>1</sub>' cv. They showed, however, a very large variation in estimated parameters of the utility and biological values of fruits. 'Caryca F<sub>1</sub>' and 'Mino' cv. appeared to be the most attractive in reference to the fruit weight. Their fruits were characterized by the highest weight of edible parts and a large share of the pericarp weight in total weight of fruit. Fruits of 'Caryca F<sub>1</sub>' cv. were also outstanding in terms of pericarp thickness. This feature of fruits greatly determines the selection of a given cultivar for large-scale growing and market attractiveness of fruits. Czech 'Jova' cv., fruits of which have very thick pericarp, can be recommended for the amateur cultivation. 'Roberta F<sub>1</sub>', 'Robertina', and 'Corrida F<sub>1</sub>' cv. achieved the greatest biological value; their dry matter, L-ascorbic acid, and extract contents were the highest. 'Caryca F<sub>1</sub>' cv. plants accumulated relatively small amounts of dry matter and extract, and in particular L-ascorbic acid as compared to other cultivars.

## ACKNOWLEDGMENTS

Research supported by the Ministry of Science and Higher Education of Poland as the part of statutory activities of Department of Vegetable Crops and Medicinal Plants, University of Life Science in Lublin. We thank Mrs Grażyna Turczyn for her help with the agricultural experiment and Mgr Klaudia Świca for her help with the chemical analysis.

## REFERENCES

- Ayuso M.C., Bernalte M.J., Lozano M., Garcia M.I., Montero de Espinosa V., Perez M.M., Hernandez M.T., Somogyi N., 2008. Quality characteristics of different red pepper cultivars (*Capsicum annuum* L.) for hot paprika production. *Eur. Food Res. Technol.*, 227, 557–563.
- Buczkowska H., 2007. Evaluation of yielding of Polish sweet pepper cultivars in the field cultivation in the aspect of breeding progress. In: *Progress in research on Capsicum & Eggplant*, Niemiriwicz-Szczytt K. (ed.). Warsaw Univ. of Life Sci. Press, 257–265.
- Buczkowska H., Bednarek H., 2005. Ocena plonowania dwóch odmian papryki słodkiej w polu w odniesieniu do warunków termicznych. *Acta Agroph.*, 5(3), 567–575
- 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.
- Buczkowska H., Sawicki K., 2008. Zawartość wybranych składników w owocach papryki słodkiej w zależności od odmiany i terminu sadzenia rozsady. *Zesz. Post. Nauk Rol.*, 527, 73–79.
- Dasgan H.Y., Abak K., 2003. Effects of plant density and number of shoots on yield and fruit characteristics of peppers grown in glasshouses. *Turk. J. Agric. For.*, 27, 29–35.
- Frary A., Keçeli M.A., Ökemen B., Sığva H.Ö., Yemenicioğlu A., Doğanlar S., 2008. Water-soluble antioxidant potential of Turkish pepper cultivars. *HortSci.*, 43(3), 631–636.
- 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 Goteo and BM 86 on field and fruit quality of sweet pepper (*Capsicum annuum* L.) cultivars in the field production. In: *Progress in research on Capsicum & Eggplant*, Niemiriwicz-Szczytt K. (ed.). Warsaw Univ. of Life Sci. Press, 267–274.
- Golcz A., Kozik E., 2004. Effect of several agrotechnical factors on vitamin C content in pepper (*Capsicum annuum* L. and lettuce (*Lactuca sativa* L.)). *Rocz. AR Poznań*, 356, Ogrodnictwo, 37, 67–74.
- Jadcak D., Grzeszczuk M., Kosecka D., 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.
- Kmieciak 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.
- Korzeniewska A., Niemiriwicz-Szczytt K., 2007. Improvement of pericarp thickness: an important goal for field-grown sweet pepper (*Capsicum annuum* L.) in Poland. In: *Progress in research on Capsicum & Eggplant*, Niemiriwicz-Szczytt K. (ed.). Warsaw Univ. of Life Sci. Press, 291–296.

