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BIOCHEMICAL COMPOSITION OF PERSIMMON FRUIT (*DIOSPYROS KAKI* L.) BRED IN UKRAINE

Short communication

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ABSTRACT

The study of the fruit quality of five Ukrainian persimmon cultivars 'Pamiat Cherniaeva' ("Memory of Cherniaev"), 'Chuchupaka', 'Sosnivska', 'Bozhyi Dar' ("God's gift"), and 'Dar Sofiivky' ("Gift of Sofiivka") showed that their fresh mass varies from 48.4 g ('Chuchupaka') to 113.2 g ('Pamiat Cherniaeva'). 'Pamiat Cherniaeva' and 'Dar Sofiivky' produced the largest fruits. 'Dar Sofiivky', 'Sosnivska', and 'Chuchupaka' fruits had the highest dry matter content. The highest sweetness level expressed in the sugar-acid index was in the 'Dar Sofiivky' fruits, the lowest in 'Pamiat Cherniaeva'. This cultivar also had the lowest amount of total pectins and polyphenols. All evaluated parameters varied considerably between cultivars.

Key words: ascorbic acid, dry mater, polyphenols, sugars

INTRODUCTION

The fruit of persimmon (*Diospyros kaki* L.), known also as the fruit of Sharon, kaki, and Japanese persimmon, is a fleshy and fibrous tropical fruit. Persimmon belongs to the Ebenaceae family (Díaz et al. 2020), with more than 500 species. The quality and taste of the fruit depend on the growing conditions (Bejanidze et al. 2019). The People's Republic of China ranks first in the world in the area of cultivation of this crop and produced more than 3.2 million tons (approximately 76.04% of global production) in 2020 (FAO 2021). There are no industrial plantations of persimmon in Ukraine due to adverse climatic conditions, but homeowners received good yields from homestead plots. In 2022, the State Register of Plant Varieties Suitable for Distribution in Ukraine entered six persimmon cultivars bred by Ukrainian breeders N.V. Derevianko and V.M. Derevianko. They are winter- and frost-resistant (can withstand a decrease in temperature to −32 °C), of high productivity, and good fruit quality (Derevianko et al. 2018, 2020). The high yield and high fruit quality are essential for accepting cultivars for growing (Lv et al. 2020). The mass and the size of the fruit, the index of its shape, and the hardness of the flesh are the main components of external quality, which are consequences of the content of nutrients and biologically active substances (Del Bubba et al. 2009; Veberic et al. 2010), including vitamin C, soluble sugar, anthocyanins, flavonoids, polyphenols, etc. (Lv et al. 2020). In addition, persimmon fruits contain a significant amount of pectins, which have gelling and thickening properties (Wu et al. 2021). This paper presents the characteristics of five newly bred Ukrainian persimmon cultivars in terms of fruit quality to identify those most useful for wider cultivation.

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MATERIALS AND METHODS

This study was conducted in the laboratory of postharvest quality of fruit and berry products of the Institute of Horticulture of the National Academy of Agrarian Sciences (NAAS) of Ukraine in 2020. The fruits of 'Bozhyi Dar', 'Chuchupaka', 'Dar Sofiivky', 'Pamiat Cherniaeva', and 'Sosnivska' were selected from the research plantation of the Research Farm "Novokakhovskoye" of the Rice Institute of the NAAS of Ukraine, Kherson region, at the altitude above sea level of 8 m, 46°08′34″ N and 32°57′15″ E. The climate of this territory of the southern part of the Steppe of Ukraine is moderately arid. The weather is characterized by insufficient precipitation, at a level of 355 mm per year, and the average annual sum of air temperatures is +9.6°C (in July +23.7°C, in January −3.4°C).

The care of persimmon plantation was conducted according to the recommendation for the Steppe zone of Ukraine. All cultivars were grafted on the seedlings of *Diospyros virginiana* L. and planted in the research field in a spacing of 6 × 6 m. The fruits were harvested in a state of commercial stiffness when their firmness was 5.8 ± 1.2 kg·cm^{-2}. Samples for the study were taken according to the recommendations of the Methodology for assessing the quality of fruit and berry products (Kondratenko et al. 2008). The sample weight met the requirements of State Standard ISO 874. All measures were performed in triplicate.

