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Influence of different pre-treatments on the content of bioactive compounds of dried plum fruits

Utjecaj različitih predtretmana na sadržaj biološki aktivnih spojeva u plodu sušenih šljiva

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ABSTRACT

Plum (*Prunus domestica* L.) is mostly represented on the European market as fresh or industrially processed as dried fruit. The plum drying process is usually carried out at higher temperatures between 85 and 90 °C, which can result with loss of bioactive compounds, sensory attributes, texture, taste and aroma. Therefore, the aim of this study was to examine the efficiency of applying different pre-treatments in combination with a lower drying temperature (42 °C) in order to obtain a high quality product and the highest retention of bioactive compounds (total phenols, total hydroxycinnamic acids and total flavonols). Three plum cultivars: cv 'Hauszwetschge Schuffer', cv 'President' and cv 'Topend plus' were treated with 11 different pre-treatments: abrasion in duration of 5, 10 and 15 minutes; submersion in KOH solution in concentration of 0,5, 1,0 and 1,5% at two temperatures of 22 °C and 60 °C in duration of 1 minute, and submersion of fruits in distilled water at two temperatures (22 and 60 °C) in duration of 1 minute. The highest retention of bioactive compounds (total phenols, total hydroxycinnamic acids and total flavonols) was obtained in the dried fruits of all plum cultivars treated by chemical and thermal pre-treatment while the lowest values were determined in fruits pre-treated with abrasion.

Keywords: drying, plum, pre-treatments, total phenols, total flavonols, total hydroxycinnamic acids

SAŽETAK

Šljiva (*Prunus domestica* L.) uglavnom je prisutna na tržištu EU kao svježa ili industrijski prerađena kao sušeni plod. Tehnologija sušenja šljive uglavnom se provodi se na visokim temperaturama između 85 i 90 °C koji mogu rezultirati gubitkom bioaktivnih spojeva, senzornih svojstava, teksture, okusa i arome. Stoga je cilj ovog rada bio istražiti učinkovitost primjenjenih različitih predtretmana u kombinaciji s nižom temperaturom sušenja (42 °C) radi dobivanja visoko-kvalitetnog proizvoda, koji će imati visok stupanj zadržavanja biološki aktivnih spojeva (ukupnih fenola, ukupnih hidroksicimetnih kiselina i ukupnih flavonola). Tri sorte šljive 'Hauszwetschge Schuffer', 'President' i 'Topend plus' tretirane su s 11 različitih predtretmana: abrazija u trajanju od 5, 10 i 15 minuta, potapanje u otopinu KOH u koncentracijama od 0,5, 1,0 i 1,5% na temperaturi od 22 °C i 60 °C u trajanju od 1 minute te sa destiliranom vodom na dvije temperature (22 i 60 °C), također u trajanju od 1 minute. Najviši sadržaj bioaktivnih spojeva (ukupni fenoli, ukupne hidroksicimetne kiseline i ukupni flavonoli) utvrđeni su u sušenih plodova svih sorti tretiranih s kemijskim i termičkim predtretmanima, dok su najniže vrijednosti spomenutih bioaktivnih spojeva utvrđeni u plodovima predtretiranih abrazijom.

Ključne riječi: sušenje, šljive, predtretmani, ukupni fenoli, ukupni flavonoli, ukupne hidroksicimetne kiseline

INTRODUCTION

Plum (*Prunus domestica* L.) is mostly present on European market as fresh fruit or industrially processed in plum brandy, jams or dried fruits. It is valued for its exceptional quality due to relative low energy and high nutritional value. Plum fruits contain carbohydrates, organic acids and dietary fibers, aromatic components and enzymes. They are significant source of minerals, vitamins and phenolic compounds to which strong antioxidant activities are attributed which have numerous positive influences on human health (Gil et al., 2002; Chun and Kim, 2004; Attaluri et al., 2011; Mihalache Arion et al., 2014).

