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Changes in the biochemical indices of plums as a result of drying at low positive temperature

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ABSTRACT
This study aimed to assess the impact of heat pump drying on biochemical properties of plums (*Prunus domestica L.* Var. Stanley, Gabrovska, Strinava, Mirabelle de nancy) and to determine the informative indication to select suitable varieties for drying. Drying process was carried out using heat pump dryer at initial temperature 45°C, air flow velocities of 4.6 $m.s^{-1}$ and initial air humidity of 8-10 $g.kg^{-1}$ up to equilibrium moisture content. The assessment was based on total sugars, sucrose, invert sugar, organic acids, ascorbic acid and anthocyanins in fresh and dried fruits. A trend towards reducing the values of the indicators, which leads to discernibility at α=0.05 for the four varieties was established. In terms of taste was used the total sugars and organic acids ratio, which have a statistical equality between the values of fresh and dried fruit at varieties *Stanley* and *Strinava*.

Key words: heat pump drying, sucrose, invert sugar, organic acids, ascorbic acid, anthocyanins

Introduction

Prunes are perspective crop in Bulgaria in the horticulture sector in terms of domestic demand and export potential. Fresh plums have a high nutritional value and biological effects on human health. Because of their sweet flavor and well-known mild laxative effect, prunes are considered to be an epitome of functional foods. Prunes are good source of energy in the form of simple sugars, but do not mediate a rapid rise in blood sugar concentration, possibly because of high fiber, fructose, and sorbitol content. Sweet, with a deep flavor and chewy texture, prunes are highly nutritive (Stacewicz-Sapuntzakis et al., 2001; Cho et al., 2004). Like other dried fruits, they are available throughout the year. Heat pump drying provides a controllable drying environment (temperature and humidity) for better products quality at low energy consumption (Patel & Kar, 2011). In this sense the study of the changes in the native biochemical composition of different varieties of plums at heat pump drying is needed.

This study aimed to assess the impact of heat pump drying on biochemical properties of plums (*Prunus domestica L*. Var. Stanley, Gabrovska, Strinava, Mirabelle de nancy) and to determine the informative indication to select suitable varieties for drying.

Materials and Methods

The study was carried with plums varieties Stanley, Gabrovo, Strinava and Mirabelle de nancy, derived from collection of perennial plants of IMAL, Troyan. After cleaning, pitting, cutting into eighths, again washing with running water and drained, fruits were dried using heat pump dryer at initial temperature 45°C, air flow velocities of 4.6 $m.s^{-1}$ and initial air humidity of 8-10 $g.kg^{-1}$. The process was taken place in a thin layer in transverse air flow compared to layer product up to constant sample mass.

The biochemical compositions of the fresh plum and prunes were followed up by total sugar, invert sugar, and sucrose ($g.kg^{-1}$) by the Schoorl-Regenbogen method; acids such as malic acid, ($g.kg^{-1}$) by titration with 0.1 N NaOH; ascorbic acid ($mg.dL^{-1}$) by the Fialkov method, anthocyanins ($mg.dL^{-1}$) - by the Fuleki and Franciss method (Fuleki & Francisss, 1968).

For statistical analysis of the results were used ANOVA single factor (Microsoft office Excel, 2003), Tukey's Post

Hoc test (HSD test) and Independent-Samples Student *t*-test (SPSS 16.0.1).

Results and Discussion

The results of the ANOVA test show discernibility of the studied indexes for the four plum varieties, wherein a significance level for all signs smaller than the critical p=0.05, and obtained F values over the critical. To analyze the differences in multiple comparisons in pairs, the names of varieties are coded as follows:

R1 – Stanley raw material
R2 – Gabrovska raw material
R3 – Strinava raw material
R4 – Mirabelle de nancy raw material
D1 – Stanley dried
D2 – Gabrovska dried
D3 – Strinava dried
D4 – Mirabelle de nancy dried

Tables 1 and 2 show the overall results of the HSD test, as a sign “+” indicated mean values equality of the biochemical signs of the relevant varieties and the sign “-“ means that there is a statistical difference between the mean values at 0.05 significance level. When comparing the indexes are equated to absolute dry matters.