Physical parameters

The average mass of 20 fruits randomly selected was determined by weighing with an accuracy of the first sign; the largest transverse diameter (width) and height of the fruit by a caliper; the hardness of the flesh by a portable penetrometer "Wagner FRUIT TEST" with a nozzle FT 30 FT716 with a diameter of 11 mm.

Biochemical parameters

Segments of the same size were cut out from the four sides of the fruit and homogenized. To determine dry matter (moisture), the samples of 5 g were kept at a temperature of 98–100°C to a constant weight. The soluble solids content was determined by the refractometric method.

Sugars

Extraction of sugars was carried out with hot distilled water. The extract was purified from proteins and pigments by precipitation with acetic lead. Sucrose was subjected to hydrolysis when heated with 10% hydrochloric acid. The hydrolysis products were oxidized with Fehling's solution. The optical density of the resulting solutions was determined on a KFK-3-0.1 spectrophotometer at a wavelength of 640 nm. The content of total sugars in the sample was calculated with the aid of the standard constructed on the glucose concentration (mg per ml).

Organic acids

The homogenized samples were diluted with hot distilled water and heated for 30 min at 80°C, cooled, amended with 0.1 N sodium hydroxide and titrated with 0.1 N sodium hydroxide until a pink coloration corresponding to pH 7.0.

Sugar-acid index and taste evaluation

The sugar-acid index (SAI) was defined as the ratio of the total amount of sugars to the amount of titrated acids. The taste of fruits was determined by ten specialists, using a 5-point scale, where 5 is the sweetest fruit.

Pectin substances

The sample was prepurified from sugars and pigments with ethyl alcohol. Soluble pectins were extracted with water, and protopectin was extracted with 1N sulfuric acid, and hydrolysis of the latter to galacturonic acid was accomplished with heating. 0.2% carbazole solution was added to the extract to form a colored complex. The optical density of the resulting solutions was recorded on a KFK-3-0.1 spectrophotometer at a wavelength of 535 nm. The sample's soluble pectin and protopectin content was calculated as compared with the curve prepared with a standard of galacturonic acid (μg per ml).

Ascorbic acid

The samples were mashed with broken glass and a mixture of 2% oxalic and 1% hydrochloric acids (80+20, vol+vol) and filtered. The resulting extract was titrated with 2,6-dichlorophenolindophenol (Tilman's paint). The content of ascorbic acid in the sample was calculated by the formula using Tilman's paint titer.

Polyphenolic substances

The samples were mashed with a small amount of ethyl alcohol and filtered under a vacuum through a "blue ribbon" paper filter. To this extract, Folin–Denis reagent was added, and the optical density was recorded on a spectrophotometer KFK-3-0.1 at a wavelength of 640 nm. The content of polyphenols in the samples was calculated on the base of the standard curve of chlorogenic acid (μg per ml).

Statistical analysis

Statistical analysis of the research data was performed using STATISTICA 13.1 (StatSoft, USA) software. The results were presented as mean values with their standard errors (x ± SE). The Shapiro–Wilk test was used to evaluate the assumptions of normality and homogeneity of variances. The significant differences between the means were determined by applying a one-way ANOVA analysis. The results were presented at a level of reliability of $p < 0.05$.

RESULTS AND DISCUSSION

The fresh mass of evaluated fruits varied from 48.4 g ('Chuchupaka') to 113.2 g ('Pamiat Cherniaeva'). The fruit of 'Dar Sofiivky' also had a high fresh mass – 102 g (Table). 'Pamiat Cherniaeva' produced the largest fruits in addition to the heaviest. Only 'Pamiat Cherniaeva' formed elongated-oval fruits with shape index of 1.11. The remaining cultivars produced flat-rounded shape fruits with ratios ranging from 0.79 to 0.91.Compared to Ukrainian-bred persimmons, persimmon fruits grown in Spain have diverse masses, ranging from 52.4 g to 186.7 g, as well as their size (Diaz et al. 2020). Similar results were reported from Turkey (Altuntas et al. 2011), which means that some fruits of Ukrainian cultivars are smaller and lighter.

