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**EFFECT OF STORAGE TIME
ON CONTENTS OF POLYPHENOLIC COMPOUNDS
IN SELECTED CULTIVARS OF PLUM (*Prunus domestica* L.)**

**WPLYW CZASU PRZECHOWYWANIA
NA ZAWARTOŚĆ ZWIĄZKÓW POLIFENOLOWYCH
W WYBRANYCH ODMIANACH ŚLIWEK (*Prunus domestica* L.)**

Abstract: The aim of the conducted investigations was to determine the effect of storage in selected cultivars of plum *Prunus domestica* L. on changes in contents of polyphenolic compounds, fruit mass as well as dry mass and solids contents. Plums harvested at the stage of harvesting maturity were stored for the period of 2 and 4 weeks in an ordinary refrigerator. During storage the total content of polyphenolic compounds, depending on the cultivar, increased by 16–88 % in comparison with the initial content in fruits after harvest. Fruits of ‘Wegierka Dabrowicka’ cv. exhibited a relatively low content of polyphenolics in comparison with the other analyzed cultivars, ie ‘Wegierka Zwykla’, ‘Valor’ and ‘Cacanska Lepotica’. After storage an increase of dry mass and solids contents in fruits was observed, while fruit mass decreased.

Keywords: plum, polyphenolics, storage

Plums are fruits with high nutritional and dietary value, both when fresh and dried as prunes. They are a raw material rich in polyphenolic compounds, minerals (potassium, phosphorus, calcium and magnesium) and pectin substances and they are characterized by high antioxidant activity. According to literature data, in terms of their antioxidant properties, plums exceed such fruits as oranges, grapes or apples [1–3]. Diet rich in bioactive compounds found in plums *P. domestica* results, among other things, in reduced blood pressure, an improved blood lipid profile, a reduced risk of cancer and improved functioning of the alimentary tract [4–6].

The content of polyphenolics in plant raw materials, even within one species, varies considerably, since it depends on many factors, particularly the cultivar, maturation stage, environmental and agritechnical conditions during growth as well as conditions

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and time of storage after harvest [7]. Among polyphenolic compounds found in plums derivatives of caffeic acid (neochlorogenic, chlorogenic, cryptochlorogenic acids) predominate, while flavanols (catechin, epicatechin, proanthocyanins), flavonols (quercetin) and anthocyanins (derivatives of anthocyanidins: cyanidin and peonidin, for example cyaniding-3-glucoside) are found in smaller amounts [8, 9]. Contents of phenolic acids fall within a wide range of values, with neochlorogenic acid at 85–1300 mg · kg⁻¹ d.m., chlorogenic acid at 13–430 mg · kg⁻¹ d.m. and cryptochlorogenic acid at 9–56 mg · kg⁻¹ d.m. [8, 10–12].

Cultivars of biggest importance in plum processing in Poland include ‘Stanley’, ‘Wegierka Zwyczajna’ and ‘Wegierka Dabrowicka’. In recent years several new cultivars have been introduced, with advantageous sensory attributes and pomiculture characteristics, such as ‘Bluefre’ and ‘Valor’ [13]. Cultivars are to have attractive fruits, they should be resistant to diseases and productive, while another important trait is potential long cold storage of fruits, since for such fruits higher prices are obtained than during harvest. The longer the supply period for a given plum cultivar on the market, the more competitive in terms of prices they are in relation to cultivars with a short shelf-life. Consumer acceptance of plums is closely related with the date of harvest and maturation stage of fruits [14, 15].

The aim of the study was to determine the effect of storage time on changes in contents of polyphenolics in plums. During storage of plums changes in fruit mass and contents of dry mass and solids were also determined.

Materials and methods

Analyses were conducted on plums (*Prunus domestica*) of ‘Wegierka Dabrowicka’, ‘Wegierka Zwyczajna’, ‘Cacanska Lepotica’ and ‘Valor’ cultivars from season 2008. Plums were obtained from orchards of the Agricultural and Pomological Station in Przybroda, belonging to the Department of Pomology, the Poznan University of Life Sciences. Fruits came from trees in full fruiting, growing on Wagenheim rootstocks, on grey-brown podsolic soils. Fruits after harvest were sorted depending on their maturation stage. The primary criterion in the evaluation was fruit hardness. In the experiments plums were used at the stage of harvesting maturity. After fruits were sorted they were placed in cold storage at 0 °C and stored for 4 weeks. Fruits were analyzed in order to determine fruit mass, contents of dry matter, solids and polyphenolics, after harvest as well as after 2 and 4 weeks of storage.

Fruit mass was determined for fruits in two batches of 20 plums. Contents of dry matter were determined by gravimetry, while solids were determined by refractometry in three samples with five replications. The total content of polyphenolics was determined by spectrophotometry according to Folin-Ciocalteu at a wavelength of $\lambda = 750$ nm [16]. Polyphenolics were extracted using 80 % methanol solution for 24 h. Contents of polyphenolics were presented in terms of chlorogenic acid equivalents.