Table 1. *Raw materials HSD test results*

Variety	Total sugar	Sucrose	Invert sugar	Acids (as malic)	Ascorbic acid	Anthocyanins
R1-R2	+	-	-	-	-	-
R1-R3	-	-	-	-	-	-
R1-R4	-	-	-	-	-	-
R2-R3	-	-	+	-	-	-
R2-R4	-	-	+	-	-	-
R3-R4	-	-	-	-	-	-

Table 2. *Prunes HSD test results.*

Variety	Total sugar	Sucrose	Invert sugar	Acids (as malic)	Ascorbic acid	Anthocyanins
D1-D2	-	-	-	+	-	-
D1-D3	+	-	-	+	-	+
D1-D4	-	+	-	-	-	-
D2-D3	-	-	-	-	+	-
D2-D4	-	-	-	-	-	-
D3-D4	-	-	-	-	-	-

The Tukey’s Post Hoc test results show that Stanley and Gabrovo differ in the six biochemical parameters from the other varieties, but they are statistically equal in total sugars. Varieties Gabrovska, Strinava, and Mirabelle de nancy had statistically equal invert sugar values in fruit.

The drying process eliminates the difference between the total sugars in fresh fruit varieties Stanley and Strinava. The dried Stanley and Mirabelle de nancy become indistinguishable in sucrose content, dried Stanley, Gabrovska and Strinava in the acid content, dried Gabrovska and Stranava in the ascorbic acid content.

To determine the informative indicators which will be used in the selection of varieties for drying is filled Independent-Samples Student t-test with verification for the hypothesis of mean values equality between fresh and dried fruits of the same variety. The tests results are given in Tables 3, 4, 5, and 6.

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Table 3. *Independent-Samples Student t- test for Stanley variety.*

Indicator	R1		D1		d	t	P(t)
	$\bar{x}$	SD	$\bar{x}$	SD			
Total sugar, g.kg^{-1}	62.10	0.40	23.00	0.07	39.11	135.15	99.60
Sucrose, g.kg^{-1}	22.08	0.71	8.66	0.83	13.42	17.45	99.70
Invert sugar, g.kg^{-1}	38.65	0.01	14.51	0.07	21.14	482.80	99.90
Acids (as malic), g.kg^{-1}	2.58	0.02	0.77	0.06	1.81	38.16	99.90
Ascorbic acid, mg.dL^{-1}	82.53	0.11	11.22	0.17	71.30	489.11	99.90
Anthocyanins, mg.dL^{-1}	36.52	0.04	20.66	0.05	15.85	368.51	99.90

Table 4. *Independent-Samples Student t- test for Gabrovska variety.*

Indicator	R1		D1		d	t	P(t)
	$\bar{x}$	SD	$\bar{x}$	SD			
Total sugar, g.kg^{-1}	62.01	0.23	29.43	0.68	32.58	64.19	99.60
Sucrose, g.kg^{-1}	24.58	0.49	2.39	0.10	22.19	62.01	99.30
Invert sugar, g.kg^{-1}	36.06	0.13	27.30	0.26	8.75	42.07	99.90
Acids (as malic), g.kg^{-1}	2.92	0.09	0.99	0.01	1.93	27.29	99.90
Ascorbic acid, mg.dL^{-1}	88.00	0.13	8.04	0.11	79.97	660.70	99.90
Anthocyanins, mg.dL^{-1}	57.09	0.13	12.74	0.13	44.35	330.11	99.90