Due to the relatively high water content, fresh plum fruits are prone to microbial spoilage and deterioration and therefore are processed into different types of products. Dry plums are one of the most important plum products being produced by various drying processes, mainly carried out at high temperatures between 85 and 90 °C, until a lower moisture content in final products is reached (20 to 26%). (Cvejanov et al., 2004).

Drying time is influenced by air-drying temperature, product type, raw material preparation, application of pre-treatments and type of dryer used, and in average lasts between 16 and 30 hours (Okos et al., 1992; Cvejanov et al., 2004; Grabowski et al., 2003; Živković, 2011). Fruit dehydration at high temperatures can result in decrease of the product quality through loss of bioactive compounds and nutritional values, as well as changes in texture, color and taste. Another disadvantage of using high temperatures is high energy consumption. Therefore, recent research of fruit drying involve temperatures lower than 50 °C, with higher final fruit moisture content of approximately 35%. This type of drying has a positive influence on mentioned characteristics of dried fruit and it implies relative low energy consumption, thus requiring longer drying time between 50 and 72 hours (Cinqvanta et al., 2002; Doymaz and Pala, 2002; Adiletta et al., 2014).

Plum drying process is slow and energy demanding due to specific waxy layer which covers fruit skin surface. Removal of this waxy layer enables free movement of water. Different pre-treatments are used in order to degrade it and to create microscopic fractures which enable water permeability. Pre-treated fruits are drying significantly faster in comparison to untreated ones (Cinqvanta et al., 2002; Doymaz and Pala, 2002; Gazor et al., 2014; Bursać et al., 2014). Most common pre-treatments used in plum drying technology are based on different thermal and chemical treatments. Thermal treatments incorporate: fruit blanching, steam treatment and dipping of fruits in boiling water with addition of sodium chloride. Chemical pre-treatments include plum fruit treatment with water solvents of chemical compounds, mostly alkaline (potassium and sodium hydroxide) in different concentration, fatty acid esters (methyl and ethyl oleate), and with solution of potassium carbonate (Cinqvanta et al., 2002; Doymaz and Pala, 2002; Bursać et al., 2014).

However, increasing market demand for ecologically acceptable products has influenced development of abrasive pre-treatments used in removal of fruit skin waxy layer in which different inert materials are used (Di Matteo et al., 2000; Di Matteo et al., 2002; Cinquanta et al., 2002; Adiletta et al., 2014; 2016). This type of pre-treatments on plum fruits has not been sufficiently investigated, and further research is needed related to influence of abrasive pre-treatments on drying time, sensory characteristics and nutritive value of dried fruits.

Polyphenols are widely distributed group of secondary plant metabolites known as bioactive compounds which have significant role in defense mechanisms of plants against infections and injuries. They participate in biochemical changes that occur during fruit maturation thus influencing color, aroma and taste (Robards, 1999). Distribution and phenol content in plums are dependent on maturation stage, cultivar, growing type, agro-technical measures and processing (Kim et al., 2003).

Research done on dried plum fruits indicated that they are rich in bioactive compounds which show high antioxidative activity due to polyphenol content (phenolic acids and flavonoids) (Chun and Kim, 2004). Donovan et al. (1998) have determined that in total phenol content of dried plums, phenolic acids are dominant containing up to 98% of total phenol compounds. Dried plums contain caffeic acid and its derivatives: neocholorgenic, cholorogenic and cryptocholorgenic acids.

Therefore, the aim of this study was to investigate efficiency of different pre-treatments application in combination with a lower drying temperature (42 °C) in order to obtain a high quality product and the highest retention of bioactive compounds (total phenols, total hydroxycinnamic acids and total flavonols).

MATERIALS AND METHODS

The research was conducted in experimental orchard of the Centre of Pomology and Vegetable Crops of the Croatian Agency for Agriculture and Food in Donja Zelina, near Zagreb. Experimental orchard is located on 180 m above mean sea level (AMSL), 45° 55′ north latitude, 16° 14′ east longitude. The soil in orchard is described as albic stagnosol. The area is characterized by average annual temperature of 10.7°C, and 855.1 mm of total rainfall (DHMZ, 2015).