'Pamiat Cherniaeva' cultivar produced the softest fruits, with the lowest dry matter, 19.2%. Similar values were obtained by Young and How (1986). According to Díaz et al. (2020), the water content in persimmon depends on the genotype and the course of the weather. 'Pamiat Cherniaeva' fruits had the least soluble dry solids, sugars, and acids. 'Chuchupaka' fruits had the highest content of dry solids, soluble dry substances, sugars, and acids. 'Dar Sofiivky' produced relatively heavy and large fruits with high dry solids, soluble dry substances, and sugars but with low content of acids.

With soluble solid contents ranging from 15.97% to 24.70% (Table), fruits of Ukrainian persimmon cultivars contain more soluble solids than cultivars from Turkey, with soluble solid contents from 16.2% to 21.2% (Baltacioğlu & Artik 2013), and cultivars in Spain, with soluble solids from 15.8% to 19.4% (Díaz et al. 2020). The sugar content of Ukrainian persimmon fruits ranged from 10.27% to 12.73% (Table). Yaqub et al. (2016) reported fruit sugariness of 12.5% in Pakistani persimmons, which is comparable to Ukrainian cultivars. In contrast, sugar contents in Georgian fruit ranged from 13.0% to 19.1% (Bejanidze et al. 2019), and the sugar content in Turkish fruit was recorded as 16.3% (Altuntas et al. 2011) and 14.6% (Candir et al. 2009). The titrated acids content in Ukrainian persimmon ranged from 0.12% to 0.32% (Table). Baltacioğlu and Artik (2013), recorded that the content of titrated acids in persimmon fruits produced in Turkey ranged from 0.28% to 0.46%, while in Georgia, the titrated acid contents ranged from 0.05% to 0.18% (Bejanidze et al. 2019).

The sweetness of the fruits depends on the sugar-acid index (SAI). The higher the index value, the sweeter the fruit. The highest SAI (97.8) was found in the fruits of 'Dar Sofiivky', and the lowest in 'Chuchupaka' (39.8) and 'Bozhyi Dar' (37.8) (Table). These chemical results corresponded with the results of the taste test. Persimmon fruits of 'Dar Sofiivky' were the sweetest; the overall tasting score was 5 points (data not shown) whereas, the fruits of 'Pamiat Cherniaeva' and 'Sosnivska' had a balanced, pleasant taste, the corresponding rating was 3.5 points for both cultivars. The fruits of 'Chuchupaka' and 'Bozhyi Dar' had an unbalanced, closer to sour taste.

Table. Physical and biochemical characters of persimmon fruits, n=3

Cultivar	Weight and size of persimmon fruit				Organic matter content in persimmon fruit									
											Pectin content, % per raw mass			
	Mass, g	Width, mm	Height, mm	Shape Index	Dry solids (DS), %	Soluble dry substances (SDS), % per raw mass	Total sugars, % per raw mass	Titrated acids, % per raw mass	Sugar Acid Index (SAI)	Ascorbic acid, mg 100 g^{-1}	Soluble	Insoluble	Total amount	Total polyphenols, mg 100 g^{-1}
'Bozhyi Dar'	53.4± 3.5^{a}	48± 4^{a}	40± 4	0.83	24.20± 0.63	23.37± 0.53	11.73± 0.85	0.31± 0.05^{b}	37.8	28.9± 5.9	0.266± 0.026^{a}	0.776± 0.101^{b}	1.042± 0.011	1251± 263^{b}
'Chuchupaka'	48.4± 6.2^{a}	44± 4	40± 6^{b}	0.91	28.93± 0.46^{b}	24.70± 0.47^{b}	12.73± 0.79	0.32± 0.05^{b}	39.8	36.1± 4.5	0.053± 0.022	0.897± 0.099^{b}	0.950± 0.152	889±33^{b}
'Dar Sofiivky'	102± 3.8^{a}	59± 5	51± 4	0.86	27.57± 0.58^{b}	23.70± 0.85	11.73± 0.91	0.12± 0.03^{a}	97.8	30.1± 3.9	0.114± 0.031	1.293± 0.032	1.407± 0.147	659±21
'Pamiat Chernyaeva'	113.2± 2.8^{b}	61± 8^{b}	68± 12	1.11	19.17± 0.28^{a}	15.97± 0.51^{a}	10.27± 0.79	0.22± 0.07	46.6	30.0± 5.9	0.237± 0.022	0.599± 0.124^{b}	0.836± 0.088^{a}	456±33^{a}
'Sosnivska'	54.0± 11.3^{a}	38± 5^{a}	30± 4	0.79	27.50± 0.57^{b}	21.40± 0.45^{a}	11.67± 0.74	0.17± 0.07	68.6	59.1± 4.3^{b}	0.253± 0.018	0.877± 0.087^{b}	1.130± 0.083^{a}	423±10^{a}
Average±SE	74.2± 7.0	50± 5	46± 5	0.9	25.47± 0.29	22.11± 0.65	11.63± 0.50	0.23± 0.04	50.6	36.9± 4.5	0.185± 0.028	0.889± 0.097	1.073± 0.072	736±58
CV.%	42	20	32		15	20	8	46		30	52	29	20	47