- Lee S.K., Kader A.A., 2000. Preharvest and postharvest factors influencing vitamin C content of horticultural crops. *Postharvest Biol. Technol.*, 20, 207–220.
- 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.
- Milenković L., Ilić Z.S., Durovka M., Kapoulas N., Mirecki N., Fallik E., 2012. Yield and pepper quality as affected by light intensity using colour shade nets. *Agricult. Forest.*, 58,1, 19–33.
- Navarro J.M., Flores P., Garrido C., Martinez V., 2006. Changes in the contents of antioxidant compounds in pepper fruits at different ripening stages, as affected by salinity. *Food Chem.*, 96(1), 66–73.
- Nowaczyk P., Nowaczyk L., 2007. Technological performance of *Capsicum frutescens* L. × *Capsicum annuum* L. soft-flesh hybrid fruit. In: *Progress in research on Capsicum & Eggplant*, Niemiriwicz-Szczytt K. (ed.). Warsaw Univ. of Life Sci. Press, 305–310.
- Nowaczyk L., Nowaczyk P., 2008. Ocena technologiczna linii soft-flesh *Capsicum* spp. *Zesz. Probl. Post. Nauk Rol.*, 527, 227–232.
- Nowaczyk P., Nowaczyk L., Olszewska D., 2005. Technological characteristic of the lines selected out from interspecific hybrids *Capsicum annuum* L. × *Capsicum chinense* Jacq. *Veg. Crops Res. Bull.*, 62, 91–96.
- Nowaczyk L., Nowaczyk P., Olszewska D. 2008. Cechy technologiczne owoców jako kryterium oceny linii wyselekcjonowanych z mieszańców międzygatunkowych *Capsicum annuum* L. × *C. chinense* JACQ. *Zesz. Probl. Post. Nauk Rol.*, 527, 233–238.
- Orłowski M., Grzeszczuk M., Jadczyk 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.
- Perucka I., Materska M., 2003. Antioxidant activity and content of capsaicinoids isolated from paprika fruits. *Pol. J. Food Nature. Sci.*, 12/53, 2, 15–18.
- Pokluda R., 2004. Content of selected nutritional elements in fruits of several pepper cultivars. *Annales UMCS, sec. EEE, Horticultura*, 14, 37–43.
- Rożek E., Nurzyńska-Wierdak R., Kosior M., 2012. The yield structure and technological traits of fruits of several sweet pepper cultivars from a single harvest. *Acta Sci. Pol., Hortorum Cultus*, 11(5), 31–41.
- Shukla Y., Chhopal T., Sharma R., 2011. Effect of age of transplants on growth and yield of capsicum. *Inter. J. Farm Sci.*, 1(2), 56–62.
- Szafirowska A., Elkner K., 2008. Yielding and quality of three sweet pepper cultivars from organic and conventional cultivation. *Veg. Crops Res. Bull.*, 69, 135–143.
- Szafirowska A., Elkner K., 2009. The comparison of yielding and nutritive value of organic and conventional pepper fruits. *Veg. Crops Res. Bull.*, 71, 111–121.
- Topuz A., Ozdemir F., 2007. Assessment of carotenoids, capsaicinoids and ascorbic acid of some selected cultivars (*Capsicum annuum* L.). *J. Food Comp. Anal.*, 20(7), 596–602.

## RÓŻNORODNOŚĆ WARTOŚCI UŻYTKOWEJ I BIOLOGICZNEJ OWOCÓW KILKU ODMIAN PAPRYKI SŁODKIEJ

**Streszczenie.** Atrakcyjność konsumpcyjną oraz przydatność surowcową odmian papryki słodkiej warunkują cechy jakościowe owoców. Za najważniejsze uważa się dużą masę owoców, grubą owocnię, intensywną barwę w dojrzałości fizjologicznej a także udział masy perykarpu w całej masie owocu. Aktualnie w Polsce dostępne są odmiany papryki

słodkiej o takich owocach. Odmiany te odznaczają się także dostosowaniem do uprawy w mniej korzystnych warunkach środowiska i dużą stabilnością plonowania. W niniejszej pracy dokonano oceny plonowania w polu i porównania wartości użytkowej i biologicznej owoców siedmiu odmian papryki słodkiej w aspekcie przydatności do bezpośredniego spożycia oraz dla przetwórstwa. Największy średni plon handlowy owoców otrzymano z odmiany Caryca F<sub>1</sub>, który był większy w porównaniu z plonem odmian Roberta F<sub>1</sub> i Jova. Plon pozostałych odmian nie różnił istotnie od plonu odmiany Caryca F<sub>1</sub>. Oceniane odmiany wykazywały duże zróżnicowanie pod względem wartości użytkowej i biologicznej owoców. Owocami o największej masie wyróżniła się odmiana Mino, zaś najgrubszym perykarpem odmiana Jova, również odmiana Caryca F<sub>1</sub> charakteryzowała się owocami o dużej masie, grubym perykarpie i dużej masie części jadalnej. Najwięcej kwasu L-askorbinowego zawierały owoce odmian Roberta F<sub>1</sub>, Robertina i Corrida F<sub>1</sub>, a ekstraktu – Roberta F<sub>1</sub>.

**Słowa kluczowe:** *Capsicum annuum* L., jakość owoców, plon handlowy, kwas L-askorbinowy, ekstrakt

Accepted for print: 21.03.2014