Plum trees were planted in 2006, 4,0 × 2,2 m planting distance, grafted on WaxWa rootstock and trained as a spindle bush. Trial was set up as randomized block design in three replicates whereas each replicate comprises of ten trees from which fruits were harvested. Three cultivars were used in this research: cv 'Hauszwetschge Schuffer', cv 'President and cv 'Topend plus'. Trees were drip irrigated and covered by anti-hail net. Standard agro technological measures are implemented in line with integrated agriculture production system.

Fresh plum fruits were harvested in optimum harvest window for cultivars 'Hauszwetschge Schuffer', 'President' and 'Topend plus' during August 2015. Optimal harvest window was determined by monitoring of physical and chemical characteristics during maturation time, ie by measuring fruit firmness (gcm^2), soluble solids content (°Brix), total acids (g/L) and pH value. Fruits of all cultivars were harvested manually in plastic containers in early morning hours during dry weather. Fruits were transported to the Laboratory of the Centre of Pomology and Vegetable Crops of CAFA immediately after the harvest, which was followed by analysis of pomological, physical and chemical characteristics. Plum fruits were subjected to pre-treatments and drying two days after the harvest.

Plum fruits intended for drying were sorted according to size. All fruits with possible mechanical damages were removed from the process of pre-treatment and drying. Washed and mechanically pitted fruits were treated with mechanical, chemical and warmed water pre-treatments in order to remove waxy layer.

Mechanical pre-treatment included use of inert abrasive material type PW400 within the cylinder. Rotation speed was 120 rpm, with three different rotation timing: 5, 10 and 15 minutes. Chemical pre-treatment consisted of fruit submersion in KOH solution of three different concentrations: 0,5; 1 and 1,5% at two temperatures: 22 and 60 °C, with 60 seconds of submersion time. Chemically pre-treated fruits were washed with distilled water and drained in order to remove water excess. Third pre-treatment included submersion of fruits in distilled water at two different temperatures of 22 °C and 60 °C in 60 seconds duration. Table 1 shows experiment design of all used pre-treatments. Control sample contained unwashed and untreated fruits of cultivars in this research with waxy layer present. In table 2 fruit, skin damage after implemented pre-treatments is presented.

Pretreated fruits were dried in convection chamber drier (Buchner AG, Typ 20B, Switzerland) of 30 kg capacity. Drier air flow speed was 2,0 m/s, with constant air temperature of 42 °C. Drying experiment was conducted in three repetitions, whereas one shelf represented one repetition with approx. 2,2 kg of fruits of each cultivar. The fruits were dried until 35% moisture content.

Phenolics were extracted from homogenized dried plum fruits. Exactly 5 g of samples were weighed out and extracted using 20 mL of 80% (by volume) aqueous ethanol. The mixture was extracted for 20 min in ultrasonic bath at 50 °C, filtered through Whatman No. 40 filter paper (Whatman International Ltd, Kent, UK) using a Büchner funnel. The filtrates were adjusted to

25 mL in a volumetric flask with 80% aqueous ethanol. The obtained extract was used for determination of total phenols, total hydroxycinnamic acids and total flavonols.

For the determination of total phenols, the adjusted method (Ough and Amerine 1988; Singleton and Rossi, 1965) with Folin-Ciocalteu reagent was used.

Table 1. Experiment design of pre-treatments used on plum fruits of cultivars 'Hauszwetschge Schuffer', 'President' and 'Topend plus'

Pre-treatment	Treatment time (min)	Solvent	Concentration (%)	Temperature (°C)
Mechanical- abrasion	5	-	-	-
	10	-	-	-
	15	-	-	-
Chemical	1	KOH	0,5	22
	1	KOH	1,0	22
	1	KOH	1,5	22
	1	KOH	0,5	60
	1	KOH	1,0	60
	1	KOH	1,5	60
Distilled water	1	H_2O	-	22
	1	H_2O	-	60

Table 2. Fruit skin damage after pre-treatments of fresh plum fruits. Intensity scale from 1 to 9. 1 - no damage, 5 - moderate fruit skin damage (50%) and 9 – more than 90% of damage