$^{a; b}$ are values of indicators that differ significantly from the average for the studied group at $P < 0.05$

The structural characterization of persimmon pectin indicates that it belongs to a low-methoxy acetylated genotype (Jiang et al. 2020). The total amount of pectin ranged from 0.836% ('Pamiat Cherniaeva') to 1.407% ('Dar Sofiivky'), including 1.293% of insoluble pectin. In the remaining cultivars, the amount of pectin in insoluble form was less than one percent. Given the significant range of pectin in persimmon fruits from 0.29 to 2.77% (Méndez et al. 2022), the cultivars of Ukrainian breeding can be considered highly pectin-containing.

The amount of ascorbic acid in Ukrainian cultivars varied from 28.9 mg·100 g^{-1} ('Bozhyi Dar') to 59.1 mg·100 g^{-1} ('Sosnivska'), which is significantly more than in Turkish and Spanish persimmon fruits but less than in the genotypes studied by Homnava et al. (1990) and Butt et al. (2015). In particular, Giordani et al. (2011) found high ascorbic acid content in persimmon fruits, 47 ± 39 mg·100 g^{-1}, and Homnava et al. (1990) from 35 mg·100 g^{-1} to 218 mg·100 g^{-1}. The concentration of ascorbic acid in persimmon grown in Turkey ranged from 14.9 mg·100 g^{-1} to 15.8 mg·100 g^{-1} (Baltacioğlu & Artik 2013). Persimmon fruits are a good source of polyphenols (Zillich et al. 2015), which attributes them to products with high antioxidant capacity (Yaqub et al. 2016). The results of our studies confirm the significant dependence of the level of total polyphenols on the cultivar, with a coefficient of variation of 47% (Table). The most polyphenolic substances were noted in the fruits of 'Bozhyi Dar' (1251 mg·100 g^{-1}) and the least in 'Sosnivska' (423 mg·100 g^{-1}).

CONCLUSION

As a result of this preliminary evaluation, it was found that the persimmons of 'Dar Sofiivky' and 'Pamiat Cherniaeva' grow fruits of a mass higher than 100 g. The fruits of the cultivar 'Chuchupaka' had the highest content of dry matter (28.9%), soluble dry substances (24.7%), sugars (12.7%), and titrated acids (0.3%) per raw mass. The fruits of 'Dar Sofiivky' are the sweetest (with an SAI of 97.8), and 'Pamiat Cherniaeva' and 'Sosnivska' were distinguished by a pleasant, balanced taste. The maximum ascorbic acid content was found in 'Sosnivska', more than 95 mg·100 g^{-1}, a polyphenols content in 'Bozhyi Dar' was 1251 mg·100 g^{-1}. This demonstrated that this five persimmon cultivars can be grown in the Steppe zone of Ukraine as they can accumulate fruit mass with a high-quality biochemical composition, similar to the persimmon cultivars grown in the world-leader countries in persimmon production. Among them there are cultivars more suitable for fresh consumption and others for processing.

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