Statistical analysis of results was conducted using the analysis of variance (at the significance level $p \leq 0.01$), with the application of Statistica ver. 7.1 software.

Results and discussion

In analyzed plum cultivars the total content of polyphenolics was determined after harvest of fruits and during their storage. Results of measurements are presented in the chlorogenic acid equivalents, since it is one of the dominant phenolic acids found in plums (Fig. 1).

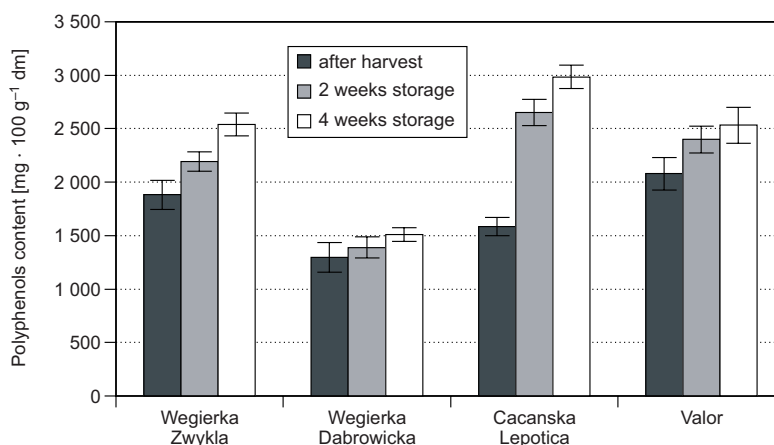


Fig. 1. Changes in polyphenolics contents during storage of plums depending on the cultivar; contents of polyphenolics are expressed in chlorogenic acid equivalents

The highest content of phenolics in fruits after harvest was recorded in plums of 'Valor' cv., 2080 mg · 100 g⁻¹ d.m., while it was slightly lower in fruits of 'Wegierka Zwykla' cv. – 1882 mg · 100 g⁻¹ d.m. (Fig. 1). The lowest amounts of polyphenolics in fruits immediately after harvest were determined in plums of 'Wegierka Dabrowicka' cv. at 1300 mg · 100 g⁻¹ d.m., while in fruits of 'Cacanska Lepotica' cv. it was 1583 mg · 100 g⁻¹ d.m. In all cases an increase was recorded in contents of polyphenolics during storage of plums, both after 2 and 4 weeks of storage. The highest, 88 % increase in the content of phenolic compounds was found during storage of fruits of 'Cacanska Lepotica' cv., while it was lowest in fruits of 'Wegierka Dabrowicka' cv., amounting to only 16 %.

Fruits tested in this study were harvested in the first stage of maturation, i.e. harvesting maturation, and next placed in a cold storage. After storage they exhibited a higher maturation stage and higher contents of phenolic compounds, which shows that the process of ripening is accompanied by the synthesis of these compounds. In literature sources one may find examples of both an increase and a decrease in the polyphenolic contents during ripening of fruits. In case of sweet cherries the content of phenolic compounds was found to increase in the final stage of their ripening [17]. During ripening and storage of plums of different cultivars, peaches and nectarines both an increase and a decrease were observed in the levels of polyphenolics and either no definite direction of changes in the contents of these compounds was found or these

changes were statistically non-significant [12, 18]. When investigating changes in the content of selected phenolic compounds during 30-day harvest period of plums, Usenik et al [18] found a significant increase in the content of anthocyanins in the four investigated cultivars. When analyzing the results of this study it was found that during 4-week storage of plums gathered at harvesting maturation the total polyphenolics content increased significantly. Based on the multivariate analysis of variance it was stated that changes in the content of polyphenolics were significantly affected by the plum cultivar and storage time ($p \leq 0.01$).

The authors of this study conducted analogous investigations also in the previous vegetation season of 2007 for selected plum cultivars. Based on the analyses of results it was found that after 4-week storage of plums in case of 'Valor' cv. polyphenol content increased by 17 % (from 1594 to 1866 mg · 100 g⁻¹ d.m.), while for 'Wegierka Zwykla' cv. this increase amounted to 42 % (from 728 to 1036 mg · 100 g⁻¹ d.m.) [unpublished data; studies conducted at the Laboratory of Fruit and Vegetable Technology, the Poznan University of Life Sciences]. In the vegetation season of 2008 polyphenol content increased by 21 % in 'Valor' cv. and 35 % in 'Wegierka Zwykla' cv.