Pre-treatment	cv 'Hauszwetschge Schuffer'	cv 'President'	cv 'Topend plus'
Untreated reference sample, control	1	1	1
Abrasion 5 min	2	2	2
Abrasion 10 min	2	2	2
Abrasion 15 min	3	3	2
dH_2O 22 °C	1	1	1
KOH 0,5% at 22 °C	1	1	1
KOH 1% at 22 °C	1	1	1
KOH 1,5% at 22 °C	1	1	2
dH_2O 60 °C	1	1	1
KOH 0,5% at 60 °C	3	4	5
KOH 1% at 60 °C	4	5	6
KOH 1,5% at. 60 °C	6	7	8

The content of total phenols was measured as follows: 0,25 mL of sample, 15 mL distilled water (dH_2O), 1,25 mL Folin-Ciocalteu reagent (diluted with distilled water in 1:2 ratio) were added to a 25-mL volumetric flask containing and shaken. To the mixture 3,75 mL of saturated Na_2CO_3 solution (m/V) were added with mixing and the solution was immediately filled up to 25 mL with ddH_2O. After incubation at 50 °C for 20 min, the absorbance of the solution was measured by the spectrophotometer Unicam Helios b (Spectronic Unicam, Cambridge, UK) at 765 nm. The results were calculated according to the calibration curve for gallic acid (y=0.0009x, y=absorbance at 765 nm, x=concentration of gallic acid in mg/L, R2=0.9986). The content of total phenols was expressed as mg of gallic acid equivalents (GAE) per 100 g of fresh mass (FW).

Total hydroxycinnamic acids and flavonols was determined in ethanol extract of sample by spectrophotometric method at which intensity of coloring was measured at 320 nm for hydroxycinnamic acids and at 360 nm for flavonols (Howard et al., 2003). The content of total hydroxycinnamic acids was expressed as mg of caffeic acid equivalents and flavonols as mg of quercetin equivalents per 100 g of fresh mass (FW).

Results were analyzed by „STATISTICA 64 ver. 10“, StatSoft, Inc (SAD) statistical programme. All analysis was performed in three repetitions and tables show mean values and standard deviation values (±SD), while different letters represent significant statistical differences between researched parameters at $p \leq 0,001$.

RESULTS

Mean values of fruit firmness, soluble solids content, total acids and pH value of harvested fresh fruits of plum cultivars in research were presented in table 3.

The results of total phenols, total hydroxycinnamic acids and total flavonols (mg/100 g FW) of dried plum fruits treated with different pre-treatments were presented in Tables 4-6.

Analysis of variance for cv ‘Hauszwetschge Schuffer’ revealed significantly higher statistical differences ($p \leq 0,001$) between all pre-treatments in research. Chemical pre-treatment (KOH of all concentration at 22 and 60 °C) had the highest total phenols content, hydroxycinnamic acids and flavonols. The highest value of total phenols (228,92 mg/100 g) was determined in fruits treated with KOH 1% at 22 °C, and total hydroxycinnamic acids (46,28 mg/100 g) and flavonols (54,52 mg/100 g) at KOH 1% at 60 °C treatment. In abrasive pre-treatment the lowest values of total phenols were determined (64,66 mg/100 g), especially at abrasive pre-treatment in duration of 10 minutes. The lowest value of total hydroxycinnamic acids (12,74 mg/100 g) was determined at abrasive 5 minutes’ treatment, whilst abrasive 15 minutes’ treatment had the lowest content of total flavonols (20,06 mg/100 g).

At cv 'President' statistical differences ($p \leq 0,001$) were determined between all pre-treatments in all analyzed bioactive compounds, and these differences were significant. The highest values of total phenols (118,49 mg/100 g), total hydroxycinnamic acids (41,81 mg/100 g) and total flavonols (53,09 mg/100 g) were determined in fruits treated with distilled water at 60 °C. The lowest values of total phenols (57,48 mg/100 g), total hydroxycinnamic acids (18,92 mg/100 g) and total flavonols (25,32 mg/100 g) were determined in samples treated with abrasion in duration of 10 minutes.