Table 5. *Independent-Samples Student t- test for Strinava variety.*

Indicator	R1		D1		d	t	P(t)
	$\bar{x}$	SD	$\bar{x}$	SD			
Total sugar, g.kg^{-1}	45.77	0.39	22.89	0.23	22.87	70.38	99.90
Sucrose, g.kg^{-1}	10.12	0.17	4.94	0.13	5.18	34.53	99.90
Invert sugar, g.kg^{-1}	34.95	0.35	17.57	0.60	17.38	35.24	99.70
Acids (as malic), g.kg^{-1}	1.81	0.78	0.62	0.09	1.19	13,97	99.50
Ascorbic acid, mg.dL^{-1}	41.00	0.06	8.66	0.15	32.33	287.78	99.90
Anthocyanins, mg.dL^{-1}	28.83	0.25	20.00	0.14	8.83	43,78	99.90

Table 6. *Independent-Samples Student t- test for Mirabelle de nancy variety.*

Indicator	R1		D1		d	t	P(t)
	$\bar{x}$	SD	$\bar{x}$	SD			
Total sugar, g.kg^{-1}	50.90	0.17	21.06	0.42	29.84	93.71	99,80
Sucrose, g.kg^{-1}	13.34	0.16	7.19	0.26	6.15	28.23	99.90
Invert sugar, g.kg^{-1}	36.69	0.24	12.73	0.37	23.96	76.12	99.90
Acids (as malic), g.kg^{-1}	1.03	0.05	0.29	0.02	0.73	19.17	99.70
Ascorbic acid, mg.dL^{-1}	79.18	0.26	10.05	0.09	69.13	349.52	99.90
Anthocyanins, mg.dL^{-1}	11.46	0.13	2.89	0.16	8.56	58.65	99.90

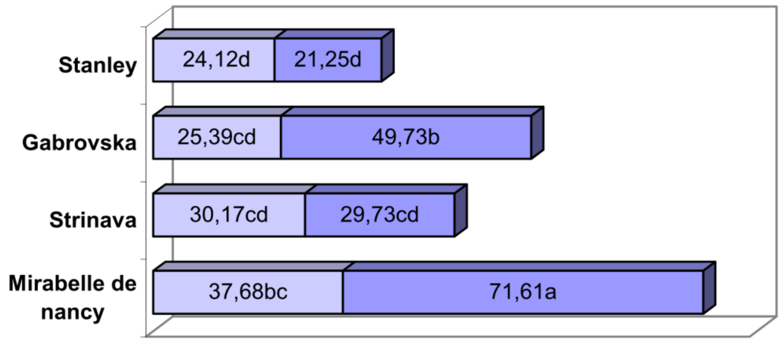

Figure 1. *Ratio of total sugars/acids of Stanley, Gabrovo, Strinava, Mirabelle de nancy as a function of drying process.*

The empirical value of t-criteria for independent samples is greater than the critical value 4.30 at $k=n_1+n_2-2=2$, $\alpha=0.05$. The probability degrees P(t) calculated for the relevant significance level are greater than 95%. Therefore established downward trend in the value of each indicator leads to discernibility in all varieties between fresh and dried fruits. For the selection of plums varieties for drying is necessary to use another sign of individual varieties for which there is a statistical equality between the values of fresh and dried fruits.

Figure 1 shows the HSD test results of the ratio of total sugars/acids in the four varieties tested before and after drying.

From the data analysis it is found that the heat pump drying is accompanied by an equal and simultaneous change in the substrates during the process of varieties Stanley and Strinava. This may explain the indistinguishability of the ratio sugars to organic acids between fresh plums and dried product.

Conclusion

A trend towards reducing of total sugars, sucrose, invert sugar, organic acids, ascorbic acid, and anthocyanins in varieties Stanley, Gabrovo, Strinava and Mirabelle de nancy, which at heat pump drying leads to identifiability in all varieties between fresh and dried fruits. In terms of taste for variety selecting for drying is used another indicator, for which there is a statistical equality between the fresh and dried fruits. Such is the ratio of total sugars and organic acids before and after heat pump drying at varieties Stanley and Strinava.

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