An increase in the contents of phenolic compounds during cold storage may be caused by physiological stress in plant material, such as eg mechanical damage, tissue decomposition or microbial infection [19]. On the other hand, during storage of fruit harvested at picking maturity, their further ripening occurs, including changes of many chemical compounds, such as saccharides, acids and polyphenols. Low storage temperature reduces the intensity of these changes, but they still occur, which leads to ripening and next overripeness of crops. Thus, frequently in the initial period of storage one may observe an increase in the contents of selected components, connected with the ripening process. Examples are also presented in literature showing increased polyphenol contents in stored processed fruit products, which may be explained by the decomposition of complex phenolic compounds (eg ellagitannin) and release of simpler phenols [20, 21].

During storage of tested plums fruit mass was found to decrease (Table 1). The highest weight loss was observed in fruits of 'Wegierka Zwykla' cv., while it was lowest in fruits of 'Valor' cv., by 15 % and 1 %, respectively. Mass loss during storage of fruits is related with the process of transpiration. It was observed that in small fruits mass loss was bigger (15 %) than in medium-sized fruits (8–11 %) and large ones (1 %). This may be explained by the ratio of fruit surface area to its volume, which is higher in case of small fruits, thus they are at risk of higher water losses. A similar level of mass losses during storage of plums was observed by Guerra and Casquero [22] and Serrano et al [23].

Fruit mass losses during storage were accompanied by an increase in the contents of dry mass and solids (Table 1). Statistical analysis showed a significant effect of the cultivar and storage time of plums on changes in fruit mass as well as contents of dry mass and solids ($p \leq 0.01$). Depending on the cultivar, contents of dry mass and solids increased from 3 to 18 %. This is probably connected with loss of water as well as an increase in the content of simple sugars as a consequence of ripening of stored fruits. This is confirmed by studies conducted by Ustnik et al [18], Guerra and Casquero [22]

Table 1

Changes in fruit weight, contents of dry mass and solids in plums during storage

Cultivar	Time of storage [weeks]	Fruit mass* [g]	Dry mass content** [%]	Solids content** [%]
Wegierka Zwykła	0	20.9 ± 3.12	19.8 ± 0.52	18.6 ± 0.69
	2	20.6 ± 3.07	19.9 ± 0.47	18.2 ± 0.79
	4	17.9 ± 2.68	21.7 ± 0.42	19.7 ± 0.52
Wegierka Dabrowicka	0	43.0 ± 5.04	12.9 ± 0.37	12.3 ± 0.71
	2	40.2 ± 4.05	12.4 ± 0.10	12.2 ± 0.90
	4	38.3 ± 4.48	13.3 ± 0.26	12.7 ± 0.78
Cacanska Lepotica	0	44.7 ± 5.23	14.3 ± 0.30	12.7 ± 0.15
	2	43.5 ± 5.11	14.9 ± 0.68	14.4 ± 0.49
	4	41.3 ± 4.84	15.0 ± 0.21	14.5 ± 0.37
Valor	0	77.3 ± 9.47	17.4 ± 1.02	16.7 ± 0.87
	2	74.3 ± 10.73	19.8 ± 0.18	18.6 ± 0.90
	4	76.9 ± 8.27	20.7 ± 0.79	19.3 ± 1.21

* ± standard deviation from 20 replications; ** ± standard deviation from 3 samples with 5 replications each.

and Serrano et al [23]. In contrast, in a study by Lysiak [24] no increase in the solids content was observed during fruit storage in plums of 'Valor' cv. or a decrease was recorded in the contents of solids compounds in the other analyzed cultivars.

Conclusions

1. During storage of selected plum cultivars *Prunus domestica*, harvested at the stage of harvesting maturation, their total content of polyphenolic compounds increased.
2. As a result of storage of analyzed plums fruit mass decreased.
3. Contents of dry mass and solids in plums increased during fruit storage.

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WPLYW CZASU PRZECHOWYWANIA NA ZAWARTOŚĆ ZWIĄZKÓW POLIFENOLOWYCH W WYBRANYCH ODMIANACH ŚLIWEK (*Prunus domestica*)

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Abstrakt: Celem przeprowadzonych badań było określenie wpływu przechowywania owoców wybranych odmian śliw *Prunus domestica* L. na zmiany zawartości związków polifenolowych, masy owoców oraz zawartości suchej masy i ekstraktu. Śliwki zebrane w stadium dojrzałości zbiorczej, przechowywano przez okres 2 i 4 tygodni w chłodni zwykłej.

W czasie przechowywania ogólna zawartość związków polifenolowych, w zależności od odmiany, zwiększyła się o 16–88 % w porównaniu do początkowej zawartości w owocach po zbiorze. Owoce odmiany ‘Węgierka Dąbrowicka’ cechowały się stosunkowo małą zawartością związków polifenolowych w porównaniu do pozostałych badanych odmian, tj. ‘Węgierka Zwykła’, ‘Valor’ i ‘Čaćanska Lepotica’. Po okresie przechowywania stwierdzono wzrost zawartości suchej masy i ekstraktu w owocach oraz ubytek masy całkowitej.

Słowa kluczowe: śliwka, polifenole, przechowywanie