Analysis of variance of researched bioactive compounds at cv 'Topend plus' indicated to significantly high statistical differences ($p \leq 0,001$) between all parameters in research. The highest total phenol content (216,06 mg/100 g), total hydroxycinnamic acids content (65,30 mg/100 g) and total flavonols (68,48 mg/100 g) were determined at KOH 1,5% pre-treatment at 60 °C. The lowest value of total phenols (118,75 mg/100 g) was determined at fruits treated with distilled water at 60 °C, and total hydroxycinnamic acids (38,91 mg/100 g) and flavonols (43,92 mg/100 g) at KOH 0,5% pre-treatment at 60 °C.

Table 3. Endophytic isolates obtained from two soybean cultivars

Cultivar	Fruit firmness (g/cm^2) (±SD)	Soluble solids content (°Brix) (±SD)	Total acids (g/L) (±SD)	pH (±SD)
'Hauszwetschge Schuffer'	690 ± 0,22	16,60 ± 0,001	7,20 ± 0,15	3,47 ± 0,02
'President'	1190 ± 0,43	11,37 ± 0,06	11,92 ± 0,21	3,89 ± 0,03
'Topend plus'	1554 ± 0,30	11,10 ± 0,001	7,63 ± 0,08	3,92 ± 0,01

Table 4. Total phenols, hydroxycinnamic acids and flavonols in dried fruits of cv 'Hauszwetschge Schuffer'

Pre-treatment	Total phenols (mg/100 g)	Total hydroxycinnamic acids (mg/100 g)	Total flavonols (mg/100 g)
Control	105,24e ± 26,79	26,98e ± 2,72	33,83f ± 0,55
Abrasion 5 min	73,80h ± 9,16	12,74l ± 0,75	28,72i ± 1,08
Abrasion 10 min	64,66l ± 13,06	16,99j ± 0,56	24,32k ± 0,80
Abrasion 15 min	64,80k ± 7,73	16,15k ± 11,57	20,06l ± 11,37
KOH 0,5%, 22 °C	73,42i ± 3,78	17,05i ± 0,63	27,32j ± 0,54
KOH 1%, 22 °C	228,92a ± 8,66	41,56c ± 4,41	53,58b ± 2,81
KOH 1,5%, 22 °C	118,06d ± 0,16	27,74d ± 2,14	34,14d ± 0,42
KOH 0,5%, 60 °C	102,93g ± 27,81	20,44h ± 6,9	31,14h ± 8,04
KOH 1%, 60 °C	166,15c ± 10,93	46,28a ± 5,77	54,52a ± 10,54
KOH 1,5%, 60 °C	170,10b ± 25,47	41,82b ± 0,65	53,12c ± 0,31
dH_2O 22 °C	71,14j ± 17,60	26,63f ± 1,64	33,97e ± 0,11
dH_2O 60 °C	103,68f ± 14,88	21,07g ± 3,10	32,38g ± 5,34
Pr>F	***	***	***

* Values marked with different letter are significantly differ according to (Fisher LSD) test. ***- when P≤0.001

Table 5. Total phenols, hydroxycinnamic acids and flavonols in dried fruits of cv 'President'

Pre-treatment	Total phenols (mg/100 g)	Total hydroxycinnamic acids (mg/100 g)	Total flavonols (mg/100 g)
Control	70,65j ± 2,34	28,93h ± 3,93	34,83h ± 0,09
Abrasion 5 min	85,81g ± 0,97	33,36e ± 0,67	35,19g ± 0,70
Abrasion 10 min	57,48l ± 8,61	18,92l ± 0,36	25,32l ± 7,56
Abrasion 15 min	88,95f ± 5,90	32,31f ± 2,77	40,01e ± 3,95
KOH 0,5%, 22 °C	105,90b ± 11,74	34,20d ± 0,36	41,72d ± 1,41
KOH 1%, 22 °C	68,15k ± 15,01	26,76k ± 5,39	33,18k ± 3,13
KOH 1,5%, 22 °C	75,14i ± 2,90	27,08i ± 1,71	34,02i ± 0,02
KOH 0,5%, 60 °C	84,18h ± 10,48	26,91j ± 2,29	33,85j ± 0,14
KOH 1%, 60 °C	89,83e ± 1,73	36,05b ± 1,19	42,58b ± 0,45
KOH 1,5%, 60 °C	93,15d ± 11,60	31,80g ± 1,97	37,15f ± 1,86
dH_2O 22 °C	94,34c ± 0,37	35,25c ± 0,34	42,23c ± 0,11
dH_2O 60 °C	118,49a ± 5,75	41,81a ± 2,38	53,09a ± 0,80
Pr>F	***	***	***

*Values marked with different letter significantly differ according to (Fisher LSD) test. ***- when P≤0.001

Table 6. Total phenols, hydroxycinnamic acids and flavonols in dried fruits of cv 'Topend plus'

Pre-treatment	Total phenols (mg/100 g)	Total hydroxycinnamic acids (mg/100 g)	Total flavonols (mg/100 g)
Control	176,19e ± 1,00	52,76d ± 6,25	62,18d ± 4,92
Abrasion 5 min	176,43d ± 12,23	45,66i ± 11,56	53,28j ± 6,98
Abrasion 10 min	140,28i ± 13,92	47,39g ± 3,42	54,82g ± 5,11
Abrasion 15 min	162,87g ± 15,92	41,92k ± 7,90	53,24k ± 3,68
KOH 0,5%, 22 °C	125,29k ± 5,67	46,67h ± 2,80	54,23h ± 2,73
KOH 1%, 22 °C	148,98h ± 16,46	48,59e ± 3,04	55,23e ± 2,16
KOH 1,5%, 22 °C	186,10c ± 19,42	48,49f ± 7,81	55,18f ± 6,37
KOH 0,5%, 60 °C	133,45j ± 17,78	38,91l ± 4,14	43,92l ± 2,41
KOH 1%, 60 °C	167,59f ± 17,73	59,80b ± 9,22	62,02c ± 2,85
KOH 1,5%, 60 °C	216,06a ± 3,19	65,30a ± 4,41	68,48a ± 0,61
dH_2O 22 °C	210,29b ± 3,51	59,44c ± 1,50	64,32b ± 2,12
dH_2O 60 °C	118,75l ± 12,38	43,23j ± 8,50	54,21i ± 7,07
Pr>F	***	***	***

*Values marked with different letter significantly differ according to (Fisher LSD) test. ***- when P≤0.001

DISCUSSION

Results of analyzed bioactive compounds from this research show clear differences in total phenol, hydroxycinnamic acids and flavonols content between cultivars in research. Cv 'Topend plus' had the highest values of analyzed bioactive compounds, while cv 'Hauszwetschge Schuffer' had the lowest content of total phenols. Cv 'President' had the lowest content of total hydroxycinnamic acids and total flavonols (Tables 4 - 6).

Content of bioactive compounds in dried fruits can vary significantly and mostly depend on drying temperature and applied pre-treatments. At cv 'Hauszwetschge Schuffer' increase in total phenol content was noticed in comparison to control sample for up to 49% and at cv 'Topend plus' up to 79%. Increase in total phenol content in dried fruits is in line with results of Izli (2016), which cites increase in content of total phenols during drying of date fruits at different temperatures (60-80 °C). Values of total hydroxycinnamic acid content of dried plum fruits from this research are in line with results published by Miletić et. al. (2014) in which total hydroxycinnamic acids ranged from 32,21 to 60,61 mg/100 g. Also, significant decrease of total hydroxycinnamic acids and flavonols content in relation to cultivar and drying temperature was determined by Piga et al. (2003) during plum drying process.

Previous research also confirms significant influence of individual pre-treatments on content of bioactive compounds in dried fruits. According to results of this research at all plum cultivars the lowest values of all analyzed bioactive compounds were determined in abrasive pre-treatments, followed by thermal pre-treatments by distilled water at both temperatures (22 and 60 °C). The highest polyphenol content was determined in samples treated with KOH of all concentrations (0,5; 1 and 1,5%) at both temperatures (22 and 60 °C). According to obtained results, it is evident that solution temperature used for plum fruits pre-treatment had significant influence on retention of bioactive compounds. In fact, at cv 'Hauszwetschge Schuffer' significantly higher values of total phenols were determined in samples treated at 22 °C in comparison to 60 °C for treatments with distilled water, KOH 0,5% and 1,5%, except for KOH 1%. Similar trend can be noticed at cv 'President' for treatments with distilled water, KOH solution of 1% and 1,5% concentration, except for KOH of 0,5%. At cv 'Topend plus', KOH treatments of all concentrations had significantly higher total phenols content except in fruits treated with distilled water. Distilled water treatments also increased total phenol content depending on solution temperature, which at cv 'Hauszwetschge Schuffer' accounted to 46% and higher, at cv 'President' 26% higher than samples treated at 60 °C in comparison to 22 °C. Deviation from mentioned trend was identified in cv 'Topend plus' at which temperature increase of distilled water treatments resulted in decrease of total phenol content.

Besides temperature, another important influencing factor to bioactive compounds content is a solvent concentration. Significantly higher content of total phenols was determined in fruits treated with KOH of higher concentration (1,5%) at both temperatures, except for cv 'Presdent'. This is in line with data published by Bursać et al. (2014), where significant increase in total phenol content was determined in KOH of 1% concentration at 60 °C pre-treatment in comparison to distilled water pre-treatment at the same temperature. In addition, content of total phenols in plum fruits in this research was increasing with the KOH concentration. The highest values of total phenols were determined in fruits treated with KOH of 1 and 1,5% concentration at both temperatures (22 and 60 °C), except in cv 'President' at temperature of 22 °C. It can be concluded that alkali solution of KOH of all concentration, and especially of 1 and 1,5% concentrations had significantly positive influence on preservation of analyzed bioactive compounds. Plum fruits treated with abrasive treatments in duration of 5, 10 and 15 min had significantly lower values of all analyzed bioactive compounds in comparison to other implemented pre-treatments of all cultivars in research.

At cv 'Hauszwetschge Schuffer', two times lower values of total phenol, total hydroxycinnamic acid and total flavonols were determined in fruits treated with abrasive pre-treatments in comparison to KOH pre-treatment of all concentration at 60 °C. Identical trend of decrease of analyzed bioactive compounds of fruits treated by abrasion was determined at cvs 'President' and 'Topend plus', however in a bit less percentage. Other authors have determined negative influence of abrasive pre-treatment on preservation of bioactive compounds as well (Cinquanta et al., 2002; Somsong et al., 2010). The later can be explained with the fact that abrasive treatment not only removes waxy skin layer but also degrades the fruit skin. Precisely, it removes parts of fruit skin in which majority of plum polyphenol compounds are present (Pevalek-Kozlina, 2003).

CONCLUSIONS

Used pre-treatments facilitate better water migration from inner parts of plum fruits thus enabling efficient drying process even at lower temperatures.

The highest content of bioactive compounds (total phenols, total hydroxycinnamic acids and total flavonols) was determined in dried fruits of all three cultivars which were treated with chemical and thermal pre-treatments, while the lowest values were determined in fruits treated with abrasive pre-treatments.

Pre-treatments with KOH of 1 and 1,5% concentrations at both temperatures had positive influence on bioactive compounds content and were cultivar dependent. The best pre-treatment for cv 'Hauszwetschge Schuffer' was KOH 1% at 60 °C for total hydroxycinnamic acid and total flavonols content and KOH 1% at 60 °C for total phenols content. For cv 'President' the highest content of all bioactive compounds were obtained by distilled water pre-treatment at 60 °C and for cv 'Topend plus' by pre-treatment with KOH of 1,5% solution at 60 °C.

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